Incidence of CNS Side Effects and Thrombophlebitis in Intravenous Regional Anaesthesia with 2-Chloroprocaine or Xylocaine.

P. Korzeniewski, MD; S.A. Lang, MD, FRCPC
Department of Anaesthesia, University of Saskatchewan, Saskatoon, Saskatchewan S7N 0X0

INTRODUCTION: Chloroprocaine (CP) has been shown to be an effective agent for Intravenous Regional Anaesthesia (IVRA).[1,2,3] Despite this, Xylocaine (XYL) remains the drug of choice for IVRA, because thrombophlebitis (TP) has been reported with CP use.[1] However, more recent studies demonstrated that CP does not cause clinically significant TP.[2,3] CP has been suggested as an ideal agent for IVRA, because it's rapid hydrolysis in blood by pseudocholinesterase may result in a lower incidence of minor central nervous system (CNS) side effects.[1] Therefore, we tested the hypothesis that the incidence of CNS side effects and TP, was not different, using CP or XYL for IVRA, in a randomized, double-blind trial.

METHODS: In a study approved by the Ethics Committee, 55 patients scheduled for elective or emergency procedures on an upper extremity were randomly allocated to receive IVRA with either 0.5% CP (3.5 $mg \cdot kg^{-1}$) or 0.5% XYL (3.5 $mg \cdot kg^{-1}$) using identical techniques in both groups. CNS side effects were elicited by first asking the patient to report any unusual symptoms and then by specific questions about dizziness, lightheadedness, tinnitus, perioral numbness, unusual taste in the mouth and nausea. Objective evidence of CNS toxicity such as: muscular twitching, or overt seizure activity - was documented by the anaesthetist performing the procedure who was blinded as to which agent was used. Patients were contacted by phone 2 - 3 weeks following the procedure. They were asked about symptoms of TP, by a blinded observer. Thrombophlebitis was defined as any area that was tender, discoloured, itchy or painful, with or without a cord-like mass. Data was analyzed using t-tests and Chi-squared test with Yate's correction. Statistical significance was defined as a p value ≤ 0.05.

RESULTS: Three patients were excluded from the study. One because of documented psueodocholinesterase deficiency, one secondary to a cuff failure which necessitated a general anaesthetic, and in one patient IVRA and the surgery were abandoned due to manifestations of Sick Sinus Syndrome. In the remaining 52 patients, there were no statistically significant differences between the two groups, with respect to sex or weight (Table 1). Cuff inflation time was not significantly different between the two groups. There was a 19% incidence of CNS side effects in the CP-group and 66% incidence of CNS side effects in the XYL-group. This was statistically significant by student t-test ($p<0.01$). Symptoms that were recorded included: metallic taste, dizziness, tinnitus and lightheadedness. There were no seizures in either group. All but two of the 52 patients were contacted by phone. Of these contacted by phone in our follow-up, none reported TP. There were no drug failures in either group.

DISCUSSION: We have demonstrated that IVRA is equally efficacious when done with either CP or XYL in doses of $3.5 mg.kg^{-1}$. Furthermore, neither drug was associated with any cases of TP. However, IVRA is associated with statistically significant increase in the incidence of CNS side effects when performed with XYL rather than CP. A previous study has shown that CP can be used safely in IVRA at an average dose of 7.8 $mg \cdot kg^{-1}$.[3] In contrast XYL is not recommended for IVRA at doses >3-3.5 $mg \cdot kg^{-1}$ due to an unacceptable incidence of both minor and major (i.e seizures) CNS side effects.[4,5]. CP, therefore, has a larger margin of safety in IVRA than XYL. There were no cases of TP in the CP group, in our study. However, assuming the previously reported incidence of TP with CP (8%)[1], the number of cases in our study was too low to achieve an adequate power ($1-\beta=33\%$) of the study. It is estimated that to demonstrate a difference with the 8% incidence of TP, a total of more than 1000 cases would need to be studied.

CONCLUSION: We have demonstrated that there is a significant reduction in the incidence of CNS side effects when IVRA is done with CP ($3.5 mg.kg^{-1}$) as opposed to XYL ($3.5 mg.kg^{-1}$).

REFERENCES:

1. Harris W: Regional anesthesia by the intravenous route. JAMA, 1965, 194:105-8.
2. Palar TAR: Garber H.R. Intravenous regional anesthesia for operations in the lower limb. Reg Anesth, 1982, 7:29-32.
3. Lang SA, Ha HC: Intravenous regional anaesthesia with 2-Chloroprocaine does not cause clinically significant thrombophlebitis. Can J Anaesth, 1989, Vol 36:3,S-160.
4. Sorbie C, Chacha P: Regional Anesthesia by the Intravenous Route. Br Med J, 1965, 1:957-960.
5. Bell HM, Slater EM: Regional Anesthesia with Intravenous Lidocaine. JAMA, 1963, 186:544-549.

Table I

	N	Weight kg	Sex M:F
CP	26	74.6 ± 2.31*	13:13
XYL	26	80 ± 2.9	17:9

*Values ± SEM. NS - Non-significant; $P \leq 0.05$

Table II

	N	Drug Failure	Cuff Inflation Time	CNS Side Effects
CP	26	0	26.1 ± 1.8*	5**
XYL	26	0	31.4 ± 2.3*	16**

* Values ± SEM. NS - Non-significant. $P \leq 0.05$
** $P \leq 0.01$ - for CNS side effects in the CP and XYL group.

EFFECT OF INTRATHECAL FENTANYL ON THE INCIDENCE OF TOURNIQUET PAIN DURING SPINAL ANAESTHESIA

R Grant MD FRCPC, C Loader MB BS, H Vaghadia MD FRCPC, D Wong MB BS FRCPC, T Waters MD FRCPC, P Merrick RN BSN

Department of Anaesthesia, Faculty of Medicine, University of British Columbia and Vancouver General Hospital, Vancouver, B.C.

INTRODUCTION

Pneumatic tourniquets are widely used to facilitate limb surgery. An adverse effect of concern is the occurrence of moderate to severe tourniquet pain during otherwise satisfactory spinal anaesthesia. This may be so severe as to necessitate general anaesthesia. Small amounts of morphine added to the spinal anaesthetic mixture has been reported to reduce the incidence of tourniquet pain but with a significant frequency of side effects including emesis, urinary retention and generalised pruritus.[1] Fentanyl has been documented to be effective as an epidural analgesic by itself or in combination with local anaesthetics and with a lower incidence of side effects. We therefore conducted a randomized, double blind, placebo controlled study to determine the effect of subarachnoid fentanyl on the incidence of tourniquet pain during isobaric tetracaine anaesthesia for lower limb orthopaedic surgery.

METHODS

Following institutional approval and informed consent 25 patients were studied. Patients were premedicated with an oral benzodiazepine and sodium citrate 30 mls. Spinal anaesthesia was performed at the L23 interspace with the patient in the lateral position. Patients were randomized to a tetracaine saline group (group 1, n=12) or a tetracaine fentanyl group (group 2, n=13). Both groups received 3 mls of spinal solution containing 15 mg of isobaric tetracaine. Fentanyl 25 µg was added to the solution in group 2 only. Sensory level to ice was recorded every 5 minutes for 30 minutes following completion of the block. Sensory level and motor block were recorded in the recovery room together with the time of first analgesic requirement, as an indication of duration and regression of block. Degree of motor block was assessed on a standard 0 to 3+ scale. Presence or absence of tourniquet pain was noted and its relationship to tourniquet time, duration and height of block. Tourniquet pain was defined as a spontaneous complaint of discomfort directly related to the tourniquet site or operative limb. This was treated with intravenous fentanyl and diazepam and when unsatisfactory, general anaesthesia was instituted. Due to technical difficulties five patients had their blocks performed either sitting or at adjacent interspaces. The characteristics of spinal blockade were compared using the Mann-Whitney test. The incidence of tourniquet pain and side effects of spinal anaesthesia were compared using Fisher's exact test. A p value < 0.05 was considered significant.

RESULTS

Groups 1 and 2 were demographically similar. Surgery involved either total knee joint replacement or various procedures on the ankle or forefoot. No statistical difference could be shown in block height, duration, regression, or onset time of block. Median time to maximal block height on the tourniquet side was 17.5 minutes in the saline group and 15 minutes in the fentanyl group. There was no significant difference in nausea, hypotension and pruritus between the 2 groups. No patient in the fentanyl group had problems with apnoea or bradypnea. No patient vomited, however, 2 patients experienced mild transient nausea in the fentanyl group. Five patients experienced tourniquet pain - 3 in the saline group and 2 in the fentanyl group. Of these, one patient required general anaesthesia (saline group). Results are summarised in the table. In the remaining 20 patients, 1 required general anaesthesia for a C6 block (saline group) and another for an iliac crest bone graft (fentanyl group). There was no statistical difference in the incidence of tourniquet pain between the 2 groups (p=0.52). Sensory block in patients experiencing tourniquet pain was T12 or higher. Motor block was complete in all these 5 patients. Although not statistically significant, pain tended to occur earlier in the saline group (see table).

DISCUSSION

Only one patient experienced tourniquet pain severe enough to warrant general anaesthesia (saline group). However, the actual incidence of tourniquet pain was moderately high (20%) despite sensory and motor block at the site of tourniquet application. This confirms what several authors have previously noted and may be related to ischemia induced firing of neurones in the C fibre range.[2,3] In a limited number of patients we were unable to demonstrate a difference in the incidence of tourniquet pain, following intrathecal administration of fentanyl. The potentially beneficial role of subarachnoid fentanyl on tourniquet induced pain requires further evaluation.

REFERENCES

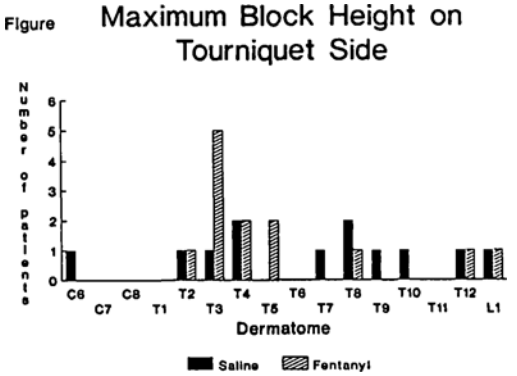
1. Acta Anaesthesiol Scand 1988;32:113-116.
2. Anesthesiology 1990;72:1038-1044.
3. Anesth Analg 1988;67:828-32.

Table: Patients Experiencing Tourniquet Pain

Pt #	Group*	Ipsilateral Sensory Level	Time after Tourniquet Inflation (minutes)	Time Post Block (mins)	Dose IV Fentanyl	GA
3	S	T12	20	30	25 µg	Y
11	S	T8	13	21	150 µg	N
18	S	T7	90	100	125 µg	N
1	F	T4	102	110	75 µg	N
10	F	T4	66	72	50 µg	N

*S=Saline, F=Fentanyl

Figure



IS SHOULDER MOBILITY AFFECTED BY THE TYPE OF POSTOPERATIVE ANALGESIA

M.J. Ali MD, W. Dobkowski MD, T. Cornelius Bsc (PT), R. Hawkins MD, G.P Varkey MD
Department of Anaesthesia, University Hospital, 339 Windermere Road London, Ontario, N6A 5A5

INTRODUCTION: Shoulder surgery results in severe often intractable pain that is thought to hinder mobilization of the joint. Continuous interscalene bupivacaine infusion (IS) produces better pain relief and results in a lower narcotic requirement after shoulder surgery.[1,2] However, there is no objective documentation of shoulder mobility with different analgesic techniques after shoulder surgery.
OBJECTIVE:1) To determine which of the three modalities of postoperative analgesia: IS, PCA using morphine (PCA) or intramuscular morphine (IM) is superior. 2) To compare the passive range of shoulder motion between these three techniques of analgesia after shoulder surgery.**DESIGN**: Prospective randomized, nonblinded clinical trial **METHODS**: 21 patients undergoing shoulder surgery (arthroplasty, acromioplasty, rotator cuff or capsule repairs) were enrolled after an informed consent and randomized to IS (n = 8), PCA (n = 6) and IM (n = 7) groups. The technique of catheter insertion in the interscalene group has been described elsewhere[1]. 20cc of .25% bupivacaine with 1 in 200,000 epinephrine was injected through the interscalene catheter after surgery followed by an infusion of .125% bupivacaine with 1/400,000 epinephrine at 5-10cc per hour (based on the weight of the patient) for 48 hours. The PCA group received intravenous morphine in the recovery room until they were comfortable and then demand morphine, 2mg up to every six minutes. Similarly, patients in the IM group received intravenous morphine in the recovery room and then 5-10mg morphine intramuscularly every three to four hours as needed. A 100mm closed visual analogue pain score (VAS) was used to observe subjective pain in each patient every 8 hours for 72 hours. A physiotherapist measured passive forward flexion (FF) and external rotation (ER) of the shoulder joint in each patient prior to surgery (PREOP), after surgery in the recovery room (OR), first and second post operative days(POD 1,2) as well as on the return visit to the clinic two weeks later (2WKS).One way Anova, one way Anova with repeated measures, student Newman-Keuls and chi-square were used to compare the results between and within the three groups, $P < .05$ was considered significant. **RESULTS**: Patients did not differ with respect to age, sex, weight, height and intraoperative fentanyl administration. Patient's in the IS group had a significantly lower VAS than the other two groups which did not differ from each other (Fig I). FF and ER decreased significantly with surgery in each group and then showed a gradual recovery(Fig II). The IS group demonstrated a smaller decline in FF (POD 2, $P < .05$) and a greater recovery (2WK,$P < .05$). **CONCLUSION**: After shoulder surgery IS produced far better analgesia than IM and PCA morphine. This was associated with improved shoulder joint mobility.
REFERENCES:1) Anesthesiology 73: A828, 1990.2) Acta Anaesthesiol Scan 31: 276-278, 1987.

Fig 1

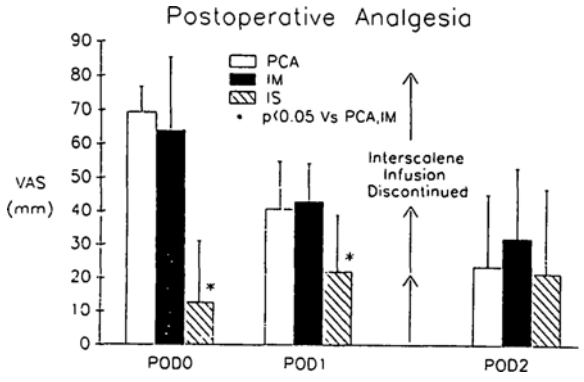
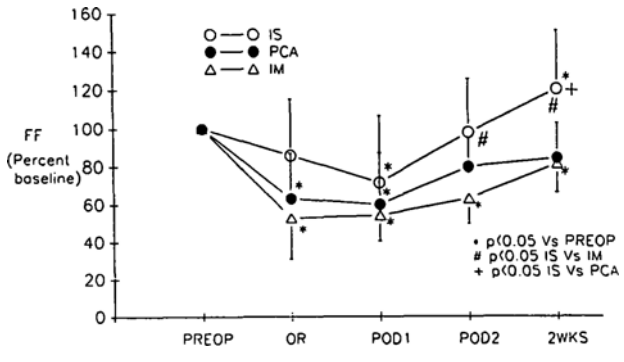


Fig II



FLUMAZENIL FOR REVERSAL OF SEDATION WITH MIDAZOLAM DURING REGIONAL ANAESTHESIA

Liam Claffey[1] MB FFARCS, Gilles Plourde[1] MSc MD*, Michel Trahan[1] BSc, Joan Morris[2] BSc MHSc, Deanne M. Dean[2] PhD

[1]Department of Anaesthesia, Royal Victoria Hospital, 687 Pine Avenue West, Montreal, H3A 1A1
[2]Hoffmann-LaRoche Ltd., 2455 Meadowpine Blvd., Mississauga, Ontario, L5N 6L7

INTRODUCTION:

The aim of this study was to assess the efficacy of flumazenil [1], a specific benzodiazepine receptor antagonist, for reversal of sedation with midazolam during regional anaesthesia.

METHODS:

Patients. After Hospital Ethics Committee approval, all patients gave written informed consent. Twenty-four ASA I or II patients undergoing elective surgery under epidural anaesthesia participated. Following epidural block, midazolam was administered (0.03 $mg.kg^{-1}$ loading, followed by 0.008 $mg.kg^{-1}$ increments), until the patient reached level 2 on the Alertness Scale (Table I, adapted from [2]). Additional midazolam (increments of 0.008 $mg.kg^{-1}$) was given as needed to maintain the same level of sedation, until the end of surgery. At the end of surgery, the patients were randomly allocated to receive, in a double-blind manner, either a flumazenil (0.1 $mg.ml^{-1}$) or placebo solution. Two ml of the study solution was administered initially, followed by 1 ml every minute, until the patient reached level 4 on the Alertness Scale or until a maximum of 10 ml had been administered.

Assessment of Alertness. Critical flicker frequency (CFF) [3] and the Trieger dot test (TDT) [4] were selected to assess central nervous system impairment. The CFF measures the maximum visual flickering rate that can be perceived by the patient. When experimental conditions (light, intensity, color, pupillary diameter) are kept constant, the CFF reflects the level of alertness. The Trieger test is a paper-and-pencil test. The patient must trace a line over a series of dots that form a picture. Scoring is based on the number of dots that have not been touched by the line. It is a sensitive indicator of sensory or motor impairment.

The assessments were done at the following times: before surgery (baseline), immediately before administration of study drug, and serially afterwards, at 10, 30, 60, 90, 120, 150 and 180 minutes.

Analyses of variance for repeated measures and t-tests (based on the pooled estimate of variance) were used. Analysis of covariance was also used to control for age differences between groups and for changes in pupillary diameter. For the t-tests, a P value of 0.007 or less is required for significance (Bonferroni). All values below 0.05 are nevertheless indicated.

RESULTS

There was a significant age difference between the two groups of patients: 41 years (SD 7) in the flumazenil group versus 31 (SD 7) in the placebo group ($P < 0.001$). The two groups of patients were otherwise comparable with regard to gender, ASA class, height, and weight.

The mean duration of surgery was 0.72 hours (SD = 0.25) in the flumazenil group and 0.74 hours (SD 0.28) (NS). The mean total dose of midazolam was 9.5 mg (SD 2.3) for the flumazenil group and 11.2 mg (SD 2.8) for the placebo group. The mean volume of flumazenil solution administered was 5.5 ml (SD 1.9) (equivalent to 0.55 mg). The mean volume of placebo was 6.7 ml (SD 2.2). There was no significant difference between flumazenil and placebo for the three measures above.

The CFF and level of alertness (Table II) were significantly higher in the flumazenil group at 10 minutes. The number of dots missed on the TDT (Table II) was larger in the flumazenil group at 90, 120 and 150 min, and the difference approached statistical significance.

Results remained the same when controlling for the age difference between groups. Changes of pupillary diameter were similar for both groups and could not account for the CFF difference.

DISCUSSION.

The significant differences in the CFF and Alertness Scale at 10 min confirmed the efficacy of flumazenil for reversal of sedation mediated by midazolam. The trend toward a worse performance in the Trieger Test from 90 to 150 min is surprising. It probably indicates that the more alert patients were bored and lost interest in the test.

ACKNOWLEDGEMENTS.

Statistical analysis performed by JC Baskerville, PhD and LW Stitt, MSc, STATLAB, University of Western Ontario, London, Ontario. Supported by a grant from Hoffmann-LaRoche Ltd.

REFERENCES.

[1] Eur J Anaesth Suppl 2: 65-80, 1988
[2] Br J Anaesth 58: 1005-11, 1986
[3] Psychopharm 47: 175-82, 1976
[4] Anesth Analg 48: 136-40, 1969

TABLE I
- Alertness Scale -

5 = Awake, tense
4 = Awake, not tense
3 = Drowsy
2 = Sleepy, verbally arousable
1 = Sleepy, arousable only with physical stimulation
0 = Not arousable

TABLE II - Mean (Standard Deviation)

Time	CFF (Hz)		Trieger (# of dots missed)		Alertness Scale	
	Flumazenil	Placebo	Flumazenil	Placebo	Flumazenil	Placebo
Pre-op	45.0 (3.7)	47.0 (2.8)	9 (6)	9 (4)	4.0 (0.0)	4.1 (0.3)
0*	36.4 (4.7)	38.6 (4.1)	26 (11)	29 (9)	1.9 (0.3)	2.1 (0.3)
10 min	42.9 (3.4)	39.6 (3.5)**	16 (9)	18 (9)	3.9 (0.6)	3.6 (0.5)**
30 min	42.2 (3.7)	42.2 (3.6)	12 (9)	9 (6)	4.0 (0.0)	3.8 (0.6)*
60 min	42.6 (3.4)	42.7 (3.4)	14 (12)	9 (9)	3.8 (0.6)	3.8 (0.6)
90 min	41.5 (3.5)	44.1 (3.5)	14 (10)	8 (5)*	3.8 (0.6)	4.0 (0.0)
120 min	42.4 (3.9)	43.5 (3.7)	15 (11)	7 (7)*	3.8 (0.6)	3.8 (0.6)
150 min	43.0 (3.5)	44.9 (2.7)	12 (9)	5 (5)*	4.0 (0.0)	3.8 (0.6)
180 min	44.0 (3.3)	44.8 (3.6)	12 (10)	8 (5)	4.0 (0.0)	4.0 (0.0)

a: Time 0 is immediately before flumazenil/placebo administration
*: Near-significant difference from Time 0 ($P \leq 0.05$)
**: Significant difference from Time 0 ($P \leq 0.005$)

EFFECT OF LUMBAR EPIDURAL ANAESTHESIA ON PROSTAGLANDIN E1-INDUCED DIURESIS IN ANAESTHETIZED HUMANS.

Hiroshi Yamaguchi, M.D., Izumi Harukuni, M.D., Hiroshi Naito, M.D.
Department of Anesthesiology, Institute of Clinical Medicine, University of Tsukuba, Tsukuba-city, Ibaraki, 305, JAPAN.

INTRODUCTION Prostaglandins are endogenous biological analogues which are derived from arachidonic acid. Prostaglandin E_1 (PG_{E1}) is used as a hypotensive agent in the practice of delibrate hypotensive anaesthesia (DHA). PG_{E1} has major advantages in DHA that it provides us easy blood pressure control without peripheral hypoperfusion. For example PG_{E1} increases or maintains renal blood flow during DHA. Besides it increases excretion of sodium from renal tubules in the presence of antiduretic hormone (ADH). Through these 2 mechanisms PG_{E1} produces diuretic effect. During surgery under epidural anaesthesia plasma ADH level is suppressed compared with that under general anaesthesia. It is unclear whether an epidural block effects PG_{E1}-induced diuretic effect or not.

In this study, we compared the effect of PG_{E1} on Ccr and FE_{Na} between in patients under general anaesthesia with and without lumbar epidural block.

METHODS Eighty-five patients who underwent elective surgery were included in this study. Among them 43 patients (group A) recieved lapalotomy or lower extremeties surgery under epidural anaesthesia combined with general anesthesia, and the remaining 42 patients underwent head, neck or breast surgery under general anaesthesia. Patients who had renal and/or heart disorders or were prescribed diuretics were excluded from the study. The study protocol was approved by the local ethical commitee. Written informed consent was obtained from each patient.

Patients in each group were furtherly divided into 2 subgroups (PG and CONT groups). Oral diazepam, 5-10mg, and H_2-blocker were given po. to each patient as a premedication 90 minutes before entering the operating theater. In group B patients anaesthesia was induced with thiamilal, 5mg/kg iv., and intubation was facilitated with vecuronium, 0.2mg/kg iv. Anaesthesia was mainteined with 1-1.5% enflurane, 67% nitrous oxide and oxigen (GOE). In group A patients, before anaesthesia induction, epidural catheter was placed through L1/2 or L2/3 and epidural block (Epi) ranging T6 through L5 was established by 2% lidocaine solution, and anaesthesia was accomplished as that in group B patients. During the study blood pressure and heart rate were determined every 5 minutes. In each patient, after surgery started, the first 1-hour urine was collected and its volume, creatinine and sodium levels were determined. Next, in PG group the infusion of PG_{E1}, 0.05 micrograms/kg/min, and in CONT group the infusion of saline, 15 ml/hour, was started. From the 15 minutes after infusion started, the second 1-hour urine was collected and its volume, creatinine and sodium levels were determined. Thereafter the infusion was stopped and blood pressure and heart rate were determined for the additional 30 minutes. The calculated values of Ccr and FE_{Na} were obtained. The percent changes from before to during infusion in blood pressure, heart rate, Ccr, FE_{Na} were compared between PG and CONT groups in group A or B. $P<0.05$ was considered to be significant.

RESULTS In both PG groups blood pressure and heart rate significantly changed during PG_{E1} infusion (Table II). In B-PG group urinary volume, Ccr and FE_{Na} significantly increased from 99 ± 20 to 171 ± 24 (ml/hr), from 96 ± 6 to 178 ± 21 (ml/min), and 0.85 ± 0.15 to 1.74 ± 0.39 (%), $p<0.01$, respectively, but not in the other 3 groups. (Figure I)

Table I. Patients data. (Mean ± SE) Not significant among 4 groups.

group	Anaesthesia	n (m/f)	age (yrs)	height (cm)	weight (kg)	$PaCO_2$ (mmHg)
A-CONT	Epi-GOE	20 (9/11)	52 ± 3	157 ± 6	61 ± 3	33 ± 1
A-PG	Epi-GOE	22 (13/9)	52 ± 2	161 ± 2	54 ± 2	34 ± 1
B-CONT	GOE	21 (12/9)	45 ± 4	160 ± 2	54 ± 2	35 ± 1
B-PG	GOE	22 (6/16)	47 ± 4	155 ± 2	57 ± 2	33 ± 1

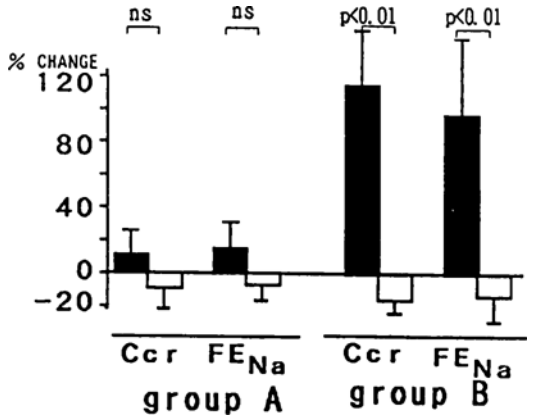
Table II. Blood pressure (BP) and heart rate (HR) changes during the study. (Mean ± SE) BP is systolic/diastolic. (*: $p<0.05$ vs. Before)

group		Before	During	After
A-CONT	BP (mmHg)	116 ± 3/65 ± 2	114 ± 3/65 ± 2	114 ± 2/64 ± 2
	HR (bpm)	72 ± 2	73 ± 3	73 ± 3
A-PG	BP	120 ± 2/67 ± 2	91 ± 2/52 ± 2*	120 ± 2/65 ± 1
	HR	67 ± 2	80 ± 4*	77 ± 3
B-CONT	BP	115 ± 2/68 ± 2	113 ± 2/66 ± 2	115 ± 2/67 ± 2
	HR	80 ± 3	80 ± 3	81 ± 3
B-PG	BP	131 ± 4/72 ± 3	99 ± 2/55 ± 2*	126 ± 3/67 ± 2
	HR	75 ± 3	92 ± 2*	83 ± 2

DISCUSSIONS In general anaesthesia group (group B) diuretic effect by PG_{E1} infusion was demonstrated, but not in epidural anaesthesia group (group A). PG_{E1} acts directly on vascular smooth muscle as vasodilator, and antagonizes vasoconstriction induced by angiotensin and norepinephrine, but which action is little unless renal vasoconstriction is present (1). Prostaglandins act as negative feedback modulators of the action of ADH on the kidney. PG_{E1} inhibits ADH-stimulated cAMP synthesis, or antagonizes the ability of ADH to stimulate adenylate cyclase. PG_{E1} inhibits Na absorption in the collecting tubules by acting on the peritubular membrane. Plasma ADH level during surgery under epidural anaesthesia is reported to be suppressed compared with that under general anaesthesia (2). The mechanism in which group A failed to demonstrate PG_{E1}-induced diuresis was supposed to be dilated renal artery by epidural anaesthesia and suppressed plasma ADH level.

REFERENCES 1. Am J Physiol 233:F169-F184, 1977. 2. Br J Anaesth 54:29-36, 1982.

Figure I. Percent changes in Ccr and FE_{Na} during infusion. Closed bar and open bar indicate PG and CONT group, respectively. (0%: base line)



CONTINUOUS SPINAL ANAESTHESIA: EFFECTS OF TITRATED LIDOCAINE BOLUSES

V.W.S. Chan FRCPC, N. Mati MD, C. Seyone MD, D. Evans FRCPC, F. Chung FRCPC
Department of Anaesthesia, Toronto Western Division, The Toronto Hospital, University of Toronto, Toronto, Ontario

Introduction- Recent renewed interests in continuous spinal anesthesia (CSA) is the result of smaller sized spinal catheters. While CSA is perceived to be 'safer', the effect of low dose lidocaine given in incremental boluses has not been examined. This study evaluates the progression of neuronal blockade and hemodynamic changes following titration of hyperbaric lidocaine in 25 mg doses through an indwelling spinal catheter.

Method- After institutional approval and informed consent, 25 ASA II-III male patients (54-82 yo, 53-123 kg, 157-182 cm) presented for transurethral resection of prostate were studied. Patients with neurological deficit or uncontrolled hypertension were excluded. A dilute lidocaine solution 25 mg/ml was prepared by mixing 2 ml of commercially available lidocaine 50 mg/ml in 7.5% dextrose with 2 ml of 7.5% dextrose. Prior to the conduct of spinal anesthesia, patients were premedicated with 5-10 mg diazepam p.o. and prehydrated with 500 ml of crystalloid solution (plasmalyte). Each patient received a 27 gauge continuous spinal catheter which was threaded through a 22 gauge spinal needle inserted at L3-4 interspace. A 2-3 cm catheter segment was left in the subarachnoid space. With the patient lying supine, a 25 mg lidocaine bolus (1 ml) was injected within 10 sec through the catheter. Injection of the same dose was repeated q 15 min until either a T6 sensory level or a maximum of 3 doses (75 mg). After each injection, the catheter was rinsed with 0.2 ml CSF.

Blood pressure and heart rate were measured pre-injection, q 1 min x 45 min and then q 10 min till the end of study. Left ventricular stroke volume, ejection fraction and cardiac output measurements by a non-invasive thoracic electrical bioimpedance method (BoMed NCCOM3^{TM}, Irving, CA) were carried out pre-injection and then q 3 min x 45 min. Pinprick sensory level and degree of motor blockade (Bromage scale) were assessed q 3 min x 45 min and then q 10 min until complete recovery. Data were expressed as mean ± SEM and analysed using ANOVA. $P < 0.05$ was considered significant.

Results- Eight patients received 2 doses and 17 received 3 doses. Peak effect of sensory and motor anesthesia following each dose appeared within 9 min. Stepwise progression of sensory blockade, as shown in figure 1, achieved a mean level of T11 after one dose, T8 after two doses and T6 after three doses. Motor blockade was complete in 3 patients (12%) after only one dose (25 mg) while it was incomplete in 2 patients at the end of three doses (Table 1).

Blood pressure declined proportionately to the number of doses given. Although significant, the maximal drop in systolic, diastolic or mean blood pressure was within 20% of preop value (figure 2). No vasopressor was required. Infusion of plasmalyte solution was 910 ± 177 ml over 137.5 ± 4.9 min of study period. Changes in heart rate, stroke volume, ejection fraction and cardiac otput were not significant.

Discussion- Our results show that by using repeated, small doses of lidocaine in CSA, sensory anesthesia can be titrated to a desired level in a stepwise manner. An arbitrary 75 mg dose would have been excessive in 8 study patients who only required 50 mg to reach a T6 level. Although the degree of motor blockade after lidocaine administration is dose related, the response at low dose (25 mg) is highly variable. Hemodynamic parameters of stroke volume, ejection fraction and cardiac output are all well preserved during the study period with the exception of blood pressure which declines with increasing lidocaine doses.

Figure 1

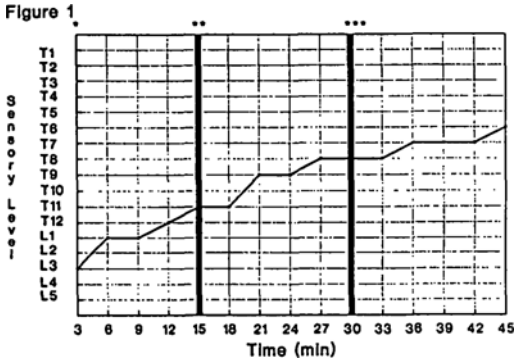
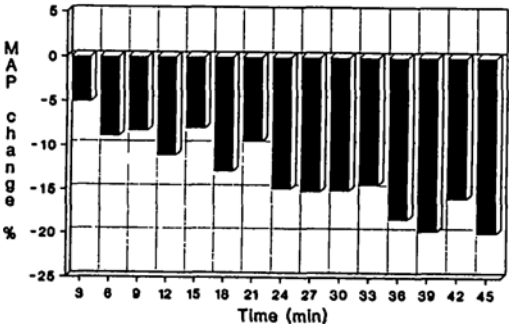


TABLE 1: **Motor Blockade (Bromage Scale)**

% of patients	1 Dose *n = 25*	2 Doses *n = 25*	3 Doses *n = 17*
No Block	16 %	0 %	0 %
Partial Block	24 %	8 %	0 %
Almost Complete Block	48 %	28 %	8 %
Complete Block	12 %	64 %	92 %

Figure 2



THE P2 WAVE OF THE LONG-LATENCY AUDITORY EVOKED POTENTIAL REFLECTS THE VIGILANCE IMPAIRMENT PRODUCED BY THE COMBINED ADMINISTRATION OF DIAZEPAM, MORPHINE AND SCOPOLAMINE

D. Joffe MD, G. Plourde MSc MD, C. Villemure BSc.
Departments of Anaesthesia, Royal Victoria Hospital & McGill University, Montreal, H3A 1A1

INTRODUCTION

It is difficult to quantify the vigilance impairment produced by sedative medications. Long-latency auditory evoked potentials (LLAEPs) reflect late stages of sensory processing and may help assess the level of vigilance. For example, Kerkhof reported diurnal variations of the latency of the P2 wave of the LLAEP, which correlated inversely with the efficiency of signal detection [1]. We have recorded the LLAEPs following premedication with diazepam, morphine and scopolamine prior to cardiac surgery, in order to assess their usefulness for measuring the impaired level of vigilance. The level of vigilance was objectively assessed with a signal detection task [2].

METHODS

Institutional Ethics Committee approval and informed consents were obtained from all participants. Twelve patients (11 males, mean age 54 years, SD 9) about to undergo cardiac surgery were tested. Diazepam (0.06 $mg.kg^{-1}$ p.o.) was given 60 min. before testing if surgery was planned in the morning. For afternoon surgery, diazepam (0.12 $mg.kg^{-1}$ p.o.) was given 240 min. before testing. Morphine (0.10 $mg.kg^{-1}$) and scopolamine (0.4 mg) were given i.m. to all patients 50 minutes before testing. The EEG was recorded from Fz, Cz and Pz with reference to the right mastoid. The bandpass was 0.3 to 100 Hz. LLAEPs were evoked by 1000 Hz tones (50 msec) presented every 1.5 sec. The tone frequency was occasionally and unpredictably increased to 2000 Hz to produce "target stimuli" that the subject was required to respond to by button-press. The probability of occurrence of the 1000 Hz tones was 0.8 and that of the 2000 Hz tones was 0.2. Sequencing was pseudorandom. The N1 and P2 waves of the LLAEP were measured on the potentials evoked by the 1000 Hz stimuli. N1 was identified as the maximum Cz negativity from 80 to 140 ms after stimulus; P2 as the maximum Cz positivity 120-250 ms. Peak latency and peak-to-baseline amplitude were measured for each wave. Subjects' level of vigilance was assessed with d', which is a measure of signal detection efficiency. A "d'" of zero means chance level of performance. A "d'" of 6 means an almost perfect performance (close to 100% detection rate for targets with a 0% false alarm rate).

Following loss of responsiveness during induction of anaesthesia with sufentanil (mean dose 7.9 $\mu g.kg^{-1}$, SD 2.7), recordings were obtained for comparison with pre-induction. Button-pressing was, of course, not possible after induction because of unresponsiveness and myoneural blockers. Paired and unpaired t-tests were used for analysis.

RESULTS

Results of the six patients with the best detection performance (high d') were compared with those six patients with the worst detection performance (low d') (Table I). The frequency of AM and PM surgery was similar for both groups. The latency of P2 was significantly shorter in the good detection performance group. There was an inverse correlation between the latency of P2 and d' (Figure). The difference in the latency of P2 disappeared following induction. The latency of N1 and that of P2 were significantly ($P < 0.002$) increased after induction for both groups. There were no significant amplitude changes.

DISCUSSION

The results indicate that the P2 component of the LLAEP can be used to measure the level of vigilance during sedation and extend Kerkhof's findings.

REFERENCES

1. Psychophysiology 19: 94-103, 1982.
2. Green DM and Swets JA. Signal detection theory and psychophysics. Wiley-New York, 1966.

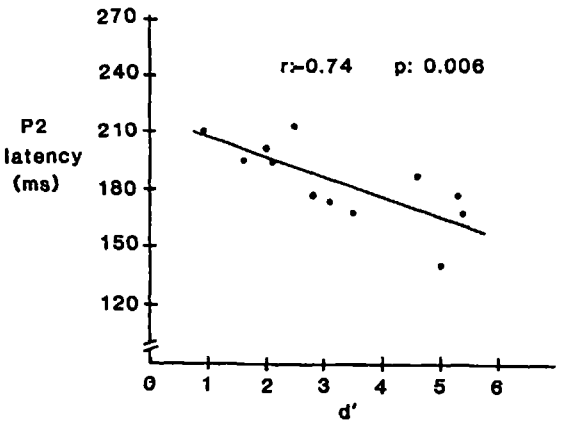


TABLE I - Mean (SD)

	BEFORE INDUCTION			AFTER INDUCTION	
	All Subjects N = 12	Detection Performance		Pre-Induction Detection Performance	
		Poor (low d') N = 6	Good (high d') N = 6	Poor (low d')	Good (high d')
d'	3.2 (1.5)	2.0 (0.7)	4.5 (1.0)*	-	-
N1 amplitude (μV)	-5.3 (2.3)	-4.7 (1.7)	-5.8 (2.9)	-4.1 (3.9)	-5.6 (2.4)
P2 amplitude (μV)	4.0 (2.1)	4.9 (2.0)	3.1 (1.9)	5.4 (3.8)	2.6 (1.9)
N1 latency (msec)	104 (8)	105 (8)	102 (9)	118 (15)	119 (12)
P2 latency (msec)	183 (21)	198 (13)	167 (16)*	223 (31)	218 (40)
No. patients with morning surgery	6	3	3	-	-
No. patients with afternoon surgery	6	3	3	-	-

* $P < 0.005$, compared with Poor (low d') group.

IN VIVO CATECHOL ACTIVITY IN THE ROSTRAL VENTROLATERAL MEDULLA: EFFECTS OF THE α_2-ADRENERGIC AGONIST DEXMEDETOMIDINE

M. Hong, M.Sc., B. Milne, M.D., C. Loomis, Ph.D., and K. Jhamandas, Ph.D.
Department of Pharmacology and Toxicology and Department of Anaesthesia, Queen's University, Kingston, Ontario K7L 3N6

INTRODUCTION

Alpha-adrenoceptor agonists, such as clonidine, are used clinically to control hypertension and to reduce the requirements for anaesthetic agents during anaesthesia. Although the precise mechanism by which α_2-agonists act in this regard is not known, it has been suggested that activation of central α_2-adrenoceptors are responsible for both the antihypertensive[1,2] and anaesthetic-reducing[3] actions of these agents. One brain site at which α_2-agonists may act to control blood pressure and modulate anaesthetic requirements is the C1 group in the rostral ventrolateral medulla (RVLM). This major adrenergic centre in the brain has been implicated in the control of blood pressure[4] and in the modulation and processing of sensory stimuli[3]. At present, few studies have examined the *in vivo* neurochemical changes that occur in the RVLM following α_2-agonists. Adrenergic activity in the RVLM can be reliably measured by monitoring catechol oxidation current using *in vivo* voltammetry[5]. The objective was to examine, using *in vivo* voltammetry, the effects of dexmedetomedine, a highly selective and potent α_2-adrenoceptor agonist, on adrenergic activity in the RVLM.

METHODS

Male rats (350-400 g), anaesthetized under halothane (1.0-1.5%) and metocurine (200 μg/kg), were stereotaxically implanted with carbon fibre microelectrodes in the RVLM. Using differential normal pulse voltammetry (DNPV), catechol oxidation current (CA*OC, % baseline) was monitored thus providing an index of adrenergic activity. Blood pressure was continuously monitored via a femoral arterial catheter. Following an initial stabilization period of 1 hour, animals were administered dexmedetomedine (50 μg/kg i.v.) or saline (0.3 ml i.v.) and CA*OC measured at 3-minute intervals. Following a 45 minute treatment period, the dexmedetomedine group received atipamezole (200 μg/kg i.v.), an α_2-adrenoceptor antagonist, and the other group received saline (0.3 ml i.v.). CA*OC was monitored at 3-minute intervals for 45 minutes.

RESULTS

Administration of the α_2-selective agonist dexmedetomedine (DEX) produced a significant decrease in CA*OC within 15 min following injection (peak 45 min, 10.30 ± 3.98% baseline) while saline had no effect (Figure 1). Administration of the α_2-selective antagonist atipamezole (ATIPAM) completely reversed the depressant effect of DEX on CA*OC within 20 minutes following injection of the antagonist. DEX also produced a significant increase in mean arterial pressure (MAP) while ATIPAM significantly decreased MAP within 1 min following injection of each drug (Table 1). These changes in MAP returned to resting MAP levels within 15 minutes following treatment and did not correlate with changes in CA*OC.

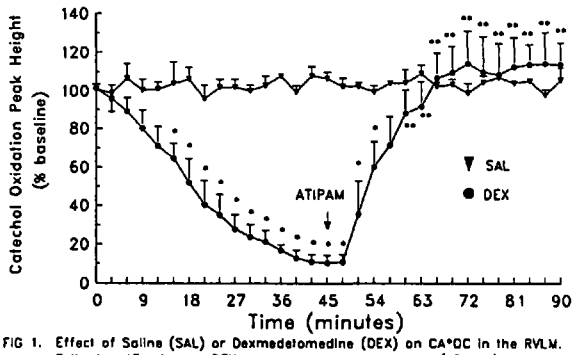


FIG 1. Effect of Saline (SAL) or Dexmedetomedine (DEX) on CA*OC in the RVLM. Following 45 minutes, DEX group received Atipamezole (ATIPAM) (mean + S.E., n = 4 (DEX), n = 3 (SAL). * $p < 0.05$ compared to control, ** $p < 0.05$ compared to peak DEX effect, ANOVA)

Table 1: Changes in Mean Arterial Blood Pressure Before and After Treatment

	TREATMENT		
Time	SALINE	DEX	ATIPAM
1 min pre	82.22 ± 8.35	83.33 ± 9.45	85.83 ± 8.07
1 min post	83.44 ± 8.48	133.17*± 9.28	62.08*± 8.26
5 min post	78.33 ± 10.84	115.42*± 8.18	80.17 ± 7.10
15 min post	80.33 ± 10.42	99.00 ± 9.27	78.50 ± 8.00
30 min post	80.11 ± 10.11	93.83 ± 8.97	77.75 ± 10.12
45 min post	78.89 ± 10.73	84.75 ± 9.21	80.33 ± 8.19

Data represents the mean ± S.E. of the MAP (mmHg) before and after saline or drug treatment. *$p < 0.05$ compared to pretreatment ANOVA.

DISCUSSION

The data show that the administration of the highly selective and potent α_2-adrenoceptor agonist dexmedetomedine produces a decrease in catechol oxidation current measured in the C1 group of the RVLM. This decrease in CA*OC is an indirect index reflecting decreased adrenergic neuronal activity in the RVLM. Although systemic dexmedetomedine also produced an increase in mean arterial pressure, it is unlikely that activation of baroreflex mechanisms, known to depress RVLM activity, are responsible for mediating the sustained decrease in CA*OC. The lack of a temporal correlate between blood pressure changes and changes in CA*OC suggests that central α_2-adrenoceptors are involved. The dexmedetomedine depressant action on CA*OC was completely reversed following the administration of the selective α_2-adrenoceptor antagonist atipamezole. Blood pressure changes observed following these α_2-adrenoceptor agents are most likely due to activation of peripheral adrenergic mechanisms. The present study clearly demonstrates that alpha$_2$ adrenoceptor agonists depress adrenergic neuronal activity in the RVLM. Such changes in the RVLM may be involved in the control of blood pressure and in the modulation and processing of sensory stimuli.

REFERENCES

1. Rev. Physiol. Biochem. Pharm. 81: 39-100, 1978.
2. J. Neurosci. 1: 908-917, 1981.
3. Eur. J. Pharmacol. 91: 29-39, 1983.
4. Hypertension Suppl. 11: I8-I13, 1988.
5. J. Neurochem. 54: 2042-2049, 1990.

The Effects of Brain Injury on the Pharmacodynamics of Pentobarbital

R Priddy FFARACS, D Archer FRCP(C), T Tang MD, M Sabourin, N Samanini.
Department of Anaesthesia, Foothills Hospital at the University of Calgary Aberta

INTRODUCTION

Recent investigations in a rat model have shown that brain injury decreases cortical local cerebral glucose utilization[1], probably due to increased serotonin turnover[2]. A study of the effects of anesthetics on glucose metabolism in injured brain has suggested that anesthetic requirements were reduced in the injured animals[3]. On the basis of these results, we speculated that anaesthetic requirements for pentobarbital would be reduced in brain-injured animals, and that this effect would be reversed by treatment with p-chlorophenylalanine(PCPA) to block serotonin biosynthesis.

METHODS

Following approval by the Animal Care Committee, two experiments were performed. In the first experiment the effect of the standardized cold injury on cortical serotonin(5-HT) and 5-hydroxyindoleacetic acid (5-HIAA) in the presence and absence of PCPA pretreatment (200 mg/kg injected intraperitoneally 24 hours before the injury) was determined. For the injured animals a standard brain injury was produced as previously described[1]. Three days after the injury, the animals were anesthetized with intraperitoneal pentobarbital (30 mg/kg) and decapitated. Following rapid removal of the brain the frontoparietal cortex was dissected free and frozen. Serotonin and 5-HIAA concentrations in the brain homogenates were determined by HPLC[2]. In the second experiment, the anesthetic requirements for normal and lesioned animals (3 days post-injury) with and without PCPA pretreatment (as above) were determined. Anesthesia was induced with a continuous intravenous infusion of sodium pentobarbital (1 $mg^{-1}.kg^{-1}.min^{-1}$). Anesthesia depth was initially assessed via lash reflex. Once this reflex was abolished, response to tail clamp was tested with a specific hemostatic clamp applied to the distal 2 cm of the tail and closed to the first rachet. At the time when the animal did not respond, the animal was decapitated and the brain removed. The brain was rapidly frozen, homogenized and the pentobarbital extracted with n-butyl chloride[4]. The extracts were analyzed by HPLC. Results were analyzed with analysis of variance followed by Bonferroni t-tests.

RESULTS

Figure 1 summarizes cortical concentrations (mean values + standard deviations) of serotonin and its first metabolite, 5-HIAA. In the untreated animals, the effect of the lesion was to increase serotonin levels on the lesioned side and to increase 5-HIAA bilaterally, suggesting a bilateral increase in serotonin turnover. PCPA pretreatment reduced both monoamines to less than 20% of normal values. Figure 2 shows the brain pentobarbital concentration (mean values + standard deviation). The untreated injured animals had a 30% reduction in brain pentobarbital concentration at decapitation in comparison to the untreated normal animals. PCPA pretreatment abolished this difference.

FIGURE 1. SEROTONIN & 5-HIAA IN CORTEX

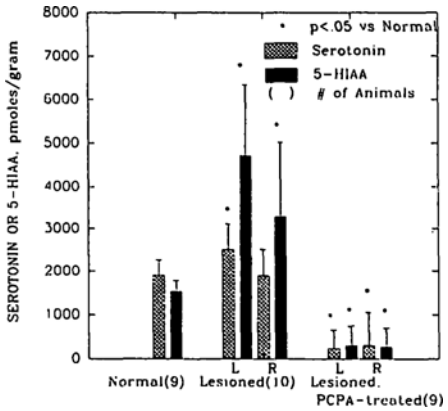
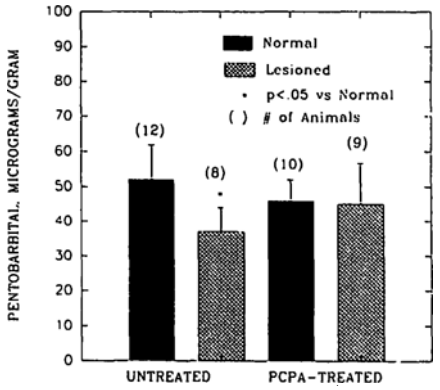


FIGURE 2. ANESTHETIC REQUIREMENTS



DISCUSSION

Anaesthetic requirements were reduced 30% in animals with cold injury. This effect was abolished by blockade of serotonin biosynthesis with PCPA. Although the mechanism of this effect is obscure, we speculate that serotonergic fibres descending to the spinal cord may be responsible.

1. Ann Neurol 9:484, 1981
2. J Cereb Blood Flow Metabol 8:324, 1988
3. J Cereb Blood Flow Metabol 10:624, 1990
4. Clin Chem 29:1097, 1983

SUFENTANIL AND NITROUS OXIDE: IMPACT ON CSF PRESSURE IN HUMANS.

IA HERRICK BSc,MD,FRCPC, PH MANNINEN MD,FRCPC, AW GELB MB,ChB,FRCPC,
DJ CUILLERIER MD,FRCPC.
DEPARTMENT OF ANAESTHESIA, UNIVERSITY HOSPITAL, UNIVERSITY OF WESTERN ONTARIO
LONDON, ONTARIO, CANADA.

INTRODUCTION:
Administration of sufentanil has been reported to cause increases in CBF and/or CSFP.[1,2] Nitrous oxide has also been reported to increase these parameters[3,4] and, at least in dog, to augment the CBF response to sufentanil.[2] This study was designed to prospectively evaluate the CSF pressure (CSFP) response to sufentanil administered in the presence and absence of nitrous oxide (N_2O).

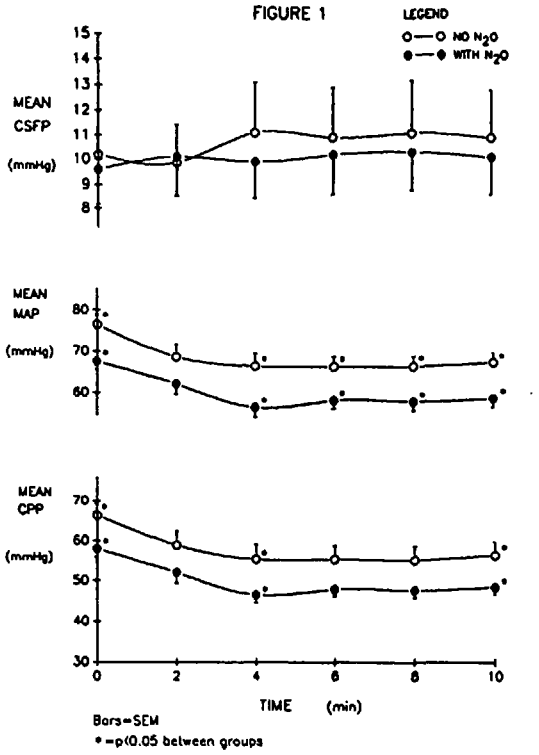
METHODS:
Following institutional ethics approval and informed consent, 28 adult patients undergoing craniotomy for aneurysm were studied. Anaesthesia was induced with thiopentone, vecuronium and fentanyl 2.0 mcg/kg and maintained with isoflurane (0-1.0 Vol% insp.) in air/O_2 (n=14) or 65% N_2O/O_2 (n=14). Monitoring included $ETCO_2$, ETN_2O, EKG, SaO_2, intraarterial BP and CSFP via a lumbar drain. Under stable conditions, sufentanil 0.2 mcg/kg was administered to each patient and CSFP response monitored continuously for 10 minutes. Statistical comparisons of HR, MAP, CSFP and cerebral perfusion pressure (CPP=MAP-CSFP) were made at 2 minute intervals following drug administration using ANOVA for repeated measures, Student-Newman-Keuls test and unpaired Student T-test. $p<0.05$ was considered significant.

RESULTS:
CSFP did not change significantly within or between groups following sufentanil. MAP and CPP declined significantly within each group by 2 minutes and beyond. Between groups MAP and CPP were significantly lower in the N_2O group at time of drug administration and some points thereafter (Fig. 1). $ETCO_2$ was similar between groups (Air; 30.6±2.8 mmHg vs N_2O; 29.9±1.8 mmHg; mean±SD). Mean inspired isoflurane was lower in the N_2O group (Air; 0.41±0.36 vol% vs N_2O; 0.29±0.21 vol%; mean±SD).

DISCUSSION:
No significant change in CSFP occurred in response to sufentanil. N_2O did not alter the CSFP response to sufentanil. With regard to impact on CSFP, either agent appears safe for use in anaesthetized, hyperventilated neurosurgical patients either alone or in combination. MAP and CPP decreased in both groups but the decrease was greater in the N_2O group likely due to a relatively greater depth of anaesthesia in this group.

REFERENCES:
1. Marx W et al. J Neurosurg Anesth 1989;1:3-7
2. Hilde L et al. Anesth Analg 1990;70:138-46
3. Archer D et al. Anesthesiol 1987;67:642-48
4. Jung R et al. J Neurosurg Anesth 1990;2:215

FIGURE 1



BRAIN WATER, ICP AND BRAIN RELAXATION: A COMPARISON OF MANNITOL AND FUROSEMIDE.

Armin Schubert M.D., Issam A. Awad M.D., Alejandro D. Perez-Trepichio M.D., Zeyd Y. Ebrahim M.D., Eric L. Bloomfield M.D.,
Cleveland Clinic Foundation, Departments of General Anesthesiology, Neurosurgery and Brain and Vascular Research

Introduction: Diuretics such as mannitol (M) and furosemide (F) are frequently used as adjunctive therapy in the treatment of elevated intracranial pressure (ICP) or to reduce brain bulk during intracranial neurosurgical procedures. These two agents have previously been compared in a heterogeneous group of neurosurgical patients (1), but the effect of diuretic treatment on intraoperative surgical conditions and brain water content (one of the mechanisms by which diuretics reduce intracranial volume) have not been systematically studied in humans. In this study we compared the effects of M and F on ICP, dural tightness and brain tissue water content in patients undergoing temporal lobectomy for seizure control.

Methods: After institutional approval and informed consent, 13 adult patients with intractable seizures were randomized to receive either M (0.5 g/kg) or F (0.5 mg/kg) approximately 40-60 min prior to craniotomy. Excluded from the protocol were patients who received preoperative diuretics, had undergone previous craniotomy and patients whose brain tissue specimen weighed less than 100 mg. Anesthesia was induced with sodium thiopental 2-4 mg/kg, sufentanil 1-1.5 µg/kg, relaxant, and was then maintained with nitrous oxide (60%), isoflurane (<0.5%) and sufentanil by continuous infusion. Fluids were limited to 10 ml/kg Ringer's lactate during the first 30 min of the procedure, followed by an infusion of 1-2 ml/kg/hr. Blood pressure was maintained within 20% of preoperative values and ventilation was controlled to a PaCO2 of 25 ± 2 mmHg. Mean arterial pressure, heart rate, temperature, end tidal CO2, end tidal isoflurane, urine output and intravenous fluids were measured at the time of surgical prep, during the drilling of the first cranial burr hole, prior to lifting of the cranial flap, at the time of the neurosurgeon's assessment of dural tightness, and at the time of retrieval of the brain tissue specimen. Epidural ICP was measured using a Gaeltek device after the first cranial burr hole was made and just prior to lifting of the cranial flap. The second ICP measurement was made while the bone flap was still connected to the cranium. During the surgical removal of the seizure focus, a specimen (100-500 mg) of brain tissue was obtained from the area of the middle temporal gyrus anterior to the resection line, in an area without preoperative MRI abnormalities. The specimen was immediately placed in an airtight container, frozen and preserved for subsequent analysis of wet and dry weight using desiccation by heat at 60°C. Tissue weight was repeated daily for up to 4 days to determine the dry weight of the tissue. Groups were compared using unpaired T-tests and Fisher's exact test. Statistical significance was assumed at the $p < 0.05$ level.

Results: Both groups were similar with respect to weight, height and gender, although group M patients were younger (28±6 vs 37±5 yrs.; $p<0.05$). Groups were also comparable with respect to baseline plasma sodium, potassium, glucose, osmolality and vital signs. Table 1 shows ICP, dural assessment, electrolytes and brain water content after M or F, when measured just prior to removal of the bone flap. Dural assessment was performed 52±23 min after M and 55±7 minutes after F. At that time, both groups had received an equivalent amount of Ringer's lactate, but urine output was higher with F (1005±42 vs. 551±195 ml; $p < 0.05$). Brain specimens were obtained 124±36 min after M and 118±12 min after F. At this point, fluids administered were also similar among groups, but urine volume was again lower in Group M (887±164 vs. 1485±700 ml; $p < 0.05$).

Discussion: When used as the sole agent for brain bulk reduction, M may transiently elevate ICP by augmenting vascular volume. Clinically, improved brain relaxation was observed when a loop diuretic was added to M (2). Our data suggest a trend toward lower ICP and the water content of normal brain with F, but barely fail to achieve statistical significance. However, this trend may become more evident with a larger sample. Furosemide was associated with significantly lower serum potassium and higher urine volume. We suggest that, if the trend in our data continues, F may be found to result in more dehydration of normal brain than M at the doses studied. When F is used for this purpose, however, larger urine and electrolyte losses should be anticipated.

References:

(1) Anesthesiology 47:28,1977
(2) J. Neurosurg. 56:679, 1982.

Table 1

	Mannitol n=7	Furosemide n=6	P
Osmo (mOSM/kg)	293±6	288±8	ns
K+ (mequ/l)	3.5±0.2	3.1±0.2	0.007
Glucose (mg/dl)	137±52	114±22	ns
PCO2 (mmHg)	24±2	24±3	ns
ICP (mmHg)	18±15	9±9	ns
Tight brain	2(29%)	1(17%)	ns
% Brain H20	81.2±1.2	78.8±3.0	0.076

The Effect of Lidocaine On Cerebral Lipid Peroxidation Following Ischemia Reperfusion

Fang Zexu, M.D., Gu Zhenghua, M.D., Zou Qing, Sung Baihua
Dept. of Anesthesiology, Plastic Surgery Hospital, Chinese Academy of Medical Science
Beijing, 100041, China

INTRODUCTION: It has been known that ischemia-reperfusion can generate free radicals which lead to lipid peroxidation. The free radicals and lipid peroxidation are contributing factors to extensive cerebral damage (1). Lidocaine can provide protection to the ischemic brain (2), but its effect on free radicals remains unclear. This study aimed to determine the effect of lidocaine on cerebral lipid peroxidation caused by free radicals following ischemia-reperfusion.

METHODS: Approval for the study was obtained from the institutional research administrative committee. 24 male Sprague-Dawley rats weighing 350-425g were anesthetized with pentobarbital (60mg/kg IP) and mechanically ventilated with 1%enflurane in oxygen via a tracheostomy to maintain normocarbia. Monitored variables were mean arterial blood pressure (MBAP), heart rate, arterial blood gases, body temperature and EEG. Body temperature was maintained at 37.5 ± 0.5°C with a heat lamp. Maintenance fluids (1.5ml/kg/hr Ringer's Lactate) and normal saline, lidocaine were administered via a catheter in the jugular vein. Cerebral ischemia was induced by simultaneous occlution of two vertebral and two carotid arteries according to the method of Pulsinelli and Briertey (3). Vascular clips on the cartoid arteries were removed after a 30-minute ischemia interval. This step resulted in reperfusion. At the end of the experiment, the animals were sacrificed by decapitation and the hippocampus tissues were removed for analysis. The degree of lipid peroxidation was measured by the thiobarbiturate acid assay for malondialdehyde (4) and the DTNB assay for glutathione peroxidase activity (5). 24 rats were grouped as follows (each group consisted of 8 rats):
G1). normal saline 1.5ml i.v.;
G2). normal saline 1.5ml i.v.+ischemia 30min. + reperfusion 20min.;
G3). Lidocaine 10mg/kg i.v. +ischemia 30min. +reperfusion 20min..
Lidocaine was diluted in 1.5ml normal saline. Normal saline was adminitered i.v. 10 minutes before ischemia.

RESULTS: 1. EEG changes: The EEG changed with lidocaine infusion, ischemia and reperfusion. Lidocaine infusion resulted in a significant reduction of voltage and slowing of EEG activity. Ischemia nearly caused an isoelectric EEG. The EEG nearly returned to normal during reperfusion.
2. The malondialdehyde (MDA) and glutathione peroxidase (GSH-px); The level of MDA in the hippocampus was significantly higher in G2 and G3 than in G1. The GSH-px activity was markly lower in G2 and G3 than in G1. There were no significant difference in the level of MDA and GSH-px activity between G3 and G2 (table 1).

DISCUSSION: Occlusion of the four vessels and controlled hypotension produced a significant ischemia. The cerebral blood flow may decrease to 10% of the normal value (6). Ischemia-reperfusion may produces a large amount of free radicals. The level of MDA and GSH-px activity in G2 suggested that this ischemia-reperfusion model may be useful for research on cerebral lipid peroxidation caused by free radicals.
Lidocaine protects the ischemic brain by reducing synaptic transmission and stablizing neuronal membranes. In this study , the data demonstrated that 10mg/kg lidocaine i.v. prior to ischemia failed to suppress or prevent cerebral lipid peroxidation caused by free radicals following ischemia-reperfusion.

REFERENCES:
1. Can. J. Anaesth. 36:663,1990
2. J. Neurosurg. 56:482,1982
3. Stroke 10:267,1979
4. Methods in Enzymology 52:302,1978
5. J Nutri. 104:580,1973
6. Stroke 13:852,1982

Table 1: The Level of MDA and GSH-px Activity in Different Groups

Group	MDA nmol/ mg.protein	GSH-px u/mg.protein/min
G 1	1.69 ± 0.59	42.15 ± 6.85
G 2	3.11 ± 0.85**	33.54 ± 6.30*
G 3	3.20 ± 0.90**	31.33 ± 9.89**

*P<0.05; **P<0.01, statistical comparisons between G1 and G2 or G3. Values are mean±se; n=8.

EFFICACY AND SIDE-EFFECTS OF ESMOLOL FOR CONTROLLING THE HAEMODYNAMIC RESPONSE TO TRACHEAL INTUBATION: THE CANADIAN MULTICENTRE TRIAL - PART I

D.R. Miller, M.D., R.J. Martineau, M.D, J.E. Wynands, M.D., J.D. Hill, M.Sc.
Ottawa General Hospital and The Heart Institute, University of Ottawa, Ottawa, Ontario

INTRODUCTION: Esmolol is a new short-acting β_1 adrenergic blocking drug which has ideal properties for use in the perioperative setting. The rapid onset and short duration of action of this drug make it suitable for bolus administration or continuous infusion. The Canadian Multicentre Esmolol Trial was designed to determine in a large series of patients the dose response and side effects of esmolol when administered as a single IV bolus prior to induction of anaesthesia for controlling the haemodynamic response to tracheal intubation.

METHODS: Five hundred and forty-eight patients from 12-university affiliated centres across Canada entered this placebo-controlled double-blind study. Subjects were at least 18 years of age and gave written informed consent to the protocol approved by the institutional review board or its local equivalent. A history of bronchospastic disease, cardiac dysrhythmias, congestive heart failure, or myocardial infarction in the previous 3-6 months resulted in exclusion. Patients were randomly assigned to one of 3 groups to receive either placebo (PLAC), esmolol 100 mg (E100) or esmolol 200 mg (E200). Following premedication with an oral benzodiazepine at 10 of the 12 centres, patients were defasciculated with either curare or pancuronium. Fentanyl (FEN) in either low (2-3 $\mu g.kg^{-1}$) or moderate dose (4-7 $\mu g.kg^{-1}$) or sufentanil (0.3 $\mu g.kg^{-1}$) was then given at five centres, whereas 320 patients in 7 of 12 centres received no narcotics. Each patient was preoxygenated and given intravenously the study drug from a coded syringe containing either PLAC, E100 or E200, following which anaesthesia was induced with thiopentone 3-5 $mg.kg^{-1}$ IV and succinylcholine 1.5-2.0 $mg.kg^{-1}$ IV. Direct laryngoscopy and tracheal intubation (11 centres) or rigid bronchoscopy (1 centre) were performed 60-90 sec after induction, and anaesthesia was maintained using 70% N_2O with low concentrations of either enflurane or isoflurane. Heart rate (HR) and systolic blood pressure (SBP) were recorded at baseline awake (BL), after induction (IND) and every minute for the first 6 minutes after intubation (INT+1...INT+6). Between groups comparison of HR and SBP was done using analysis of covariance and paired student's *t* tests, with statistical significance assumed when $P<0.05$.

RESULTS: Demographic variables were similar amongst the 3 groups, with a mean age of 56±16 years. Approximately 40% of individuals had 2 or more risk factors for coronary artery disease. Patients who received PLAC without narcotic had significantly higher HR and SBP values after intubation when compared to patients who received either E100 or E200 ($P<0.005$, Fig). The overall proportion of patients whose maximum HR exceeded 110 bpm was also greater with PLAC (22/180) than with E100 (10/187) or E200 (9/181) ($P<0.01$), but was not different when comparing E100 and E200 (P=NS). The most common side effect was hypotension, with 33% of E200 patients whose nadir on SBP was <90 mmHg, compared to 16% of the PLAC group ($P<0.01$), and 25% of E100 patients whose SBP decreased below this value. Other reported adverse event were infrequent and not different amongst the 3 groups (Table).

DISCUSSION: A 200 mg pre-intubation dose of esmolol (mean 2.8±0.4 $mg.kg^{-1}$) was shown to be no more effective than a 100 mg dose (mean 1.4 $mg.kg^{-1}$), but resulted in a greater incidence of hypotension. Other side effects were no more common with esmolol than with placebo. It is concluded from this multicentre study that 100 mg (1.4 $mg.kg^{-1}$) of esmolol given as a bolus prior to induction of anaesthesia is safe and effective for controlling hypertension and tachycardia in response to tracheal intubation.

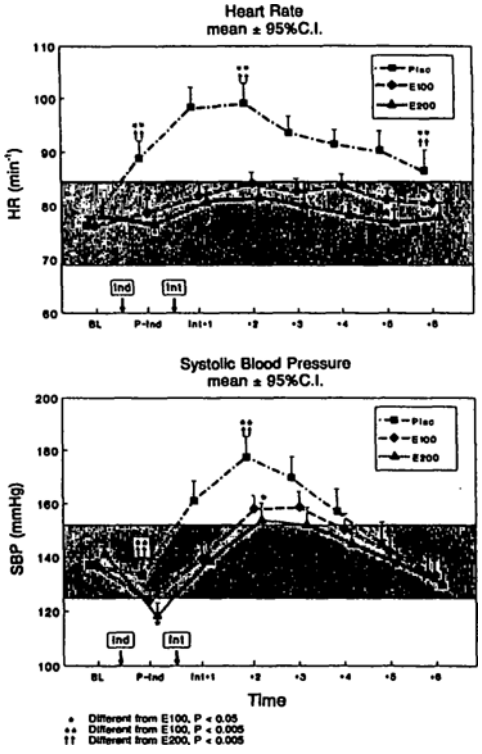


TABLE - ADVERSE EVENTS

	PLAC	E100	E200
Patients (n)	180	187	181
SBP<90 mmHg (n)	28 (15.5%)	47 (25.1%)*	59 (32.5%)**
HR<50 bpm (n)	5 (2.7%)	2 (1.0%)	5 (2.7%)
Pain on injection (n)	3 (1.6%)	3 (1.6%)	4 (2.2%)
Bronchospasm (n)	2 (2.0%)	3 (1.6%)	1 (0.5%)

** Different from PLAC, P<0.05, ** Different from PLAC, P<0.01*

THE EFFECTS OF OPIATE ANALGESICS ON THE MAXIMUM CARDIOVASCULAR RESPONSE TO INTUBATION FOLLOWING BOLUS ADMINISTRATION OF ESMOLOL: THE CANADIAN MULTICENTRE TRIAL - PART II

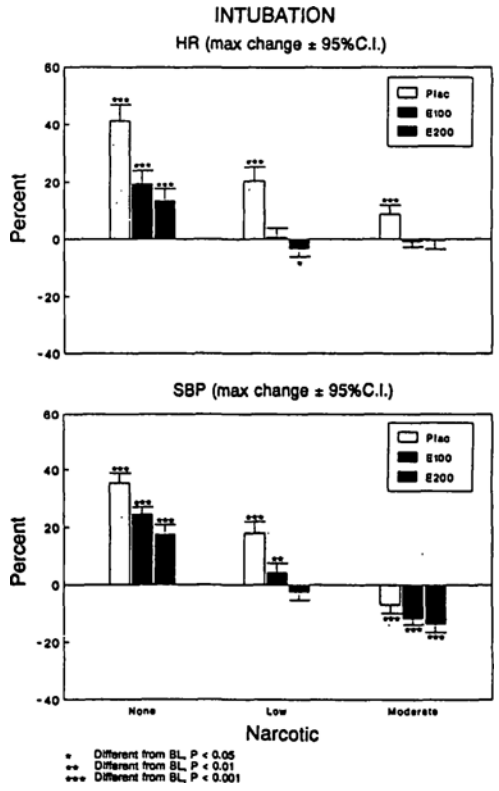
D.R. Miller, M.D., R.J. Martineau M.D., J.E. Wynands M.D., J.D. Hill, M.Sc.
Ottawa General Hospital and The Heart Institute, University of Ottawa, Ottawa, Ontario

INTRODUCTION: Esmolol is a new short-acting β_1-adrenergic blocking drug which has ideal properties for use in the perioperative setting. It has been shown that unsupplemented esmolol, when given as a bolus prior to induction of anaesthesia, is effective for controlling hypertension and tachycardia in response to tracheal intubation.[1,2] As opiate analgesics are also effective for moderating the peri-induction haemodynamic response, data from the Canadian Multicentre trial were analyzed to determine the interaction of narcotics with esmolol on the maximum cardiovascular response to tracheal intubation.

METHODS: Five hundred and forty eight patients from 12 university-affiliated centres across Canada entered this placebo-controlled, double blind study. Subjects were at least 18 years of age and gave written informed consent to the protocol approved by the institutional review board or its local equivalent. A history of bronchospastic disease, cardiac dysrhythmias, congestive heart failure or myocardial infarction in the previous 3-6 months resulted in exclusion. Patients were randomly allocated into one of 3 groups to receive either placebo (PLAC), esmolol 100 mg (E100) or esmolol 200 mg (E200). Following premedication with an oral benzodiazepine at 10 of the 12 centres, patients were defasciculated with either curare or pancuronium. Fentanyl (FEN) in either low (2-3 $\mu g.kg^{-1}$) or moderate dose (4-7 $\mu g.kg^{-1}$) or sufentanil 0.3 $\mu g.kg^{-1}$ was then given at 5 centres, whereas 320 patients in 7 of the 12 centres received no narcotic. Each patient was then preoxygenated and given intravenously the study drug in a coded syringe containing either PLAC, E100 or E200 following which anaesthesia was induced with thiopentone 3-5 $mg.kg^{-1}$ IV and succinylcholine 1.5-2.0 $mg.kg^{-1}$ IV. Direct laryngoscopy and tracheal intubation (11 centres) or rigid bronchoscopy (1 centre) were performed 60-90 sec after induction, and anaesthesia was maintained with 70% N_2O and low concentrations of either enflurane or isoflurane. Heart rate (HR) and systolic blood pressure (SBP) were recorded at baseline awake (BL), after induction (IND) and every minute for the first 6 minutes after intubation. The maximum percent changes of heart rate and SBP following intubation for each study group (PLAC, E100 and E200) were analyzed according to the pre-induction dose of opiate analgesic using paired student's t tests, with statistical significance assumed when $P<0.05$.

RESULTS: Both E100 and E200 independently modified the maximum percent increases of HR and SBP when compared to PLAC, but the combination of low dose FEN and E100 resulted in no change of HR (P=NS) and only a $4\pm3\%$ increase in SBP after intubation ($P<0.01$, Figure). Low dose FEN decreased HR by $4\pm4\%$ in the E200 group ($P<0.05$), whereas moderate dose FEN caused a significant reduction in SBP in all 3 groups following intubation ($P<0.001$), with the largest decrease in SBP ($17\pm4\%$) occurring in patients who received E200.

DISCUSSION: Esmolol is effective in moderating hypertension and tachycardia in response to tracheal intubation when given in 100 mg (mean 1.4 ± 0.4 $mg.kg^{-1}$) or 200 mg (mean 2.8 ± 0.4 $mg.kg^{-1}$) bolus doses prior to induction of anaesthesia with thiopentone. However, the administration of a low dose opiate analgesic (fentanyl 2-3 $\mu g.kg^{-1}$) results in nearly complete abolition of the maximum HR and SBP response, whereas moderate dose fentanyl (4-7$\mu g.kg^{-1}$) given prior to esmolol may result in clinically significant hypotension. It is concluded that a 100 mg bolus of esmolol (1.4 $mg.kg^{-1}$) administered in conjunction with a low dose opiate (fentanyl 2-3 $\mu g.kg^{-1}$ or equivalent) is an effective combination for attenuating the hyperdynamic cardiovascular response to intubation, while producing minimal hypotension or bradycardia.



REFERENCES:
1. Can J Anaesth 1990; 37:202-5
2. Can J Anaesth 1990; 37:206-9

INTENSE REM SLEEP CAUSES HAEMODYNAMIC INSTABILITY

RL KNILL,M.D., MI SKINNER,B.A., TV NOVICK, B.A.
Department of Anaesthesia, University of Western Ontario, London, Canada.

INTRODUCTION: Certain cardiac and cerebral complications of anaesthesia and surgery, i.e. myocardial ischemia, myocardial infarction and stroke, appear in delayed fashion after operation - i.e. about the middle of the first postoperative week. The specific factors that trigger each of these complications are not known. We recently observed that the 2nd to 4th nights after operation are associated with highly active or intense REM sleep.[1] Accompanying this change in sleep were increments in the urinary outputs of norepinephrine and dopamine - suggestive of increased sympathetic neural activity.[2] The purpose of the present study was to see how intense REM sleep, induced experimentally, would affect the heart rate and the systemic arterial blood pressure, monitored continuously.

METHODS: Six healthy volunteers (24±2 yrs) were studied in a sleep monitoring facility through five consecutive nights: an adaptation night, a control night, two nights of REM sleep deprivation and a night of REM sleep recovery. REM sleep deprivation was produced by arousing the subject at the onset of each REM sleep period. It was anticipated that the two nights of REM sleep deprivation would lead to intense REM sleep during the recovery night. From 1100 hours to 0700 hours each study night, we monitored the states of wakefulness, NREM and REM sleep by the EEG, EMG and EOG; heart rate by the EKG; and systemic arterial blood pressure on a beat to beat basis by the Penaz digital cuff (Finapres). The Penaz cuff pressures were calibrated to reflect standard Riva-Rocci cuff pressures. All night recordings were analyzed in successive 3 sec epochs. The instantaneous heart rate (HR), systolic and diastolic pressures (SBP and DBP) of each epoch were determined. From these instantaneous values, we found the mean; the standard deviation (SD); and the maximum, minimum and range values of each variable within each state. Potential differences between the control and the REM sleep recovery nights were assessed with the Wilcoxon-Mann-Whitney test.

RESULTS: In the night of REM sleep recovery, there was an increase in REM sleep time (19±3% to 27±2%, $p < 0.05$) and an increase in REM sleep eye movement activity (373±104 to 685±216 eye blinks, $p < 0.05$) - indicative of more intense REM sleep.

The control night values of HR, SBP and DBP (means and SD's) in awake, NREM and REM sleep states (Table) were as previously reported.[3] The recovery night values were similar except during REM sleep.

The intense REM sleep of the recovery night did not affect the mean values of HR, SBP or DBP. However, it brought about changes in the variability indices of both SBP and DBP. The SD and range values of SBP and DBP increased in this state. Periodically, the SBP and DBP surged to maximum values that were the highest amongst all states (Table). In general, the fluctuations of SBP and DBP during intense REM sleep were gradual rather than abrupt and paralleled each other. Amongst individual subjects, the greater SD of SBP during this state correlated with an index of increased eye movement activity ($r=0.91$; $p < 0.05$). In the subject with the second greatest eye movement activity, the SBP varied from 57 to 205 mmHg.

STATE:	AWAKE		NREM SLEEP		REM SLEEP	
NIGHTS:	CONTROL	REM RECOVERY	CONTROL	REM RECOVERY	CONTROL	REM RECOVERY
HEART RATE (beats/min)						
Mean ($\bar{x}$)	63	61	56	55	59	59
SD ($\bar{x}$)	6	7	4	4	6	7
SYSTOLIC BP (mmHg)						
Mean ($\bar{x}$)	110	111	103	105	109	111
SD ($\bar{x}$)	11	10	10	12	10	15 *
Maximum ($\bar{x}$)	142	145	142	152	149	174 *
Minimum ($\bar{x}$)	74	80	75	70	76	65 *
Range ($\bar{x}$)	68	66	68	81	72	110 *
DIASTOLIC BP (mmHg)						
Mean ($\bar{x}$)	72	71	66	67	69	71
SD ($\bar{x}$)	8	7	8	8	8	11 *
Maximum ($\bar{x}$)	93	95	97	100	97	115 *
Minimum ($\bar{x}$)	51	54	46	41	50	41
Range ($\bar{x}$)	43	41	51	58	47	74 *

Each value is the average of the individual values of 6 subjects
* Significantly different from control ($p<0.05$)

DISCUSSION: We conclude that intense REM sleep, as induced in this study, brings about haemodynamic instability - manifest as a greater variation or wider swings in systemic blood pressure. This haemodynamic instability is presumably due to greater periodic variation in the level of sympathetic vasomotor activity.

Since the increased fluctuations of systemic pressure during the intense REM sleep of this study correlated with the added eye movements or intensity of REM sleep, the more highly intense REM sleep that develops in the first postoperative week may bring about even greater haemodynamic instability. If such changes were to develop in patients with ischemic heart disease or cerebral vascular disease after operation, they could play a role in the genesis of the delayed cardiac and cerebral complications noted above.

REFERENCES

1. Anesthesiology 1990;73: 52-61.
2. Can J Anaesth 1990;37: S12.
3. Br Med J 1975;3: 346-348

EFFECT OF AMRINONE ON HYPOXIC PULMONARY VASOCONSTRICTION

R. F. McLean MD FRCPC, M. Kolton MD FRCPC, W. H. Noble MD FRCPC

Department of Anaesthesia, Sunnybrook Health Science Centre and St. Michael's Hospital, University of Toronto

Introduction: Amrinone is a phosphodiesterase III inhibitor which is used as an inotropic agent. It currently is used primarily as a second line agent, its main advantage being that it is not dependent on the beta adrenergic receptor for mediation of its effect. In the failing heart it reduces the calculated pulmonary vascular resistance[1]. Its effects on the pulmonary circulation in the absence of left ventricular failure have not been extensively studied. In neonatal lamb lungs it has been shown to reduce hypoxic pulmonary vasoconstriction (HPV)[2]. In adult sheep it reduces the calculated pulmonary vascular resistance in the presence of pulmonary hypertension induced by the infusion of a thromboxane A2 mimetic agent[3].

Our goal in this study is to study the effects of amrinone on hypoxic pulmonary vasoconstriction in adult dogs utilizing pressure flow curves.

Methods: Four Mongrel dogs (23-32kg) were anesthetized using pentobarbital 25 mg/kg. Anesthesia was maintained using a pentobarbital drip and pavulon. The animals were ventilated with 60% oxygen (Normoxia) at a rate and volume sufficient to maintain normocarbia throughout. An arterial line and Swan Ganz catheter were placed to facilitate measurement of arterial blood gases and standard hemodynamic variables. Two a-v fistulas were created and a fogarty occlusion catheter was placed in the inferior vena cava. The animal was placed in the supine position and heparinized. The transducers were zeroed to the mid axillary line.

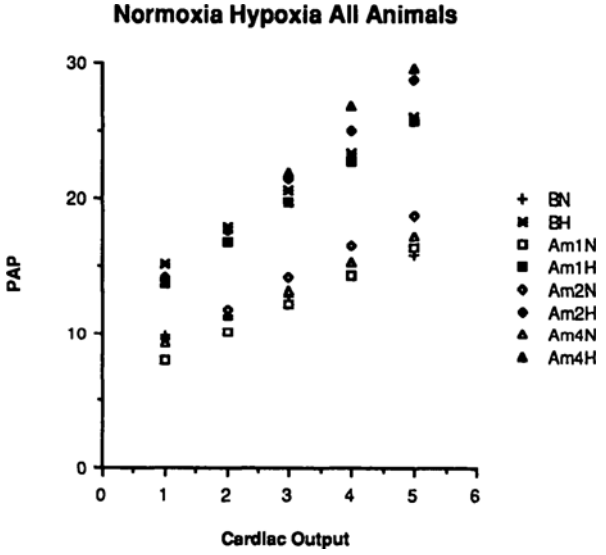
Pressure flow curves (PFC) were generated by varying flow through opening and closing of the a-v fistulas in conjunction with inflating and deflating the IVC balloon. A baseline curve was generated under normoxia (BN) and then a hypoxic challenge with an FiO2 of .12 (BH) was administered and the curves generated again. The animals were selected for study if a 3 mmHg rise in PAP was seen with hypoxia. Normoxia was re-established and the animal received 1mg/kg of amrinone and was started on a drip of 7.5ug/kg/min which ran throughout the experiment. PFCs were generated under normoxic (Am1N) and hypoxic (Am1H) conditions. The animal then received a second bolus of 1mg/kg of amrinone and PFCs were again generated (Am2N, Am2H). Finally a dose of 2mg/kg of amrinone was administered and PFCs were again generated (Am4H).

Data Analysis: For each animal PFCs were plotted for each of the conditions (BN, BH, Am1N, Am2N, Am2H, Am4N, Am4H) using linear regression. Confidence interval analysis was used to analyze the effects of hypoxia, and the three dosage levels of amrinone on the slopes and intercepts of the PFCs'.

Results: In these selected animals, hypoxia resulted in an increase in the PAP. Amrinone had no effect on the pressure flow curves during normoxia or hypoxia at any dose level.

Table I shows the mean slopes and intercepts for the four dogs under each condition. The figure shows the mean pressures at flows of 1 to 5 l/min for all dogs under each condition.

	BlN	BlH	Am1N	Am1H	Am2N	Am2H	Am4N	Am4H
Int	8.4	12.5	5.9	10.8	7.0	10.3	7.3	9.9
	±1.6	±2.4	±1.4	±2.6	±1.7	±2.4	±1.2	±2.3
Slope	1.5	2.7	2.3	3.0	2.3	3.7	2.0	3.9
	±.4	±.5	±.4	±.8	±.5	±.1	±.4	±8



Discussion: There is very little information available about the effects of amrinone on the pulmonary circulation in the absence of left ventricular failure. Earlier work in humans and in adult animals utilized PVR as a measure of pulmonary vascular tone. We are unable to demonstrate an effect of amrinone on HPV in this preparation. The previously noted reductions in PVR may reflect the dependence of PVR on the multiple factors of flow, PA pressure and left atrial pressure, rather than any direct vasodilating effect of amrinone.

Supported in part by a grant from the Physician's Services Incorporated of Ontario.

References:

1 American Journal of Cardiology 1985;56:33B-36B.
2 Pediatric Research 1983;17:720-724
3 Anesthesiology 1989;71:A531

A COMPARISON OF THE CARDIOVASCULAR EFFECTS OF ALFENTANIL-NITROUS OXIDE *vs* ALFENTANIL-ISOFLURANE ANAESTHESIA

P.J. Sullivan M.D., D.R. Miller M.D., R.J. Martineau M.D., K.A. Hull R.N.
Ottawa General Hospital and The University of Ottawa, Ottawa, Ontario

INTRODUCTION: Infusion of alfentanil in conjunction with nitrous oxide has been shown to provide haemodynamic stability during major surgical procedures.[1] However, in clinical situations where nitrous oxide is contraindicated, it may be desirable to infuse alfentanil with a potent inhalational agent. Although the haemodynamic effects of nitrous oxide and isoflurane are well documented, the interaction of each of these drugs with alfentanil on the cardiovascular system has not previously been compared. A randomized clinical trial was therefore designed to determine the cardiovascular response of alfentanil in combination with either nitrous oxide or isoflurane during general anaesthesia.

METHODS: Forty ASA class I and II patients entered this study after giving written informed consent to the protocol approved by the hospital Human Experimental Procedures Committee. Excluded were individuals greater than 60 years of age, those with a history of hypertension (BP>160/90) or other major systemic illness. Patients were randomly allocated to receive equivalent MAC end-tidal concentrations of either nitrous oxide (70% N_2O - Group I) or isoflurane (0.76% FOR - Group II) as determined by mass spectrometry. Following premedication with oral diazepam 0.15 $mg.kg^{-1}$ and application of the monitors, anaesthesia was induced with thiopentone 5.0 $mg.kg^{-1}$ and vecuronium 0.1 $mg.kg^{-1}$. Using manual ventilation, Group I patients then received N_2O at 4 $L.min^{-1}$ with O_2 at 2 $L.min^{-1}$, whereas the initial FOR concentration was set at 2% and titrated down to rapidly achieve an end-tidal concentration of 0.76% for Group II patients while they breathed O_2 at 6 $L.min^{-1}$. Seven minutes after induction, alfentanil 15 $\mu g.kg^{-1}$ was given as a bolus, followed by a continuous infusion at a rate of 0.5 $\mu g.kg^{-1}min^{-1}$. Three minutes after the alfentanil bolus, tracheal intubation was performed, while the concentrations of N_2O and FOR remained unchanged. Heart rate (HR) and systolic blood pressure (SBP) were measured non-invasively while cardiac index (CI) and ejection fraction (EF) were determined using bioimpedance cardiography (BoMed NCCOM3). Data were analyzed using a general linear models procedure and analysis of variance for a between-groups comparison, assuming statistical significance when $P<0.05$.

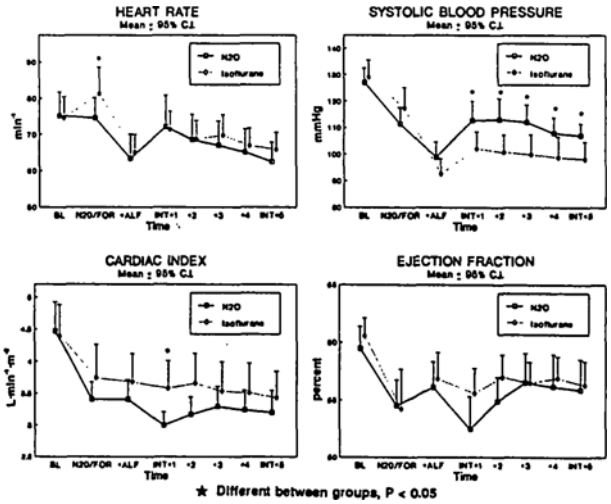
RESULTS: The groups were similar with respect to mean age, weight, sex distribution, and preoperative heart rate and blood pressure. Following induction, HR increased in the patients who received FOR ($P<0.05$), while similar decreases in SBP, CI, and EF were observed in both groups prior to the administration of ALF. Alfentanil in the presence of either N_2O or FOR caused a decrease in HR and a further decrease in SBP, without altering CI or EF. However the stimulus of tracheal intubation resulted in an increase in SBP at a lower CI in patients who received N_2O compared to FOR ($P<0.05$). Ejection fraction also tended to be lower in the N_2O group compared to the FOR group ($52\pm4\%$ compared to $56\pm3\%$ for Groups I and II respectively) in the first minute after tracheal intubation.

DISCUSSION: Important advantages in the use of alfentanil with nitrous oxide include the ability to provide haemodynamic stability while allowing for a smooth and rapid emergence from anaesthesia. In situations where N_2O is contraindicated, isoflurane may be an appropriate alternative. Compared to N_2O, an equivalent MAC concentration of FOR during infusion of alfentanil achieves more effective blunting of the SBP response to noxious stimulation, while better preserving CI and ejection fraction. These differences may relate to a reduction in systemic vascular resistance with isoflurane, and a slightly greater direct myocardial depressant effect when alfentanil is infused with N_2O.

REFERENCE:

1. Can J Anaesth 1990; 37:844-51

FIGURES



CHOICE OF NARCOTICS FOR OUTPATIENT SURGERY: POSTOPERATIVE RESPIRATORY DEPRESSION IN FENTANYL, SUFENTANIL, ALFENTANIL AND NALBUPHINE

D.C.H. Cheng, FRCPC; K.R. Chapman, FRCPC; F. Chung, FRCPC, D. Ong, MD; J. Romanelli, BSc
Departments of Anaesthesia and Medicine, Toronto Western Division, The Toronto Hospital, University of Toronto, Toronto, Ontario, M5T 2S8

Introduction: This clinical randomized blinded study evaluated the postoperative ventilatory recovery in outpatient surgery using equianalgesic doses of Fentanyl, Sufentanil, Alfentanil (narcotic agonist) or Nalbuphine (narcotic agonist-antagonist). Ventilatory recovery was assessed by respiratory inductive plethysmography (Respitrace) and ventilatory response to CO2.

Methods: Institutional Human Ethics Committee approval and informed consent were obtained. Twenty patients, ASA I-II, aged 18-60 yrs, in day bed surgery of about 60 min duration were studied. Surgical procedures that involved the thorax or abdomen were excluded. No preoperative sedation was given. Flow-volume spirometry, respiratory inductive plethysmography (Respitrace) and ventilatory response to CO2 were performed before surgery. Patients were randomly allocated into 4 groups: Fentanyl (F) 3 ug/kg, Sufentanil (S) 0.5 ug/kg, Alfentanil (A) 30 ug/kg or Nalbuphine (N) 0.3 mg/kg. Anaesthesia induction was proceeded with preoxygenation, defasciculation with curare, study medication, thiopentone for unconsciousness, succinylcholine for tracheal intubation, and controlled ventilation. Anaesthesia was maintained with 70% N2O/O2, vecuronium and isoflurane intermittently to maintain BP within 20% of preoperative level. At the end of the surgical procedure, neuromuscular blockade was reversed. Patients were extubated when clinical criteria was met and they had zero expiratory concentration of isoflurane as measured by mass spectrometry. In the recovery room, patients were continuously monitored by Respitrace at 10-20, 30-40 and 50-60 min intervals. Apnea was defined as expiratory pauses of greater than 10 sec or when tidal volume was less than 100 ml. Apnea index was defined by number of apnea per hr as expressed during the three 10 min intervals. All patients received 28% O2 by facemask for 30 min and were monitored by pulse oximeter continuously for 60 min postoperation. Prior to discharge, ventilatory response to CO2 was repeated. All data was in mean ± SEM.

Results: There were no significant differences between the 4 groups in demographic data, thiopentone dosage, duration of anaesthesia and postoperative oxygen saturation during recovery (table 1). None of the patients required naloxone. Nausea and vomiting occurred mainly in the narcotic agonist groups: A-67%, F-25%, S-25%, N-0%. The incidence of patients having postoperative apneic episodes was: A-60%, F-80%, S-100%, N-60%. The apnea index was significantly higher in S group and persisted during 60 min recovery (Fig. 1). No apnea was detected in N group post-50 min recovery. However, no significant difference was found in the duration of apnea between the 4 groups (range 11-17 sec). At postop-60 min, there was no significant difference in ventilatory response to CO2 within each drug group, with the slope of CO2 response decreased by 41%, 38%, 26% and 37% for group A, F, S and N respectively (Fig 2).

Table 1:

	A (n=5)	F (n=5)	S (n=5)	N (n=5)
Duration (min) (Anaesthesia)	55.0 ± 4.8	57.8 ± 9.7	57.2 ± 10.0	58.8 ± 9.9
SaO2 (%)				
preop	98.6 ± 0.7	98.2 ± 0.4	98.8 ± 0.6	96.2 ± 1.2
postop (10-20 min)	97.6 ± 0.6	98.4 ± 1.4	97.8 ± 1.2	97.0 ± 1.3
(30-40 min)	96.2 ± 1.2	96.2 ± 0.9	97.8 ± 1.2	96.6 ± 0.9
(50-60 min)	95.2 ± 1.0	94.4 ± 1.3	93.0 ± 2.6	94.0 ± 0.7

Figure 1

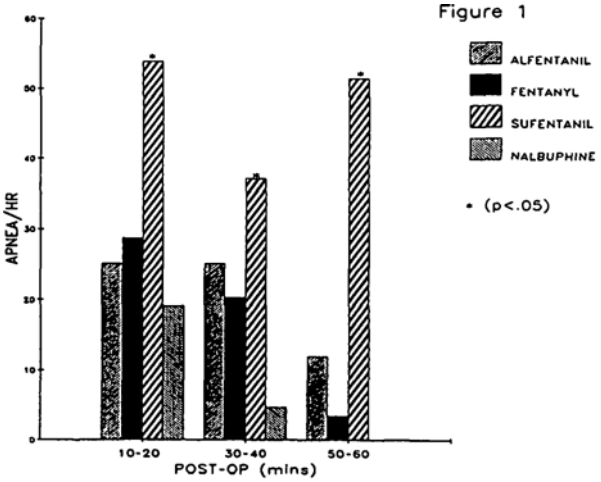
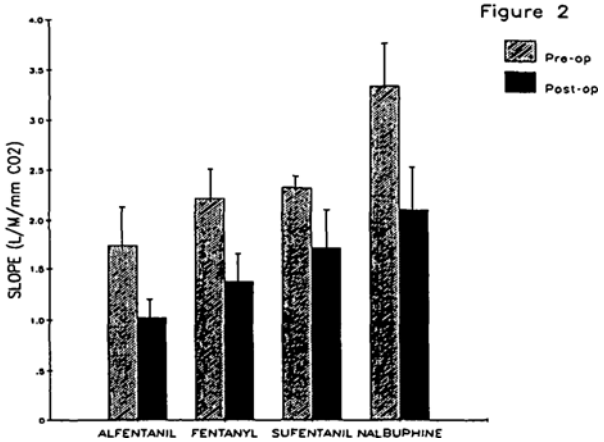


Figure 2



Discussion: When compared with the dosage used for 60 min surgical procedure, sufentanil had the highest and Nalbuphine the lowest risk of postoperative respiratory depression. Alfentanil and fentanyl were quite similar in terms of postop apnea index. However, all narcotics depressed the slope of ventilatory response to CO2 to a similar extent at 1 hr postop.

Supported in part by P.S.I. Foundation.

WORSENING OF ISCHAEMIA WHEN ISOFLURANE IS SUBSTITUTED FOR ENFLURANE OR HALOTHANE IN SWINE

Bettina Smallman, M.D., Howard J. Nathan, M.D.

Department of Anaesthesia, University of Ottawa Heart Institute, 1053 Carling Ave., Ottawa, K1Y 4E9

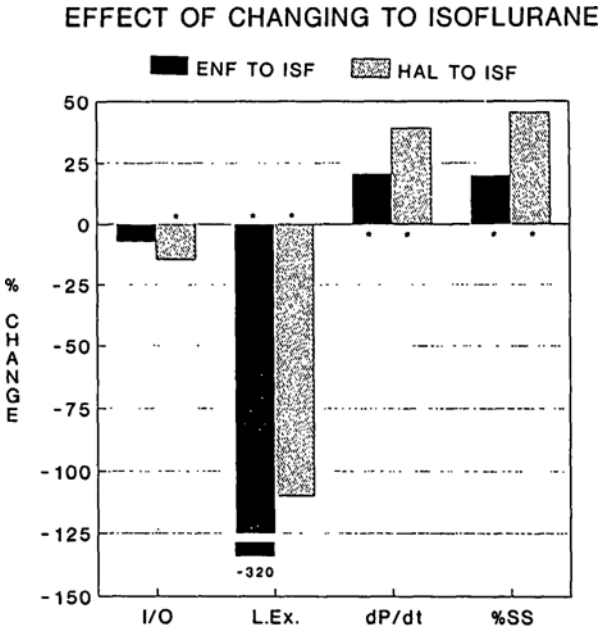
INTRODUCTION: In the presence of significant coronary stenoses small changes in myocardial oxygen supply or demand can worsen ischaemia. Isoflurane (I), enflurane (E), and halothane (H) are known to have different effects on both coronary vasomotor tone and myocardial contractility. By administering all three agents to the same animal we have been able to precisely compare their effects on myocardial function, blood flow and lactate metabolism in an ischaemic region of the heart.

METHODS: Twelve pigs were anaesthetized with I, E, or H. The heart was exposed through a median sternotomy and suspended in a pericardial cradle. The LAD coronary artery was cannulated near its origin and autoperfused using a silastic circuit originating in the left carotid artery. A stenosis could be imposed by tightening a screw clamp on the tubing and normal perfusion restored without changing the stenosis by opening a parallel bypass shunt. Blood flow through the circuit was measured with an electromagnetic flowmeter (EMF). Systolic shortening (SS) was measured using the sonomicrometer with piezo-electric crystals implanted in the LAD and circumflex regions. Lactate concentration was measured in arterial blood and blood from the great cardiac vein so that lactate extraction (L.Ex.) in the LAD region could be calculated. Regional myocardial blood flow was measured using 15 micron radioactive microspheres. Anaesthetic concentration was measured using mass spectrometry.

Isoflurane 1.5%, enflurane 2.18% and halothane 0.98% (equipotent doses), were compared in a randomized and balanced crossover design. Heart rate (HR) was held constant using atrial pacing. Mean arterial blood pressure (MAP) was held constant using a Fogarty catheter in the thoracic aorta. Left atrial pressure (LAP) and hematocrit were controlled using transfusion of donor pig blood. Measurements were made during the imposition of a coronary obstruction sufficient to reduce resting blood flow by 25%.

RESULTS: The figure illustrates the results of changing from E to I or H to I during stenosis with HR, MAP, and LAP held constant. LV dP/dt was higher during isoflurane indicating improved global LV contractility. % SS in the ischaemic LAD region also was greater with I. The ratio of blood flow between the subendocardium and subepicardium (I/O ratio) was lower with I indicating further maldistribution of blood flow. Lactate extraction was lower during I suggesting worsened ischaemia.

DISCUSSION: The results suggest that although global and regional myocardial performance improved during I, ischaemia worsened. The possibility of worsened ischaemia with I due to increased contractility must be considered both in interpreting experiments and treating patients. These data also suggest that, in certain settings, myocardial ischaemia may worsen while regional wall motion improves.



Despite improved myocardial performance there was evidence of increased ischaemia when I was substituted for E or H.
L.Ex. = Lactate Extraction %. *P<.05

EFFECTS OF MIDAZOLAM OR SUFENTANIL ON CORONARY HAEMODYNAMICS AFTER INDUCTION AND ENDOTRACHEAL INTUBATION IN PATIENTS UNDERGOING CORONARY ARTERY BYPASS GRAFT SURGERY.

JT Murphy MD,FRCPC, RI Hall MD,FRCPC, EA Moffitt MD,FRCPC and the Maritime Heart Centre.

Department of Anaesthesia, Victoria General Hospital and Dalhousie University, Halifax, NS, Canada B3H 2Y9

Introduction: Midazolam (**Mid**) is a benzodiazepine used for induction of anaesthesia. There is evidence that **Mid** may alter coronary autoregulation.[1] This prospective, randomized study compares the haemodynamics and myocardial oxygenation of a total intravenous anaesthesia technique (**Mid** induction -> variable-rate **Mid** infusion with sufentanil increments for maintenance) to a standard sufentanil (**Suf**) -> enflurane (**Enf**) combination in patients undergoing elective coronary artery bypass graft (CABG) surgery.

Methods: To date 23 patients with preserved ventricular function have been studied. With institutional approval and informed consent, all patients received a standardized premedication of morphine-promethazine. Following arrival in the operating room, arterial (**A**), pulmonary artery (**PA**) and coronary sinus (**CS**) catheters were placed. Studies were performed at the following times: awake (**AWA**), induction (**IND**), intubation (**ETT**), skin incision, sternotomy, pre-protamine, skin closure, and 1 hour after arrival in the ICU. Measurements of heart rate (**HR**), systolic and diastolic arterial pressures, right atrial pressure, PA pressures (systolic and diastolic), pulmonary capillary wedge pressure (**PCWP**), cardiac output and coronary sinus blood flow (**CSBF**) were made. **A** and **CS** blood samples were analyzed at the study times for haemoglobin (**Hgb**) and lactate concentrations, and for blood gases. Calculations included mean arterial pressure (**MAP**), coronary perfusion pressure (**CPP**), systemic vascular resistance index (**SVRI**), cardiac index (**CI**), coronary vascular resistance (**CVR**), myocardial oxygen consumption (MVO_2), myocardial lactate extraction (**MLE**), and myocardial oxygen extraction (**MOE**).

Group 1 received **Suf** (5 $\mu g \cdot kg^{-1}$) over 5 minutes for induction of anaesthesia and **Enf** (inspired concentration 0-3%) for maintenance. Group 2 received **Mid** (0.30 $mg \cdot kg^{-1}$) over 5 minutes for induction of anaesthesia. Following the **ETT** study, a 15-minute infusion of **Mid** was started at 10 $\mu g \cdot kg^{-1} \cdot min^{-1}$. The dose of **Mid** was then set at 2.5, 5.0, or 10 $\mu g \cdot kg^{-1} \cdot min^{-1}$, according to haemodynamic response to noxious stimuli. **Suf** (0.5-1.0 $\mu g \cdot kg^{-1}$, to a maximum of 5 $\mu g \cdot kg^{-1}$) was given in response to **HR** and **MAP** increases not controlled by the maximum dose of **ENF** (group 1) or **Mid** (group 2). Basal **HR** and **MAP** (average of two measurements taken on the day prior to operation) were used to define the range for each patient. **HR** or **MAP** increases (>120%) lasting longer than 1 minute were treated with the study agent in the first instance. Intravenous propranolol (**P**) or nitroglycerine (**NTG**) were given prior to the first study if the HR or MAP exceeded the upper limit. Subsequently, **P** and **NTG** were given if the haemodynamic response was not controlled by the maximum dosages of the study agents. Phenylephrine was used to maintain MAP > 80% of basal. Both groups received pancuronium (**Pan**) 0.1 $mg \cdot kg^{-1}$ and oxygen. Statistical analysis was by repeated measures (ANOVA) and chi-square tests.

Results: There were no differences in patient demographics between the study groups. Time to loss of eyelid lash reflex was 2.2 ± 0.66 min for group 1 versus 1.2 ± 0.63 min for group 2 ($p < 0.05$).

TABLE. Hemodynamics (Systemic and Coronary) and Myocardial Oxygenation in Patients Undergoing CABG Receiving Either Sufentanil-Enflurane (n=14) Midazolam-Sufentanil (n=9). (Mean ± SD)

PARAMETER	AWAKE		IND		ETT	
	SE Group 1	MS Group 2	SE Group 1	MS Group 2	SE Group 1	MS Group 2
HR(bpm)	59±10	59±8	70±13*	65±7	70±14*	74±6*
MAP(mmHg)	94±8	97±17	85±18	69±13*$	83±15*	88±13
PCWP(mmHg)	18±6	19±8	17±5	13±3*	15±3*	12±5$
CPP(mmHg)	49±9	48±14	45±12	39±9	45±12	54±8*$
$S_{cs}O_2$(%)	43±8	43±8	43±9	49±3.3	42±7	44±7
Hgb(g.l^{-1})	138±13	130±22	133±13	123±18	132±14	117±16
CVR(mmHg)	0.7±0.3	0.6±0.4	0.6±0.2	0.6±0.4	0.7±0.3	0.6±0.2
MVO2(ml.min^{-1})	140±69	172±111	141±61	123±52	127±68	146±68
MLE(%)	33±15	32±18	25±21	28±20	19±26	29±23
MOE(%)	57±8	56±9	56±9	50±3	57±7	56±7
CSBF(ml.min^{-1})	131±52	175±95	140±57	145±56	124±58	167±78
CI(l.$min.m^{-2}$)	3.1±0.4	2.8±0.9	3.5±0.7	2.6±0.3	3.4±0.7	3.2±0.5
SVRI(dynes.sec. $cm^{-5}.m^{-2}$)	595±136	700±280	469±165	545±229	484±164*	565±181

*p<.05 vs Control
$p<.05 vs Group 1

Discussion: The significant decreases in MAP and PCWP at **IND** suggest that **Mid** is primarily a venodilator, although mild reduced myocardial contractility cannot be excluded. Unchanged **CPP**, **CVR**, coronary venous haemoglobin saturation ($S_{CS}O_2$), and **MOE** at **IND** indicate that **Mid** is not a coronary vasodilator, and is not different from **Suf**. No change in **MLE** indicates the lack of global ischemia. A significantly higher **HR** occurred in group 1 at **IND** no despite the use of **Suf**; no between group difference was seen in **HR**.

Following **ETT**, **HR** increased in each group, but was not different between groups, suggesting that the group 1 protocol was no better at controlling **HR** than group 2. **MAP** returned to **AWA** levels in group 2, while in group 1 **MAP** was significantly lower. The lower **PCWP** in group 2 is compatible with continued venodilation, compared to group 1, contributing to the greater **CPP** in group 2, compared to group 1. As with the **IND** study, no difference in coronary hemodynamics was seen between groups at the **ETT** study time.

Conclusions: In this preliminary report, **Mid** was shown to have a significantly greater hypotensive effect, as compared to **Suf**, following induction. However, the absolute level of decrease (**MAP** = 70 mmHg) was not excessive. Although **Mid** was less efficacious at maintaining a lower **MAP** than **Suf** following intubation, each protocol prevented a hyperdynamic response to **ETT**. Adequate myocardial oxygenation is dependent on maintenance of **CPP**; the higher **CPP** seen in group 2 at **ETT** could be advantageous.

There is no evidence that **Mid** had an adverse effect on the myocardial oxygenation or coronary vascular resistance during the study period. The use of **Mid** for induction of anaesthesia in premedicated CABG patients would appear to be safe and can be recommended, providing a moderate decrease in **MAP** is acceptable.

References:

1. Anesthesiology 1986;64:206-210.

HIGH-DOSE THIOPENTAL ANESTHESIA FOR OPEN-HEART SURGERY: A RETROSPECTIVE ANALYSIS OF NEUROLOGIC COMPLICATIONS

R.J. Hudson, MD, E.A. Pascoe, MD, B.A. Anderson, MD, I.R. Thomson, MD, D.A. Kassum, MB BChir, A. Shanks, RN, BSc, M. Rosenbloom, BSc(Hon)
Departments of Anesthesia, Surgery, and Medicine, University of Manitoba, St. Boniface General Hospital, Winnipeg, Manitoba, Canada, R2H 2A6

Introduction. Neurologic injury continues to be a major complication of cardiopulmonary bypass (CPB). One prospective study has shown that high-dose thiopental anesthesia reduces the incidence of persistent neuropsychiatric deficits in patients undergoing open-ventricle procedures.[1] No other comparative controlled prospective trials of the role of thiopental in preventing neurologic injury during CPB have been published, and the use of high-dose thiopental is still a controversial issue.[2] Accordingly, we reviewed our experience with high-dose thiopental anesthesia for open-heart surgery over a 33-month period ending in December 1989.

Methods. Anesthetic management was determined by the attending anesthesiologist. We defined high-dose thiopental as a total dose greater than 15 $mg \cdot kg^{-1}$, titrated to produce burst suppression on the electroencephalogram, with 30-60 seconds between bursts. The first use of this technique at our hospital was on March 23, 1987. The charts of 240 adult patients undergoing elective cardiac surgery with opening of a left-sided chamber from that date until December 31, 1989 were reviewed. Data tabulated included demographics, cardiac index (CI) prior to initiation of CPB, operation performed, duration of CPB, type of oxygenator, need for inotropic support after CPB, the times to tracheal extubation, neurologic complications and survival. There were 6 intraoperative deaths, none in the high-dose thiopental (HiTP) group. Data from the 234 operative survivors are reported. An intraoperative stroke was diagnosed when an otherwise unexplained focal neurologic deficit was present upon emergence from anesthesia. Perioperative strokes were defined as focal neurologic deficits that occurred intraoperatively or within 7 days of surgery. Persistent neurologic deficits at the time of discharge from the hospital were considered indicative of a more severe stroke. Statistical analyses included unpaired t-tests and Fisher's exact test, as appropriate for the type of data being analyzed.

Results. Eighty-four patients were in the HiTP group; 150 patients were given other anesthetics (Control). The mean (± SD) dose of thiopental in the HiTP group was 37.5 ± 12.2 $mg \cdot kg^{-1}$. Seventeen patients in the control group received thiopental, primarily for induction of anesthesia; their mean dose was 5.7 ± 3.5 $mg \cdot kg^{-1}$. There were no differences between the HiTP group and the control group in age (60 ± 15 versus 60 ± 14 years, respectively) or sex ratio (41 M : 43 F in the HiTP group versus 80 M: 70 F in the control group). Hypothermic CPB (25°C - 28°C) and arterial inflow filters were used for all cases. No differences were observed between groups with regard to operative procedure (AVR, MVR or other), duration of CPB, type of oxygenator (bubble *versus* membrane), or lowest nasopharyngeal temperature. Preinduction cardiac index for 221 patients with pulmonary artery catheters, the need for post-CPB inotropic support, the time to tracheal extubation, and outcome data are shown in the Table.

	HiTP	Control	P-value
n =	84	150	
Pre-CPB CI: n =	77	144	0.224
≥2 $l \cdot min^{-1} \cdot m^{-2}$	64	108	
<2 $l \cdot min^{-1} \cdot m^{-2}$	13	36	
Post-CPB:			0.190
Inotropes	45	70	
No inotropes	39	80	
Time to extubation (h):	38.9 ± 49.7	27.1 ± 24.2	0.043
Intraoperative:			0.106
Stroke	0	5	
No stroke	84	145	
Perioperative:			0.312
Stroke	2	7	
No stroke	82	143	
Overall Mortality: n =	84	156	0.0035
Died	1	17	
Survived	83	139	

Of the 5 patients with intraoperative strokes, 2 had persistent neurologic deficits at discharge from the hospital, 2 others were maintained on anticonvulsants, and 1 recovered. Three of the patients with postoperative strokes recovered; 1 (in the control group) died with a hemorrhagic CVA, multisystem failure and coagulopathy.

Discussion. The similar distributions of preinduction cardiac indexes suggest that cardiac function was not a factor in deciding whether or not to use HiTP. HiTP did not increase the need for inotropic support to wean from CPB, but did delay tracheal extubation. Overall mortality was lower in the HiTP group. The incidence of intraoperative stroke was lower in the HiTP group, although this difference was not statistically significant (P=0.106). These data neither conclusively support nor contradict the conclusion drawn by Nussmeier *et al*[1] that high-dose thiopental may reduce the incidence of neurologic injury during cardiac surgery with opening of a left-sided chamber. Additional prospective trials of pharmacologic prophylaxis of neurologic injury in patients undergoing open-heart surgery are required.

References

1. Nussmeier NA, Arlund C, Slogoff S. Neuropsychiatric complications after cardiopulmonary bypass: Cerebral protection by a barbiturate. Anesthesiology 64:165-170, 1986

2. Govier AV. Central nervous system complications after cardiopulmonary bypass, Cardiopulmonary Bypass: Current Concepts and Controversies. Edited by Tinker JH. Philadelphia, WB Saunders, 1989, pp41-68

IS THERE ANY METABOLIC ADVANTAGE TO VAGAL STIMULATION COMPARED WITH STELLATE GANGLION ABLATION DURING ACUTE MYOCARDIAL ISCHEMIA IN DOGS?

A. Sidi, MD, T.R. Gehrig, BS, J.M. Pool, BS, W. Rush, BA
Department of Anesthesiology, University of Florida College of Medicine, Box J-254, Gainesville, Florida 32610

INTRODUCTION

Vagal stimulation (VS) and stellate ganglion ablation (SGA) have the potential, respectively, to release acetylcholine and to reduce sympathetic tone; in turn, either action can affect contractility and electrophysiologic properties of myocardial tissue and reduce metabolic demand from the ischemic myocardium [1,2]. Since SGA is available today in clinical practice [3] but VS is not, we compared these two manipulations and studied their effects during variable left anterior descending artery (LADa) constriction in dogs.

METHODS

With institutional approval, in 30 dogs, anesthetized (barbiturate infusion) and ventilated, the pulmonary artery (PA), aorta (Ao), left ventricle (LV), LADa and vein (LADv), and circumflex vein were cannulated. LADa flow was measured (flowmeter) and constricted (micrometer) to 50% or 75% of resting flow for 15 min with 1 hr of normal flow between each. In 10 dogs the left vagal nerve was stimulated in the neck before and during constrictions to create a continuous heart rate (HR) of 80-90 beats/min. In another 10 dogs, the left SG was stimulated and then removed surgically. HR, electrocardiogram, LADa flow, LV first time derivative (LV dP/dt), and Ao (AoP), PA, LADa, and LV (LVP) pressures were recorded continuously. Ten dogs received neither treatment. Cardiac output (thermodilution) and regional myocardial blood flow (RMBF) (microspheres) were measured and blood was sampled before all manipulations (baseline) and before and after each constriction for electrolyte, lactate, glucose, and blood gas analysis.

RESULTS

Baseline hemodynamic and metabolic measurements did not differ significantly between the three groups (except RMBF and stroke volume index [SVI]). VS decreased HR and nonischemic and ischemic RMBF before constrictions more than SGA did (26 ± 2, 98 ± 23, 33 ± 8% compared with 4 ± 3, 3 ± 6, 12 ± 3%, respectively). SGA also decreased HR, AoP, systolic and diastolic LVP, and LV dP/dt more but preserved SVI before and during constrictions (Table 1). However, lactate consumption and extraction and flux of O_2 delivery and consumption in the ischemic and nonischemic regions were similar in the two treatment groups (Table 2). During constrictions electrolytes and glucose concentrations and extractions in both areas were similar, as were RMBF and the endocardial/epicardial ratio.

DISCUSSION

We conclude that, although possibly causing more pronounced hemodynamic changes than SGA, VS probably will not provide more myocardial protection during ischemia.

REFERENCES

1. Berne RM, Sperelakis N (eds): Handbook of Physiology. Bethesda, Maryland, American Physiological Society, 1979, pp 581-620.
2. Cir Res 45:710-718, 1979.
3. Anesth Analg 54:567-570, 1975.

Table 1: Hemodynamic variables before and during constrictions in dogs undergoing stellate ganglion ablation, vagal stimulation, or neither (control) (n = 10 each).

	50% Constriction		75% Constriction	
	Before	During	Before	During
Heart rate (beats/min)				
Control	146 ± 8	138 ± 9	131 ± 10*	129 ± 9*
Stellate ganglion ablation	123 ± 4†	119 ± 5*	106 ± 5*†	111 ± 6*
Vagal stimulation	94 ± 3*†‡	88 ± 4*†‡	85 ± 4*†‡	80 ± 8*†‡
Systolic left ventricular pressure (mmHg)				
Control	142 ± 21	143 ± 9	151 ± 7	109 ± 10§
Stellate ganglion ablation	118 ± 3†	124 ± 6†	121 ± 7†	115 ± 7
Vagal stimulation	136 ± 7	112 ± 10*†§	103 ± 8*†‡	86 ± 8*†‡§
Left ventricular end-diastolic pressure (mmHg)				
Control	7 ± 1	9 ± 2	9 ± 2	12 ± 2*§
Stellate ganglion ablation	6 ± 1	8 ± 1	5 ± 1	8 ± 1§
Vagal stimulation	4 ± 1	3 ± 1†‡	2 ± 1†‡	2 ± 1†‡
Left ventricular first time derivative (mmHg/sec)				
Control	2300 ± 78	2143 ± 57	2133 ± 96	1857 ± 146
Stellate ganglion ablation	2000 ± 82	2010 ± 97	1830 ± 68*†	1663 ± 75*§
Vagal stimulation	1920 ± 76	1510 ± 81*†‡§	1400 ± 95*†‡	1080 ± 90*†‡§
Stroke volume index (ml/beats/m^2)				
Control	26 ± 3	23 ± 2	22 ± 3*	20 ± 2*
Stellate ganglion ablation	27 ± 3	29 ± 3	26 ± 3	22 ± 2*§
Vagal stimulation	33 ± 3†	31 ± 3†	26 ± 2	27 ± 6

*P < 0.05 compared with baseline value (not shown) in the same group.
†P < 0.05 compared with control group in the same time period.
‡P < 0.05 compared with stellate ganglion ablation group in the same time period.
§P < 0.05 compared with before constriction in the same group.

Table 2: Metabolic variables in the ischemic zone before and during constrictions in dogs undergoing stellate ganglion ablation, vagal stimulation, or neither (control) (n = 10 each).

Ischemic zone variables	Before Constrictions	During 50% Constriction	During 75% Constriction
Lactate consumption (mM/min/10^3)			
Control	12 ± 5	-19 ± 3*†	-19 ± 3*†
Stellate ganglion ablation	9 ± 3	-9 ± 5*†‡	-4 ± 2*†‡
Vagal stimulation	7 ± 9	-9 ± 7*‡	-6 ± 3*‡
Lactate extraction (%)			
Control	15 ± 7	-103 ± 40*†	-233 ± 95*†
Stellate ganglion ablation	20 ± 4	-40 ± 19*†	-47 ± 14*†
Vagal stimulation	13 ± 12	-40 ± 27*	-63 ± 30*†
Oxygen delivery (ml/min/100 g/10^2)			
Control	34 ± 7	17 ± 1*†	6 ± 1*
Stellate ganglion ablation	22 ± 1	14 ± 2*†	9 ± 1*‡
Vagal stimulation	29 ± 7	13 ± 2*†	9 ± 2*
Oxygen consumption (ml/min/100 g/10^2)			
Control	23 ± 5	13 ± 1*	4 ± 1*
Stellate ganglion ablation	14 ± 1	10 ± 1*†	7 ± 1*
Vagal stimulation	17 ± 4*	11 ± 2*	7 ± 1*

*P < 0.05 compared with baseline (not shown) in the same group.
†P < 0.05 compared with before constriction in the same group.
‡P < 0.05 compared with control group in the same time period.

COMPARISON OF CARDIOVASCULAR RESPONSES TO LARYNGEAL MASK AIRWAY INSERTION AND ENDOTRACHEAL INTUBATION

A.J. Martin FFARCS, P.D. Cooper FFARCS, J.R. Maltby FRCPC
Department of Anaesthesia, Foothills Hospital at The University of Calgary, Calgary, AB

INTRODUCTION: Laryngoscopy and tracheal intubation are associated with an increase in blood pressure and heart rate[1,2] that are usually of short duration and are well tolerated in healthy patients. However, in patients with coronary artery disease or poorly treated hypertension, the increases in blood pressure and heart rate may be accompanied by cardiac arrhythmias and E.C.G. evidence of myocardial ischaemia. These changes can be minimized by the prior administration of opioids, for example alfentanil and fentanyl,[3,4] but the high doses required (particularly of fentanyl) may produce their own side effects including postoperative respiratory depression. The laryngeal mask airway is introduced blindly into the hypopharynx thus eliminating the need for laryngoscopy and the insertion of a tube into the trachea.[5] A study suggests that the laryngeal mask may minimize increases in blood pressure and heart rate associated with establishing the airway.[6] This study therefore was designed to compare the blood pressure and heart rate changes in patients in response to laryngeal mask insertion or tracheal intubation.

METHOD: Approval for the study was obtained from the Conjoint Medical Ethics Committee of the University of Calgary. Elective patients aged 18-70 years, of ASA Class I or II, who were scheduled for surgery for which tracheal intubation would normally be used but for which a laryngeal mask (LM) airway would be equally appropriate were selected to be in the study. Verbal and written consent was obtained preoperatively and at that time admission blood pressure and heart rate were noted. Patients were excluded if a cuffed endotracheal (ET) tube was considered essential, or if they suffered from pre-existing hypertension or other cardiac disease, or were taking antihypertensive or other cardiovascular medication. Patients in whom tracheal intubation took more than 30 sec were excluded from subsequent analysis. Using a table of random numbers, patients were allocated to have their airway established either with an ET tube or LM airway. Patients had ECG, automatic blood pressure (with printer), and oxygen saturation monitoring equipment applied prior to the induction of anaesthesia. An intravenous cannula was inserted using local anaesthesia (1% plain lidocaine), and repeated blood pressure measurements were taken until subsequent readings were within 10% of one another. Preoxygenation with 100% O_2 then began and 100 µg of fentanyl were then given intravenously. Two min later the blood pressure and heart rate were measured again. Thiopentone 5 mg/Kg and vecuronium 0.1 mg/Kg were then given and 70% nitrous oxide was added to the gas mixture. The patient was then hand ventilated to normocapnia. Two min after the administration of thiopentone and vecuronium, the heart rate and blood pressure were again recorded and immediately following this, airway insertion or endotracheal intubation took place. The heart rate and blood pressure were then recorded at minute intervals for five min. After airway insertion 1% isoflurane was added to the gas mixture and ventilation was controlled to maintain normocapnia. Differences in blood pressure and heart rate between the two groups were analyzed by using Students t-test for unpaired data. Non parametric data were analysed using the Chi-squared test.

RESULTS: There was an excess of males in the study but there was no significant difference between the groups with respect to sex distribution, age or weight (Table 1). At 1, 2, and 3 min after airway manipulation the systolic blood pressure can be seen to be significantly higher in the endotracheal group (Figure 1). The same applied to mean and diastolic blood pressure except that for diastolic blood pressure the significant differences only lasted for 2 min after the establishment of the airway. The pulse rate was significantly higher in the endotracheal group following intubation and this change persisted for the five min that heart rate was measured.

DISCUSSION: Thus in the hypertensive or patient with coronary or cerebrovascular disease, these increases in blood pressure and heart rate may have clinical implications that would affect the choice of airway.

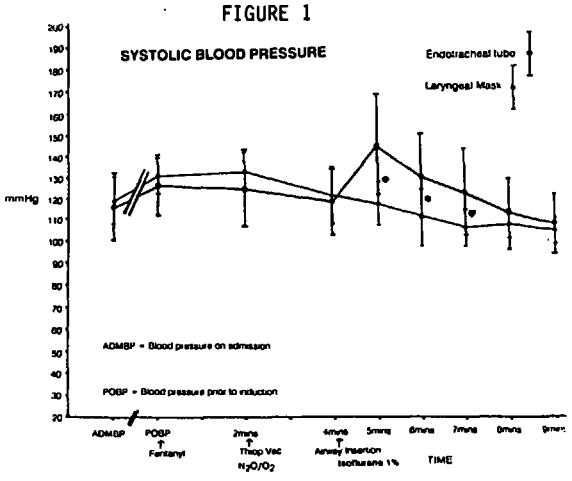
REFERENCES:

1. Bri J Anaesth 60: 579-81.
2. Bri J Anaesth 59: 300-4.
3. Bri J Anaesth 62: 385-92.
4. Acta Anaesthesiol Scand 26: 217-21.
5. Anaesthesia 44: 238-41.
6. Anaesthesia 45: 620-33.

TABLE 1

GROUP	No.	Male	Female	Age	Weight(kg)
ET	12	9	3	35.3 (13.8)	75.8 (18.3)
LM	9	8	1	29.0 (10.5)	82.2 (6.0)

FIGURE 1



THE DIFFERENTIAL EFFECTS OF HALOTHANE ON VENOUS ADMIXTURE IN ATELECTATIC CANINE LUNG

D. Johnson, M.D.C.M., T. Hurst, M.R.C.V.S., I. Mayers, M.D.
Departments of Anaesthesia and Medicine
University of Saskatchewan, Saskatoon, Saskatchewan

INTRODUCTION

Halothane inhibits hypoxic pulmonary vasoconstriction in the atelectatic lung. We wished to compare the selective effects of halothane on venous admixture and pulmonary vascular resistance when delivered to the lung by insufflation, solubilized within the inflow blood to the lobe, or the combination of both. These effects of halothane were compared to the vasodilator sodium nitroprusside (SNP).

METHODS

This study was approved by the University Animal Care Committee. The left lower lobes of 6 mongrel dogs were prepared by cannulating the lobar artery, vein and bronchus. The lobes were maintained in situ and perfused through an extracorporeal circuit primed with autologus blood. Pulmonary outflow blood was deoxygenated by bubbling with a 7% CO_2; 93% N_2 gas mixture before being returned to the inflow reservoir. Lobar flow was set in Zone 3 by adjusting the heights of the inflow and outflow reservoirs which in turn set the inflow and outflow pressures (Pi and Po). We used a stop-flow technique to partition pulmonary vascular resistance (PVR) into total (R_{TOT}), inflow, middle (Rm) and outflow resistances. We sequentially ventilated each lobe with normoxic (35% O_2) and hypoxic (3% O_2) gas. Following these baseline measurements we introduced 4.5 mm steel ball bearings into the lobar bronchus to produce sublobar atelectasis. Each lobe was ventilated with 35% O_2 (Period A_1), 35% O_2 and 2.5% insufflated halothane (Period $I_{H2.5}$), 35% O_2 and 2.5% blood solubilized halothane (Period $B_{H2.5}$), 35% O_2 and combined blood as well as insufflated 2.5% halothane (Period $C_{H2.5}$). The order of halothane periods was randomized. The lobe was then ventilated with 35% O_2 (Period A_2) and a final period in which 8 ug/kg/min SNP (Period A_{SNP}) was added to the lobar inflow. We measured segmental resistances, temperature, hematocrit, inflow blood gases, inflow oxygen saturations, outflow blood gases, and outflow oxygen saturations in each ventilatory period. Inspiratory and expiratory halothane were continuously measured. Venous admixture (Qva/Qt) was calculated from a standard equation of capillary, arterial and venous oxygen contents and expressed in %. Resistance was measured in cm $H_2O \cdot ml^{-1} min^{-1}$. Values were compared using analysis of variance and a multiple comparison test when indicated with ($p<0.05$) indicating a significant difference.

RESULTS

Values of temperature, hematocrit, Pi, Po and inflow blood gases were not different between periods. During 3% O_2 ventilation, outflow PaO_2 was significantly lower than 35% O_2 ventilatory periods. Atelectasis was also associated with a significant decrease in outflow PaO_2 compared to 35% O_2 (142 ± 27 versus 180 ± 5 mm Hg respectively). Inspired halothane concentrations were 2.4 ± .2% in Periods $I_{H2.5}$ and $C_{H2.5}$ and expired halothane concentrations were .3 ± .2% Period $B_{H2.5}$. Both R_{TOT} and Rm significantly increased with 3% O_2 or atelectasis. Inhaled halothane ($I_{H2.5}$) or combined perfused and inhaled halothane ($C_{H2.5}$) significantly decreased Rm compared to perfused halothane ($B_{H2.5}$). Qva/Qt was similar in all halothane periods. Inhaled halothane and SNP middle resistance were similar but Qva/Qt was significantly greater with SNP.

DISCUSSION

Changes in pulmonary vascular resistance were not coupled to changes in venous admixture. Perfused and inhaled halothane similarly increased Qva/Qt despite the greater middle resistance with perfused halothane. We hypothesized that inhaled halothane is unable to enter atelectatic alveoli. This will minimize the vasodilation in those units with the greatest ventilation perfusion mismatch and minimize the increase in Qva/Qt. Perfused halothane does not spare atelectatic units increasing Qva/Qt despite less effective vasodilation. We conclude that inhaled halothane is a less effective inhibitor of hypoxic pulmonary vasoconstriction than perfused vasodilators.

	R_{TOT}	Rm	Qva/Qt
35% O_2	.0581 ±.0065	.0117 ±.0066	8 ± 5
3% O_2	.0888 ±.0082	.0305 ±.0121	---
A_1	.0757 ±.0113	.0242 ±.0091	9 ± 6
$I_{H2.5}$	.0545 ±.0111	.0096 ±.0065	14[a] ± 5
$B_{H2.5}$	.0670[b] ±.0122	.0166[b] ±.0091	22 ±19
$C_{H2.5}$	.0527 ±.0090	.0067 ±.0070	16 ±13
A_2	.0859 ±.0157	.0243 ±.0099	8 ± 6
A_{SNP}	.0513 ±.0077	.0086 ±.0052	34 ±10

Where "a" represents a difference comparing $I_{H2.5}$ versus A_{SNP} and "b" represents a difference comparing $B_{H2.5}$ versus $C_{H2.5}$ or $I_{H2.5}$.

Supported by a grant from the Saskatchewan Health and Research Board and the Canadian Heart and Stroke Foundation.

A COMPUTERIZED DATA BASE TO STUDY ADVERSE ANAESTHETIC OUTCOME

DF Wigglesworth BSc, DK Rose MD
Department of Anaesthesia, St Michael's Hospital, University of Toronto.
30 Bond Street, Toronto, Ontario M5B 1W8

INTRODUCTION A data base program was developed to assist in evaluating the occurrence of adverse events during and following anaesthesia. Other computerized systems are available but they are restricted by lack of outcome data and a limited number of variables.[1,2] Our system enables rapid and accurate entry of more than 250 variables including outcomes (or adverse events) for each of 13000 patients per year.

DEVELOPMENT AND DESCRIPTION The data base program was written in dBase IV. The program is run on an IBM AT compatible microcomputer equipped with 2 Mb RAM and a 40 Mb fixed disk. Entry to the program is password protected.

Information is keyed directly from copies of the operating room anaesthetic (OR) and recovery room (RR) records. Data captured include patient demographics and medical history, ICD.9.CM surgical procedure code, types of monitoring devices, all drugs and dosages, anaesthetic techniques as well as adverse events. Information from other data bases can be linked electronically (e.g. long term outcome data from the Medical Records Department, critical care data from the hospital's ICU data base).

The data base program is essentially an electronic form with four main functions: *Entry, Edit, Delete*, and *Search*. Data may be *Entered* only if it is uniquely identified by means of chart number and the date and time of the end of the surgical procedure. Once *Entered*, data may be *Edited*, *Deleted* or *Searched*. A *Search* may be conducted based on any or all of (i) one or more parts of the unique identification, (ii) date of data entry, (iii) the entry operator's ID. When a *Search* is successful, the data may be *Edited* or *Deleted*. Certain non-numeric data such as drug names, surgical procedure codes, patient history, and adverse events, require special handling to ensure uniform entry since they may be found in a chart under any of several aliases (eg SUX, SCOLINE, SUCCINYLCHOLINE). Each item is represented in the data base by an abbreviated code. In a separate list, each code is recorded along with every name by which that item has been, or is likely to be, recorded on the chart. To enter an item from the chart, the user types the first few letters of the item (Figure 1). The computer searches the list for an item which starts with the same letters and presents the closest match. The user indicates if it is a successful match and the corresponding code is transferred to the data base. The list of names and codes may be edited as necessary.

A major concern with any data base is that data are entered accurately. During *Entry* and *Editing*, basic validity checks are made wherever possible (e.g.: patient weight must be between 10 and 200 kg). For greater accuracy and ease of use, the entry screens are designed to resemble the forms from which the data are retrieved. In addition, since many data items are the same for a majority of cases (e.g.: general anaesthetic, ASA 1) these items are assigned a default value that is automatically entered unless changed by the data entry operator (Figure 2). In order to account for every possible situation, all data items may also be entered as either '.' (period=missing) or '?' (question mark=incomplete). The former is actual data while the latter is to be modified before any statistical analysis takes place.

To minimize delays in the data base program, a 1 Mb disk cache in RAM was used to reduce the time taken to access data on the fixed disk. In order to reduce search times, active data are kept in small differential files while less active data are kept in larger master files. As the differential files grow, their contents are transferred daily to the master files. The data in the master files is transferred monthly to storage where it will be available for statistical analysis. Reports are generated immediately after this transfer takes place.

CONCLUSION This data base has been successfully used for the last six months in over 6000 patients. Rapid and accurate entry of multiple variables and outcomes has made possible a project to identify etiological factors of adverse events and thus to develop preventive strategies in both the operating and recovery rooms.

REFERENCES 1. Anesth Analg 1985;64:425-431.
2. Anesth Analg 1989;68:340-343.

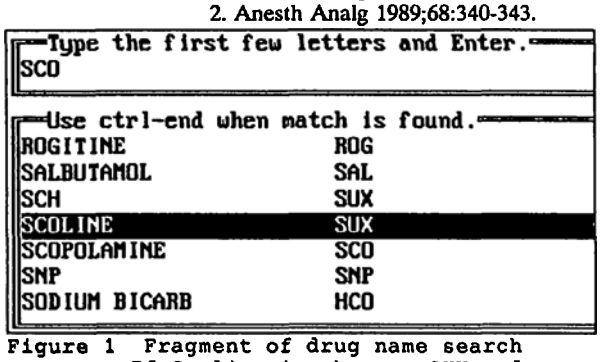


Figure 1 Fragment of drug name search screen. If Scoline is chosen, SUX code will be added to the database.

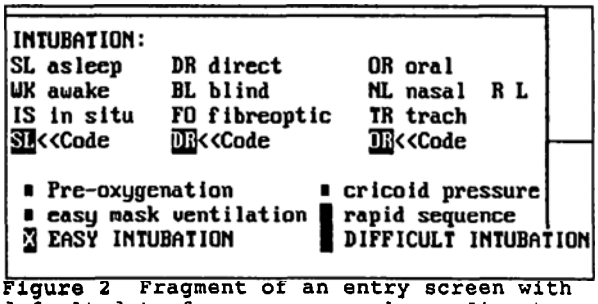


Figure 2 Fragment of an entry screen with default data for an easy, asleep, direct, oral intubation.

COMPUTER ANALYSIS OF PHYSIOLOGICAL SIGNALS

J.C. Kay, C.D. Mazer, MD
Department of Anaesthesia, St. Michael's Hospital, University of Toronto, Ontario.

Introduction

Researchers are frequently confronted with the problem of analyzing complex physiological signals. Manually, this is tedious, requires considerable time and there may be significant observer variability. Microcomputers can be used to implement solutions to these problems.

Most physiological signals recorded by anaesthetists are recorded in analog form. To be processed by a computer they have to be converted into a digital form using an analog to digital conversion board. However, a major problem is the availability of software to analyze the digitised data.

The purpose of this article is to describe how using Asyst (Asyst Software Technologies), a software program with preprogrammed features that can be customised by the individual researcher, we developed a user friendly, menu driven application program to analyze analog signals. As an example of complex physiological signals we will show how overlay plots of left ventricular pressure length loops can be generated and how the end systolic pressure length relationship can be plotted.

Methods

Data from previously reported studies was used.[1] Left ventricular pressure was measured with a Millar MPC-500 catheter tip transducer, and dP/dt was obtained by differentiating this signal using an analog circuit. Changes in segment length were measured using piezoelectric crystals implanted in the myocardium. Data was recorded for 30 seconds during transient aortic occlusion, to obtain measurements over a range of left ventricular pressures. Analog signals from the chart recorder were digitised at a sampling frequency of 200 Hz in each channel using a Data Translation DT2801 A/D conversion board and stored on floppy disks.

The program was developed for use on an IBM AT microcomputer or compatible with 1 Mb RAM and an Intel math co-processor. The digitised data was sorted into beats by detecting the R wave of the ECG signal. End-systolic length was determined as the length 20 msec before peak negative left ventricular dP/dt. Overlay plots of sequential left ventricular pressure segment length loops can be generated for as many beats as requested or individual specified beats can be plotted. From the aortic occlusion data, linear regression is performed on the end-systolic left ventricular pressure and end-systolic segment length measurements. The results are displayed on an expanded scale. Also displayed are the slope, intercept, correlation coefficient and the segment length at zero pressure.

Results

Figure 1 is an example of computer generated pressure length loops during transient aortic occlusion n=40. Figure 2 shows how the computer using the same data, plots the end-systolic pressure length relationship on an expanded scale together with the regression line.

Discussion

Figure 2 demonstrates considerable scatter in the end systolic pressure length points during the early part of the aortic occlusion in this experiment. However, this scatter is not clear from the plot

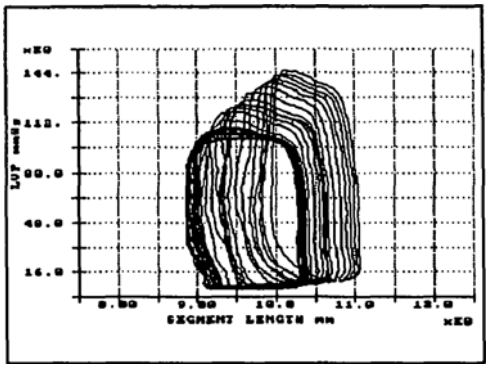


Figure 1. Pressure length loops during transient aortic occlusion n=40.

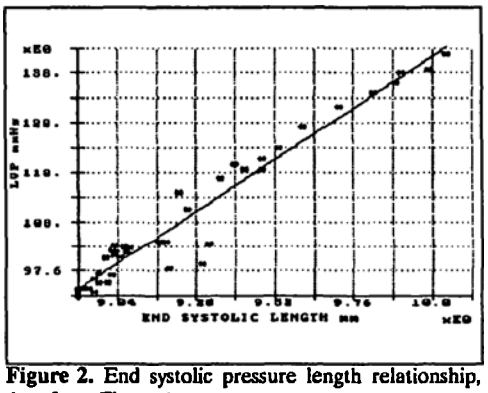


Figure 2. End systolic pressure length relationship, data from Figure 1.

of the pressure length loops (Figure 1). The end systolic pressure length relationship is frequently used as an index of myocardial function. However, some studies use only five to eight beats to plot this relationship. If only the first few beats had been used to determine the relationship in this experiment, depending on the beats used, different estimates of slope and intercept would result. Our program permits generation of the end systolic pressure length relationship from a large number of beats in less than five seconds.

Computer assisted analysis of analog data is accurate and consistent and there is considerable saving of time. Because of its powerful preprogrammed features, programming with Asyst is easier than with languages such as assembly, Fortran or Basic. The principles of this program could be applied to the analysis of many other physiological signals studied by anaesthetists.

References.

1. Kay JC, Beauchamp RJ, Mazer CD. Software to Analyze Regional Left Ventricular Function. Can J Anaesth 1990; 37(2): S74.

ATRACURIUM INFUSIONS USING CLOSED LOOP SYSTEMS

H. Yang, M.D., W.S. Beattie, M.D.
Department of Anaesthesia, McMaster University Medical Centre, 1200 Main Street West, Hamilton, Ontario, Canada L8N 3Z5

Introduction:

Infusions of non-depolarizing muscle relaxants (NDMR) have been shown to provide stable muscle relaxation with reliable reversal.[1,2] There are, however, many variables which affect the dose-responses of NDMR. It is difficult to compensate for all the variables and adjust the infusion rates accordingly in everyday practice. To address this problem, a closed-loop feedback infusion of Atracurium has been devised using existing commercially available equipment.

Method:

A Datex NMT221 monitor was used to monitor muscle relaxation and its signal sent via an RS232 cable to a COMPAQ LTE 286 computer. An appropriate infusion rate was calculated using a program written in compiled BASIC and sent via a second RS232 cable to an IVAC 560 infusion pump to deliver the appropriate amount of Atracurium. The loop was repeated every 20 seconds. System error, defined as the difference between the target and the measured level of muscle relaxation, was calculated with each measurement.

Institutional approval and patient consents were obtained. Patients were induced with thiopentone 5 mg/kg and their EMG calibrated with Datex NMT221. Atracurium 0.5 mg/kg bolus was given prior to endotracheal intubation. Anesthetic was maintained with up to 1.5% Isoflurane or Enflurane and N_2O/O_2 mix. Feedback infusion of Atracurium was started ten minutes after the initial bolus, using the level of muscle relaxation at ten minutes as the target. End-tidal pCO_2 was maintained between 30 to 35 mm Hg.

Results:

Seven patients were studied. (Table 1) The average Atracurium requirement was 8.96 ± 1.46 µg/kg/min to maintain a target T1% of 7.8 ± 5.5% during infusion. System error ranged between 1.38 and 3.02%/min with an average of 2.35%/min. Neuromuscular blockade was well reversed in all patients at the end of surgery.

Variables such as pCO_2 and inhalation agents fluctuated during the infusion as in any true clinical case. The feedback system compensated for these changes and provided constant muscle relaxation. (Figure 1)

Discussion:

The feedback system described here utilized commercially available equipment without modifications. It measures the error on the feedback algorithm and can be compared against future systems. Feedback systems described in the past provided no indices of performance.[3-6]

The level of EMG response ten minutes after the Atracurium bolus was used as the target level of muscle relaxation. This avoided some of the inconsistencies of the Datex NMT221.

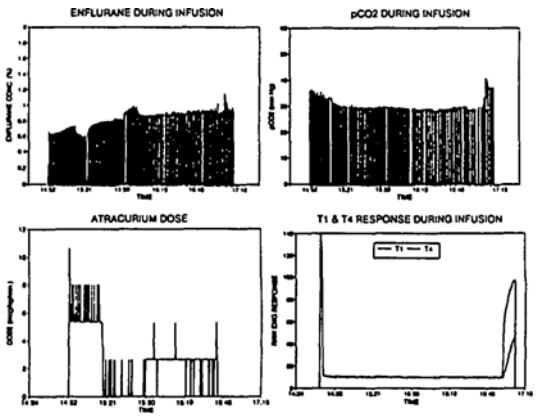
Conclusion:

A computerized feedback system for Atracurium infusion is presented here. The system utilized commercially available equipment and provided a constant level of muscle relaxation with reliable reversal.

Table 1

Sex	Age	Wt (kg)	Infusion time (min)	Dose (µg/kg/min)	Error (%/min)	Surgery
M	70	63	105	9.43	2.99	Right Hemicolectomy
M	65	76	90	9.3	3.02	Sigmoid Resection
M	81	73.5	259	8.38	2.6	Total Gastrectomy
M	61	71	306	6.97	1.95	Distal Pancreatectomy
F	74	80	118	7.62	2.05	Subtotal Colectomy
F	77	59	356	9.64	1.38	Whipple's Procedure
F	38	105	43	11.38	2.46	Laparotomy, Oophorectomy
$\bar{X}$	66.6 ±	75.4 ±	182.4 ±	8.96 ±	2.35	
STD	14.3	14.9	122.0	1.46		

Figure 1



References:

1. Anaesth Intens Care 1987;15:83-9.
2. Br J Anaesth 1984;56:447-52.
3. Clin Physics and Physiol Meas 1980;1:203-10.
4. Br J Anaesth 1986;58:670-5.
5. Anaesthesia 1987;42:1085-91.
6. Anesthesiology 1990;73:614-8.

Computer Advisor for Jet Ventilation

D. John Doyle and Wlifred Demajo
Department of Anaesthesia, Toronto General Hospital, Toronto

INTRODUCTION

High-frequency jet ventilation (HFJV) is a relatively new method of patient ventilation that delivers small tidal volumes (less that patient dead space) at supraphysiologic respiratory rates (usually over 60 breaths/min). Interest in HFJV for the treatment of respiratory failure has increased substantially in recent years and has now been used in a variety of clinical conditions [1-4]. Although this method of ventilation can be quite useful, it is still rather experimental and much equipment for HFJV has been designed on a custom basis. In general, there is a lack of experience in the operation of jet ventilators in most centers, except possibly for a few individuals with a special interest in HFJV. By contrast, knowledge of the operation of conventional ventilators is widespread. In this report, we describe a handheld microcomputer consultation system to assist in the operation of the jet ventilators in use at Toronto General Hospital. The system can be used either to assist in the adjustment of a jet ventilator in clinical use or as a teaching aid to learn about jet ventilation.

MICROCOMPUTER SYSTEM

The microcomputer used is a Sharp PC-1211 /Radio Shack PC-1 handheld model. It features a 24-character alphanumeric display, a microminature keyboard with numeric keypad, 1424 bytes of user memory and an interface to store or recall programs stored on cassette tapes. The unit is quite inexpensive and is easily programmed in the BASIC language. Once loaded into the computer's memory, the program is preserved even when the power is turned off. This feature eliminates the need to reload the program with each use. Under ordinary operating conditions, the batteries need be replaced only once or twice a year. Finally, it should be noted that the software may be easily rewritten for other computers or using other computer languages.

SOFTWARE ALGORITHM

The software associated with the system provides suggested ventilator adjustments when provided with arterial and mixed venous blood gas data. The algorithm developed was established based on ten years of clinical experience in HFJV use by one of the authors (WD). Operation of the system begins by providing initial settings for ventilator rate, fraction of inspired oxygen (FIO_2) driving pressure, and positive end expiratory pressure (PEEP). Arterial and mixed venous blood gas data are then entered after a stabilization period. This data then results in new suggested settings if needed. No adjustments are made if the arterial PO_2 is between 75 and 90 mmHg and the arterial PCO_2 is between threshold limits which are dependent on arterial hydrogen ion concentration (between 45 and 50 mmHg for $H+ < 30$ nEq/L; between 37 and 47 mmHg for 30 nEq/L < $H+ < 50$ nEq/L; and between 28 and 34 mmHg for $H+ > 50$ nEq/L. (The hydrogen ion concentration is calculated from pH.) If the arterial PO_2 is under 75 mmHg attempts are made to increase it by increasing FIO_2, PEEP and/or driving pressure; if it exceeds 90 mmHg, presumably because of patient improvement, it is decreased by reducing some of the interventions made earlier (eg decrease FIO_2). Similarly, if the arterial PCO_2 is excessive it is driving pressure, while if the arterial PCO_2 is too low, the opposite is done. Also, if the arterial PO_2 exceeds 55 mmHg while the mixed-venous PO_2 is under 30 mmHg, the computer suggests the use of inotropic support to increase cardiac output and diminish oxygen extraction.

USING THE SYSTEM

Use of the system is straight forward. Once the program is in memory and running, the user is requested via the alphanumeric display to enter initial ventilator settings (FIO_2, PEEP, rate and driving pressure) and, latter, blood gas data (arterial PO_2, arterial PCO2, pH) Suggested ventilator settings are then displayed, based on the algorithm given in Appendix. Later, another set of blood gases are requested and new ventilator settings, if needed, are provided. This cycle continues as long as the program is needed.

DISCUSSION

The use of computers in assisting in patient ventilation decisions is not new. Microcomputer-based automatic feedback control systems for conventional (volume-controlled) ventilators have been developed [5,6], and the use of artifical intelligence and expert system techniques has also been studied for these ventilators [7,8]. Similar techniques have been applied to the problem of neonatal ventilation [9,10]. However, we believe that this is the first report dealing with a computer advisory system for HFJV.

The system represents a novel and clinically convenient approach to the management of the patient undergoing jet ventilation. As with all clinical systems, however, important limitations exist. First, the algorithm used here is the embodiment of one particular clinician's approach to controlling a jet ventilator; different algorithms may be favored by other experts. Secondly, the algorithm was oriented around a particular custom-made unit, and it is possible that variations in jet ventilator design may mandate changes in the algorithm used. Nevertheless we believe that the system forms an interesting contribution to the field of computer-assisted ventilation and will likely be helpful to others wishing to develop similar systems at their center.

REFERENCES

[1] Wetzel RC, Gioia FR. High frequency ventilation. Pediatric Clinics of North America 1987; 34:15-38.
[2] Carlon GC, Ray C, Pierri Mk, et al. High frequency jet ventilation. Theoretical considerations and clinical observations. Chest 1982; 81:350-354.
[3] Carlon GC, Howland WS, Ray C, et al. High frequency jet ventilation. A prospective randomized evaluation. Chest 1983; 84:551-559.
[4] Hamilton LH, Neu J, Calkins JM. High Frequency Ventilation. Boca Raton, FL: CRC Press, 1986.
[5] Chapman FW, Newell JC, Roy RJ. A feedback controller for ventilator therapy. Annals of Biomedical Engineering 1985; 13:359-372.
[6] Ohlsson KB, Westenskow DR, Jordan WS. A microprocessor based feedback controller for mechanical ventilation. Annals of Biomedical Engineering 1982; 10:35-48.
[7] Miller PL. Goal directed critiquing by computer: ventilator management. Computers in Biomedical Research 1985; 18:422-438.
[8] Rudowski R, Frostell C, Gill H. A knowledge-based support system for mechanical ventilation. The KUSIVAR concept and prototype. Computer Methods and Programs in Biomedicine 1989; 30:59-70.
[9] Brennen J, Schulze K, James LS. A microcomputer system for monitoring ventilation in neonates. International Journal of Clinical Monitoring and Computing. 1986; 3:11-16.
[10] Boyarsky A. Computerized ventilation management system for neonates. Journal of Perinatology 1987; 7:21-29.

Computer Advisor for Oxygen Therapeutics

D. John Doyle
Department of Anaesthesia, Toronto General Hospital, Toronto

OXYGEN ADVISOR is a computer system to assist in respiratory assessment and oxygen therapeutics. The hardware consists of a SHARP 1500 handheld microcomputer with 16 k bytes expansion RAM memory (18 K bytes total) and a miniature 4-color graphics printer/plotter. A BASIC interpreter is stored in ROM memory. The software is written in extended BASIC and loaded into RAM from an external cassette data recorder. Since the system has nonvolatile RAM, the program need be reloaded only occassionally.

The Figure provides examples of the system's capabilities.

The following functions are provided:

Respiratory Assessment This module uses the alveolar gas equation to compute alveolar oxygen tension and provide gas exchange indices such as the alveolar-arterial oxygen tension difference and the arterial/alveolar oxygen tension ratio [1]. A graph plotting expected arterial oxygen tension against inspired oxygen concentration is produced. Predictions of arterial oxygen tension and alveolar-arterial oxygen tension gradient are also given for conditions of 100% oxygen.

Arterial Blood Gas Interpretation This module uses arterial pH, PCO2 and bicarbonate levels to arrive at an acid-base diagnosis. Anion-gap data can be exploited where available (anion gap metabolic acidosis.) Both pure and mixed disorders are handled. The algorithm was developed in conjunction with Dr. R. Richardson, a nephrologist at Toronto General Hospital.

Saturation-to-Tension/Tension-to-Saturation Conversion These modules convert arterial saturation (eg. from a pulse oximeter) to estimated arterial tension and vice-versa. The methods are based on the work of Severinghaus [2].

Oxyhemoglobin Dissociation Curve This module estimates a patients' oxyhemoglobin dissociation curve from arterial pH, PCO2 and patient temperature. Levels of 2,3 DPG are not considered, as these measurements are rarely available clinically. The curve is plotted in comparison with a standard normal curve. A sample curve is shown in the Figure. The method is based on the work of Kelman [3].

Target PO2 This module predicts the inspired oxygen concentration necessary to achieve a desired arterial oxygen tension. The method is based on the work of Hess [4]. Advocates of this algorithm claim that it may reduce the incidence of inappropriate oxygen orders, as well as reduce the frequency of arterial puntures for blood gas sampling.

Target PCO2 This module predicts the ventilatory frequency needed to achieve a desired arterial carbon dioxide tension in an intubated, ventilated patient. Input data consists of the present arterial carbon dioxide tension and the present ventilatory frequency. It is assumed that the existing tidal volume is satisfactory, so that adjustments in PCO2 are accomplished by changing the breathing rate. The method is based on the formula described by Wexler and Lok [5].

Air/Oxygen Mixture This module calculates the proportions of air and oxygen to blend to form a gas mixture with a particular desired oxygen concentration.

Oxygen Transport This module employs arterial and mixed venous blood gas data to calculate oxygen transport indices such as pulmonary shunt, oxygen delivery, oxygen extraction ratio etc.

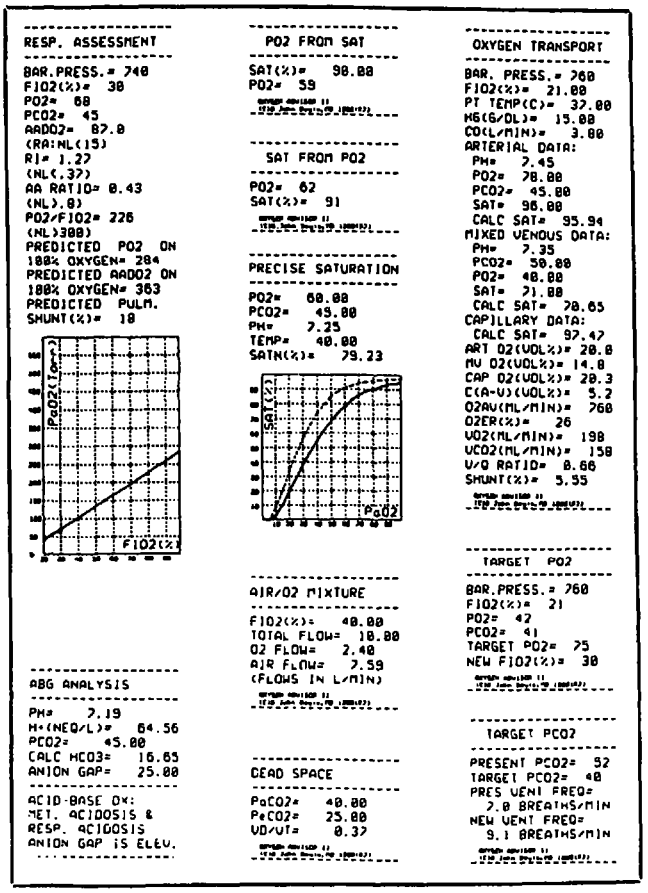


Figure: Sample outputs from OXYGEN ADVISOR. *Left column top*: Respiratory assessment program with plot of arterial oxygen tension (PaO2) versus fraction of inspired oxygen (FIO2) for the input data shown. *Left column bottom*: Arterial blood gas (ABG) analysis example showing an elevated anion gap metabolic acidosis. *Middle column top*: Examples of conversion of arterial oxygen saturation to arterial PO2 and vice versa. Middle column middle: Plot of oxyhemoglobin saturation curve as compared to a standard normal curve (P50=27) for the input data shown. *Middle column bottom*: Air/oxygen mixture and dead-space calculations. *Right column top*: Output of oxygen transport program with calculation of pulmonary shunt (SHUNT%), oxygen extraction ratio (O2ER%), oxygen availability (O2AV) and other oxygen transport parameters. *Right column middle*: Sample output of target PO2 program. *Right column bottom*: Sample output of target PCO2 program.

REFERENCES

[1] Can Anaesth Soc J 33:471-474, 1986
[2] J Appl Physiol 46:599-602, 1979
[3] J Appl Physiol 21:1375-1376, 1966
[4] Crit Care Med 7:568-569, 1979
[5] Can Anaesth Soc J 28:370-372, 1981

Computer Model for Pulmonary Oxygen Exchange

D. John Doyle
Department of Anaesthesia, Toronto General Hospital, Toronto

Introduction

The understanding and management of pulmonary oxygen exchange is frequently important in the care of the critically ill patient. Although the anaesthesia and critical care literature abounds with information on the topic, it is often unclear in terms of theoretical physiology what effects on pulmonary oxygen exchange would be expected in response to, for example, manipulations of inspired oxygen concentration, cardiac output or blood hemoglobin concentration. In particular, the potential to obtain real-time arterial and mixed-venous oximetry data (dual oximetry [1]) allows new insight into oxygen transport in any individual patient, but the problem still exists that a detailed quantitative model to examine the implications of this data is lacking. Here we present a detailed computer model to address issues of this kind.

Methods

A series of quantitative (usually nonlinear) relationships between the primary physiological variables in oxygen transport were obtained from the literature [2-8]. These relationships were formulated in mathematical terms suitable for processing by a commercial software equation solver (TK! Solver, Software Arts, Inc. [9]) which uses advanced numerical methods to solve them (e.g., successive approximation methods.) (Because these equations are often self-referencing (e.g., blood oxygen saturation expressed in terms of tension and vice-versa) they are particularly difficult to solve by traditional means.) A portion of the rules for the model are given below.

```
================== RULE SHEET ==============================
Rule
----
PaO2=PAO2 - (Cav*(Z/(1-Z)) - 1.34*Hb*(Sc-Sa) )/0.0031
SaO2=100*(((23400/(PaO2^3+150*PaO2))+1)^-1)
ScO2=100*(((23400/(PAO2^3+150*PAO2))+1)^-1)
PAO2=(PB-PH2O)*FIO2-PCO2*(FIO2+(1-FIO2)/0.8)
AaDO2=PAO2-PaO2
RI=AaDO2/PaO2
aARAT=PaO2/PAO2
PFR=PaO2/FIO2
VO2=CO*10*Cav
Sav=100*(Cav-0.0031*(PaO2-PvO2))/(1.34*Hb)
SvO2=SaO2-Sav
PvO2=exp(0.385*ln((Sv^-1 -1)^-1)+3.32-(72*Sv)^-1-(Sv^6)/6)
Sv=SvO2/100
Sa=SaO2/100
Sc=ScO2/100
```

Figure 1: Portion of oxygen transport model in rule form (using TK! Solver equation solver package.) Legend: Z= shunt fraction; PaO2=arterial oxygen tension; PAO2=alveolar oxygen tension; PvO2=mixed venous oxygen tension; SxO2=percent blood oxygen saturation(x=a,c,v); AaDO2=alveolar-arterial oxygen tension gradient; RI=respiratory index; Sav=arterial-venous oxygen saturation difference; CO=cardiac output; VO2= oxygen consumption.

Results and Discussion

The figure shows some graphical results based on the model. The system has proven to be useful in understanding oxygen transport physiology. It is hoped that it will serve as a tool for both teaching and patient management. Some possible applications include: theoretically examining the effect of transfusions on arterial oxygen tension, predicting changes in gas exchange indices (eg, alveolar-arterial oxygen tension difference, arterial/alveolar oxygen tension ratio) in response to changes in barometric pressure, and examining the effect of changes in cardiac output on arterial oxygen tension.

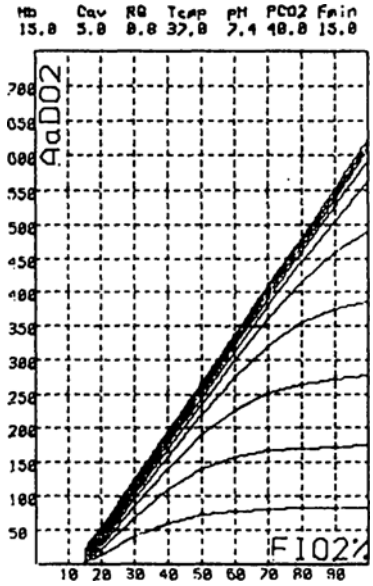


Figure 2: Influence of FIO2 and shunt fraction on the alveolar-arterial oxygen tension gradient (AaDO2) for the model. Shunt lines are at 0.05 to 0.5 in steps of 0.05. The highest line corresponds to a shunt fraction of 0.5.

References

[1] Intensive Care Medicine 14:118, 1988
[2] Journal of Applied Physiology 21:1375, 1966
[3] Clinical Chemistry 27:1856, 1981
[4] Journal of Applied Physiology 52:1043, 1982
[5] Critical Care Medicine 9:469, 1981
[6] Journal of Applied Physiology 52:1043, 1982
[7] Canadian Anaesthetist's Society Journal 33:471, 1986
[8] IEEE Transactions on Biomedical Engineering 32:882, 1985
[9] M. Konopasek, S. Jayaraman. The TK! Solver Book. Osborne/McGraw-Hill, 1984

Medical computing in the OR and ICU: Applications Using Spacelabs' PC Mode

D. John Doyle
Department of Anaesthesia, Toronto General Hospital, Toronto

INTRODUCTION The last two decades have seen an enormous change in the role of computers in medical care, especially in information-critical areas such as intensive care medicine. While many early medical computing applications concentrated on administrative considerations such as billing and test scheduling, recent years have seen an expansion of medical computing into medical decision making. In this report we present a series of medical software application programs for use in anesthesia and critical care medicine which run on certain Spacelabs patient monitors.

PC MODE Some Spacelabs patient monitors (Alpha PC, PC-II) offer the capability of operating as an IBM-PC compatible computer when a keyboard and 3.5 inch disk-drive module are plugged into the system. The MS-DOS operating system is loaded from the diskette in response to a touch-key option on the monitor screen. When MS-DOS is loaded, the monitor screen is divided into two portions, or windows, the upper window allowing the display of one physiological waveform (usually the ECG is displayed and the lower window appearing as a conventional CGA (color graphics adapter) computer display ready to accept keyboard commands. Just as with a regular IBM compatible computer, MS-DOS commands can be issued to view directories, copy files, run programs, etc. Because the central processing unit (CPU) is responsible for both patient monitoring activities (waveform displays, alarms, etc.) as well as any programs running in PC-mode, PC-mode programs generally run more slowly than in an ordinary PC. This is especially true because PC-mode is given lowest priority among the responsibilities of the CPU.

External programs which operate in PC-mode must be "well-behaved", which is to say that they must act in a manner compatible with smooth operation of the monitor. As an example, use of the video display must be done by calling on appropriate "BIOS" routines to display information on screen rather than writing to the screen directly.

Another restriction concerns program size. The original PC-Mode running on the Alpha PC has a total of 256-K bytes of RAM. While this is adequate for many applications, especially those written in GWBASIC, it may not be sufficient to run other applications or other languages.

```
     BLOOD TRANSFUSION GUIDELINES
       by D. JOHN DOYLE MD PhD

INPUT DATA

     PRESENT HEMATOCRIT (%)= 22
     TARGET HEMATOCRIT (%)= 35
     WEIGHT (KG)= 50
     PATIENT'S AGE (YEARS)= 15

DERIVED DATA

     PACKED CELLS REQUIRED (ML)= 650
     WHOLE BLOOD REQUIRED (ML)= 1138
Ok
```

Figure 1. Sample output from the program module which estimates the volume of packed cells needed to achieve a particular target hematocrit.

APPLICATIONS In the last several years, we have been developing applications to run in PC-Mode on Spacelabs monitors. Over forty clinical application programs have been written to date; many of these are described in detail in a book by the author *[D. J. Doyle. Computer Programs in Clinical and Laboratory Medicine. Springer-Verlag 1989]*. A list of applications is given below:

Cardiac
1. Corrected QT Interval (QT)
2. Digoxin Dosing Algorithm (DIG)
3. Diagnosis of Acute Chest Pain (ACP)
4. CCU Predictive Instrument (CCU)
5. Hemodynamic Monitoring Program (HDM)

Pulmonary
6. Predicted Arterial PO_2 (PREDO2)
7. Arterial Saturation from PO_2 (SAT)
8. Arterial PO_2 from Saturation (PFS)
9. Air/Oxygen Mixture (MIX)
10. Ventilator Adjustment for Target PCO_2 (TPCO2)
11. Oxygen Therapeutics (OXYGEN)
12. Alveolar Gas Equation (AGE)
13. Physiologic Dead Space (PDS)
14. Pulmonary Function Tests (PFT)
15. Asthma Severity Index (ASTHMA)

Renal
16. Measured Creatinine Clearance (MCC)
17. Estimated Creatinine Clearance (ECC)
18. Renal Failure Index (RFI)
19. Renal Free Water Clearance (FWC)
20. Fractional Excretion of Filtered Sodium (FEFS)

Trauma and Resuscitation
21. Abbreviated Burn Severity Index (ABSI)
22. Acute Trauma Index (Path Index) (ATI)
23. CHOP Trauma Index (CHOP)
24. Glasgow Coma Scale (GCS)
25. Neonatal Apgar Score (APGAR)
26. Pediatric Endotracheal Tube Selection (ETT)
27. Resting Energy Expenditure (REE)

Therapeutics
28. Maintenance Intravenous Fluids (MIV)
29. Parenteral Iron Therapy (IRON)
30. Calcium Protein Binding (CALCIUM)
31. Estimated Body Surface Area (BSA)
32. Ponderal (Obesity) Index (PI)
33. Calculated Serum Osmolality (OSM)
34. Estimated Blood Volume (EBV)
35. Allowable Blood Loss (ABL)
36. Blood Transfusion Guidelines (BTG)

Drug Dosing
37. Mcg/Kg/Min Drug Infusion #1 (MCG1)
38. Mcg/Kg/Min Drug Infusion #2 (MCG2)
39. Mg/Min Drug Infusion (MGM)
40. Mcg/Kg/Min Infusion Rate Finder (IRF)

Miscellaneous
41. Pharmacokinetic Modelling of Aminoglycosides
42. Arterial Blood Gas Interpretation

Table 1: Clinical application programs developed to run in PC-Mode on Spacelabs patient monitors. All were written in Microsoft GWBASIC. Actual program names are given in parentheses.

Naproxen Premedication For The Reduction of Postoperative Tubal Ligation Pain

V. Kim Comfort, MD, William E. Code, MD, FRCPC, Michael E. Rooney, BSP.

Department of Anaesthesia, Royal University Hospital, Saskatoon, Saskatchewan, S7N 0X0

INTRODUCTION: Postoperative pain in laparoscopic tubal ligation can be a major determinate in the recovery time of the patient [1]. This pain is felt to be the result of prostaglandin release by the traumatized Fallopian tube leading to uterine contraction and crampy lower abdominal pain [2]. Based on this premise, prostaglandin inhibition by the nonsteroidal anti-inflammatory drug (NSAID) naproxen sodium should reduce the pelvic pain experienced by these patients postoperatively. With a reduction of pain the postoperative opioid requirements and their associated side effects should be reduced. This may also lead to a decreased length of stay in the day surgery unit. Are the goals of outpatient anaesthesia more attainable by using a simple, low side effect, antiprostaglandin analgesic such as naproxen sodium 550 mg? This study evaluates this question.

METHODS: With institutional ethics committee approval, a randomized double-blind prospective clinical study was undertaken on ASA I and II patients undergoing outpatient laparoscopic tubal ligation. Patients received two identical capsules containing either placebo or 275 mg of naproxen sodium each no less than one hour preoperatively.

Patient exclusion criteria included allergies to NSAID's, history of peptic ulcer disease and bleeding disorders. No additional premedications were given and all analgesics used were recorded. A preinduction dose of fentanyl 2 ug/kg or alfentanil 20 ug/kg was allowed with no additional opioids intraoperatively. Postoperative analgesia was in the form of parental morphine or meperidine or oral acetaminophen with or without codeine.

Pain scores were measured by Visual Analogue Scale [3] preoperatively (PS0) and then 1 (PS1) and 2 (PS2) hours after the start of the procedure. Patients were then followed up by telephone the next day. Data was analyzed by the Wilcoxon Rank Sum Test, T test and Chi Square with Yates correction. A P value of <0.05 was considered statistically significant. All data was recorded with $\pm$ standard error.

RESULTS: 44 patients completed the study. 21 patients were randomized to the treatment group and 23 patients to the control group. Demographic information revealed no significant difference between the groups.

As can be seen in Table 1, the treatment group had significantly lower pain scores postoperatively at both PS1 and PS2. For those undergoing Felsche clip application in the control group (n=7), the pain scores were significantly higher (PS sum = 10.8 $\pm$ 1.83) than those undergoing coagulation (n=16) in the control group (PS sum = 3.6 $\pm$ 0.68). The requirement for parental opioids was significantly different between the 2 groups with the treatment group not requiring any parental opioids whereas in the control group, 34.8% of the patients received parental opioids. Comparison of intrahospital analgesic requirements for acetaminophen with or without codeine was again significantly less in the treatment group.

Only 1 side effect, mild stomach burning immediately preoperatively was noted in the treatment group and no preoperative complaints in the control group. No significant difference was demonstrated between the groups for postoperative nausea.

On analyzing the time spent in the day surgery unit, we found a significantly ($p < 0.01$) shorter time was spent postoperatively for the treatment group (168 minutes $\pm$ 12.66) versus the control group (188 minutes $\pm$ 14.85).

DISCUSSION: Naproxen sodium is rapidly absorbed with peak levels attained within 20-40 minutes and has a plasma half-life of approximately 14 hours which makes it an excellent choice for the treatment of the pain associated with this procedure. By giving the medication preoperative, therapeutic plasma levels are attained prior to the tissue damage in order to prevent the synthesis of prostaglandins and their resulting role in the postoperative pain [2].

In our study, we evaluated 44 patients undergoing outpatient laparoscopic tubal ligation. Pain was significantly less in the treatment group at both measurement times postoperatively. There was a significantly increased amount of pain experienced by patients in the control group who underwent Felsche clip tubal ligation compared to those who had coagulation, supporting the previous studies that clips are more painful than coagulation [1]. Postoperative opioid requirements were definitely reduced in the treatment group, especially for parental opioids. Day surgery time was significantly reduced by 10.6% in the treatment group which in this study averaged 20 minutes. Our study demonstrates the effectiveness of naproxen sodium as a premedication for the reduction of postoperative pain and opioid/analgesic requirements with a shortening of day surgery unit stay in outpatient tubal ligation patients.

REFERENCES:

1. Chi I-Cheng et al. Incidence of pain among women undergoing laparoscopic sterilization by electrocoagulation, the spring-loaded clips, and the tubal ring. Am J Obstet Gynecol, 1979, 135:397.
2. Brodie BL, Casper RF. Prostaglandins mediate postoperative pain in Falope ring sterilization. Am J Obstet Gynecol, 1985, 151:175.
3. Huskisson EC. Measurement of Pain. Lancet, 1974, 2:1127.

Table 1:

	Treatment Group	Control Group
Pain Score 1 hr (PS1)	0.9 $\pm$ 0.20	3.5 $\pm$ 0.62
Pain Score 2 hr (PS2)	1.1 $\pm$ 0.24	2.4 $\pm$ 0.49
Pain Score Sum (PS Sum) (PS1+PS2-PS0)	1.9 $\pm$ 0.40	5.8 $\pm$ 1.00

Phlebotomy *versus* sodium nitroprusside/isoflurane for treatment of increased proximal blood pressure with thoracic aortic cross-clamping in the dog: A comparison of spinal cord hemodynamics, blood flow and incidence of paraplegia

FJS Clark M.D., IR Sutton M.D., WAC Mutch M.D., IR Thomson M.D., JM Teskey M.D., DB Thiessen B.Sc., M Rosenbloom B.Sc.(Hons)
Departments of Anaesthesia and Surgery, University of Manitoba, Winnipeg, MB, CANADA R3E 1X2

Introduction: Our objective was to determine the optimal treatment of proximal aortic hypertension during thoracic aortic cross-clamping (AXC) in a canine model. We hypothesized that the treatment that best maintained spinal cord perfusion pressure (SCPP) following thoracic AXC would result in the best neurologic outcome. The SCPP is defined as distal mean aortic pressure (MAP_d) - cerebrospinal fluid pressure (CSFP). SCPP may be critically compromised (possibly risking paraplegia) when sodium nitroprusside (SNP) is used to control proximal aortic hypertension. Phlebotomy can decrease the elevation in CSFP that occurs with thoracic AXC[1] possibly resulting in greater SCPP when used to treat the hemodynamic consequences of thoracic AXC. In this study we compared the use of SNP/isoflurane *versus* phlebotomy for control of the increased proximal aortic blood pressure (MAP_p) on spinal cord hemodynamics and blood flow and the incidence of paraplegia assessed at 24 hours following thoracic AXC.

Methods: Twenty-nine dogs (21 ± 3 kg; mean ± sd) were studied. All animals received 25 mg/kg sodium thiopental IV for induction of anaesthesia. After intubation the animals were ventilated with O_2 and 1.4% end-tidal isoflurane. End-tidal CO_2, temperature, MAP_p, MAP_d, central venous pressure (CVP) and CSFP were continuously monitored. Through a left thoracotomy, a left atrial cannula was placed for radioactive microsphere injection. In each dog the thoracic aorta was occluded 2.5 cm distal to the left subclavian artery for 50 minutes. Three groups of animals were studied in a random fashion: (1) **control** (n = 8; no attempt to decrease MAP_p after AXC) (2) **phlebotomy** (P, n = 10; MAP_p controlled by phlebotomy following AXC) (3) **SNP/isoflurane** (SNP/iso, n = 11; MAP_p controlled by SNP infusion and isoflurane following AXC). SNP was infused to a maximum of 16 μg/kg/min as doses greater than this are associated with cyanide release in the dog[2]. If MAP_p remained elevated, supplemental isoflurane was administered. Radioactive microspheres were injected five times: (1) baseline, (2) AXC on after 2 minutes, (3) following intervention to control MAP_p to baseline value; or in the control dogs at 30 minutes after AXC, (4) AXC off for 5 minutes (5) 30 minutes after volume resuscitation. With each microsphere injection, blood was drawn from the brachial artery (reference organ). After the microsphere injections, the wounds were sutured and infiltrated with 0.5% bupivacaine. The dogs were given buprenorphine (0.015 mg/kg) IM for post-op analgesia and returned to animal holding. At 24 hours a blinded observer, assessed the dog as to severity of paraplegia. The dogs were sacrificed; the brain and spinal cord were removed, weighed, and the tissue radioactivity measured by gamma counter. Blood flow in ml/g/min was determined using standard formulae. Within and between group differences of hemodynamics and regional blood flows were tested by repeated measures ANOVA. When significant, the least squares means test was applied with Bonferroni's correction. A P-value of <0.05 was considered statistically significant. Incidence of paraplegia between groups was assessed by multiple Fisher's exact tests. Table data are mean values ± sd.

Results: No difference in temperature was seen at any time period between groups. In the P group 36 ± 3 ml/kg of blood was withdrawn. In the SNP/iso group all animals received the maximal allowable SNP infusion rate of 16 μg/kg/min and the isoflurane concentration was increased to 2.8 ± 0.7% end-tidal to restore MAP_p to baseline. In the SNP/iso group the SCPP became negative with return of the MAP_p to baseline values because of a significant increase in CSFP. The CVP was significantly lower in the P group at intervention. No difference in lumbar spinal cord blood flow (LSCBF) was seen between groups at AXC on or after intervention. Blood flow increased dramatically at resuscitation. Severity of paraplegia was assessed at 24 hours in 25 dogs. Paralysed were: 7/8 control, 6/9 P and 8/8 SNP/iso (P = 0.12, P *versus* SNP/iso).

Discussion: SCPP at intervention was significantly higher in P *versus* SNP/iso. The higher SCPP was primarily due to lower CSFP with P. Thus, the increase in CSFP seen with thoracic AXC was improved by P and worsened by SNP/iso. P was significantly better than control for treatment of the changes in systemic hemodynamics seen with thoracic AXC. A trend to a lower incidence of paraplegia was seen in the group treated by P *versus* SNP/iso. Failure to demonstrate a significant difference in paraplegia between the two groups may be a consequence of a 50 minute cross-clamp duration in this study (the control group had an 87.5% incidence of paraplegia). Phlebotomy may be superior to SNP/isoflurane to control proximal aortic hypertension following thoracic AXC.

References:
1) Anesthesiology 73:A630, 1990
2) Anesthesiology 46:196-201, 1977

		Baseline	AX Clamp on	Intervention	AX Clamp off	Resuscitation
$MAP_{proximal}$	Control	101 ± 25	146 ± 18*	151 ± 17*†	93 ± 25	86 ± 23
	Phleb	91 ± 18	142 ± 21*	92 ± 20	74 ± 12*†	77 ± 12
	SNP	89 ± 16	139 ± 16*	89 ± 16	64 ± 22*†	81 ± 18
MAP_{distal}	Control	100 ± 26	17 ± 4*	19 ± 4*	93 ± 26	86 ± 23
	Phleb	87 ± 17	15 ± 6*	11 ± 5*	70 ± 13*†	73 ± 11
	SNP	88 ± 17	14 ± 3*	5 ± 3*	65 ± 18*†	79 ± 20
CVP	Control	4.4 ± 4.2	7.5 ± 4.7*	7.9 ± 5.6*	5.1 ± 4.3	7.1 ± 6.7
	Phleb	4.4 ± 2.4	8.1 ± 3.0*	1.4 ± 2.0*†	3.4 ± 2.1	4.9 ± 3.3
	SNP	5.1 ± 5.0	8.1 ± 5.0*	7.4 ± 4.3*	5.8 ± 4.9	5.7 ± 3.1
CSFP	Control	7.9 ± 8.0	11.0 ± 6.6	11.2 ± 5.1	13.4 ± 7.0*	10.8 ± 6.0
	Phleb	7.3 ± 3.8	10.2 ± 4.5	6.5 ± 5.3†	13.9 ± 5.3*	6.8 ± 3.0
	SNP	7.3 ± 5.8	10.3 ± 4.8	17.0 ± 4.7*†	11.3 ± 4.5	5.8 ± 3.9
SCPP	Control	92 ± 27	6 ± 6*	7 ± 3*	79 ± 30	75 ± 24
	Phleb	80 ± 17	5 ± 6*	5 ± 6*	56 ± 15†	66 ± 12
	SNP	80 ± 19	3 ± 6*	-12 ± 5*†	53 ± 20†	73 ± 21
LSCBF	Control	0.25 ± 0.13	0.05 ± 0.06*	0.04 ± 0.03*	0.96 ± 0.38*	1.03 ± 0.19*
	Phleb	0.39 ± 0.13	0.07 ± 0.08*	0.03 ± 0.03*	0.84 ± 0.46*	0.93 ± 0.33*
	SNP	0.32 ± 0.12	0.03 ± 0.06*	0.04 ± 0.03*	0.61 ± 0.33	1.03 ± 0.27*

*P ≤ 0.05 *versus* Baseline † P ≤ 0.05 between groups

THE PERICARDIUM AND LEFT VENTRICULAR DIASTOLIC PRESSURE-VOLUME RELATION AND FILLING: AN INTRAOPERATIVE STUDY

T.K.K. Tang, M.D., J.A. Robblee, M.D., FRCPC, H.J. Nathan, M.D., FRCPC, J.E. Wynands, M.D., FRCPC, C.J. Eagle, M.D., FRCPC, I. Belenkie, M.D., FRCPC, K.L. Chan, M.D., FRCPC, J.V. Tyberg, M.D., Ph.D.
University of Ottawa Heart Institute, Department of Anaesthesia, and University of Calgary, Department of Anaesthesia

Introduction: Assessment of left ventricular (LV) function necessitates evaluation of preload which is most commonly estimated by pulmonary capillary wedge pressure (PCWP), presuming a close relation between PCWP and LV end diastolic volume (LVEDV). However, recent literature suggests that PCWP may overestimate LV transmural pressure and therefore LVEDV because of pericardial constraint.[1] An intraoperative study using routine hemodynamic and transesophageal echocardiograpic (TEE) measurements was performed to examine LV end diastolic pressure-volume relation and transmitral doppler derived indices of diastolic function. The object was to demonstrate clinical relevance of pericardial constraint.

Methods: After institutional Ethics Committee approval, twelve patients undergoing elective CABG surgery were studied. Patients with significant mitral or aortic valvular disease, abnormal rhythm, recent MI, poor LV function or contraindication to TEE were excluded. Patients were anesthetized with sufentanil and isoflurane in 0_2 and air. Hemodynamic and TEE data were recorded after sternotomy with pericardium closed, then again after pericardiotomy, both with chest wall retracted. Up to 10 ml/kg of Lactated Ringer's solution was infused over 3-5 minutes. Recordings were made during pre, mid and post infusion stages. Variables recorded include HR, BP, CVP, PCWP, CO, LV short axis x-sectional area (SaxA) at midpapillary muscle level and transmitral flow at the annulus measured by pulsed doppler. PCWP vs SaxA data for each subject was fitted to a straight line using least squares regression. The slopes of the regression lines and hemodynamic data before and after pericardiotomy were compared with paired t-tests.

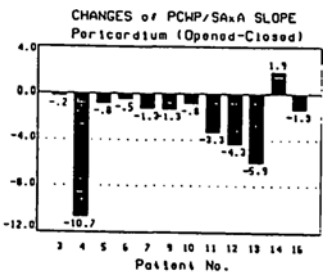
Results: CVP, PCWP, peak velocity during early filling [Vmax(E)] and SaxA increased significantly with RL infusion before and after pericardiotomy (table). A significant increase of CO (4.3 l/min to 5.1 l/min; $P<0.05$) was observed with the pericardium opened at completion of RL infusion. With the pericardium opened, prolongation of fractional early diastolic deceleration period (E wave deceleration time/total beat duration) was significant after RL infusion ($P<0.01$). No significant difference in SaxA was detected preinfusion when the pericardium was opened. However, SaxA was significantly enlarged with the pericardium opened during and after volume loading. There was a significant decrease ($P<0.05$) in the slope of the PCWP-SaxA relation after pericardiotomy (figure).

Discussion: The data indicates that although fluid loading resulted in similar rises of PCWP before and after pericardiotomy, SaxA enlargement was significantly greater after pericardial opening. This suggests that a greater increase in LVEDV occurred with an open pericardium despite similar changes in intracavitary pressure. That preload was increased is supported by a significantly higher cardiac output following volume expansion with the pericardium opened. Increases in Vmax(E) could be caused by enhanced early diastolic relaxation or increased transmitral peak pressure gradient. However, lengthening of the fractional early diastolic deceleration period in addition to increased Vmax(E) would be best explained by removal of external constraint.[2] The significant decrease in PCWP-SaxA slope with pericardiotomy, consistent with a rightward and downward shift of the LV diastolic compliance curve is also consistent with reduction of an external constraining force. These data support the pericardial constraint hypothesis. Furthermore, they show that the pericardium has a measurable constraining effect when PCWP is in the 10-15 mmHg range and that SaxA may be a more reliable method for clinical determination of preload. As fluid is infused and PCWP rises above 10-15 mmHg, the effect of pericardial constraint dictates that increases in LVEDV will be less for a given rise in intracavitary pressure as measured by PCWP. This phenomenon should be taken into account when PCWP is used to estimate preload during hemodynamic monitoring.

References: 1. Clin Physiol 5, 1986:403-15
2. JACC 16(5), 1990:1175-85

	Pericardium Closed			Pericardium Opened		
Infusion Stages	Pre	Mid	Post	Pre	Mid	Post
CVP(mmHg)	7.5 ± 0.9	10.0 ± 0.9*	10.5 ± 1.0*	9.5 ± 1.6	9.0 ± 0.9*	10.1 ± 1.0*
PCWP(mmHg)	9.7 ± 0.9	13.2 ± 0.5*	14.3 ± 0.8*	11.4 ± 1.0	13.9 ± 1.1*	15.1 ± 1.0*
SaxA(cm^2)	12.8 ± 0.8	14.1 ± 1.0*	14.5 ± 1.0*	14.8 ± 1.2	17.0 ± 1.4*#	17.7 ± 1.3*#
Vmax(E) (m/s)	0.38 ± .08		0.47 ± .07*	0.45 ± .08		0.51 ± .11*
Deceleration Time Beat Duration	.125 ± .03		.119 ± .02	.143 ± .04		.145 ± .02#

Values are mean ± SE
* Significant ($P<0.05$) change compared to pre-infusion values.
# Significant ($P<0.05$) change compared to pericardium closed at same stage.



SUPERIOR LARYNGEAL NERVE BLOCK AND THE AIRWAY PROTECTIVE RELFEXES

M. Stockwell, M.D., T. Zintel, S. Lang, F.R.C.P.(C)., C. Gallagher, FRCPC.
Departments of Anaesthesia and Medicine, Royal University Hospital, University of Saskatchewan, Saskatoon, Saskatchewan.

INTRODUCTION: Physicians are occasionally forced to anaesthetise a patient with a full stomach, and an airway difficult to intubate. Airway topicalization and awake intubation is one way of managing these patients, yet local anaesthesia might impair the protection against aspiration. This study examines the hypothesis that anaesthesia of the superior laryngeal nerve has no influence on airway protective reflexes. We used citric acid induced cough as a model of micro-aspiration of gastric acid[2].

METHODS: After Ethics Committee approval and signed informed consent, seven volunteers (three female, four male), had citric acid cough threshold determined on two separate days, once with and once without superior laryngeal nerve anaesthesia. Volunteers were between the ages of 20 and 50, ASA class I or II, non-smokers and free from acute or chronic pulmonary disease, upper respiratory tract infection in the four weeks prior to testing, symptomatic gastro-esophageal reflux, and acute or chronic sinusitis. Prior to testing, subjects were trained to perform a vital capacity maneuver at a constant inspiratory flow with feedback from a storage oscilliscope.

Cough threshold was measured after random allocation to receive transcutaneous injection of the superior laryngeal nerves with three milliliters per side of either sterile saline or preservative free 2% lidocaine. The block was performed by a blinded anaesthetist depositing the solution just external to the thyro-hyoid membrane, as identified by resistance to a B-bevel 22 gauge needle.

Cough threshold was determined by inhaling nebulised citric acid at increasing concentrations of 0% (sterile water), 2%, 5%, 10%, 20%, 35%, 50%, and 65%, until cough interrupted the inhalation maneouver. After cough was recorded, inhalation maneouvers were continued at the concentration below which cough occurred, to a total of seven inhalations.

Statistical analysis was by a paired t test comparing group mean concentration of citric acid after lidocaine vs saline.

RESULTS: All subjects completed the protocol as described. Four of the seven subjects showed no difference in cough threshold after injection with saline or lidocaine (see table). Two of the remaining three coughed at one lower concentration of citrate after receiving lidocaine while the third coughed at one higher concentration after lidocaine. No statistical difference in mean citric acid concentration necessary to induce cough was demonstrated as a result of superior laryngeal block with lidocaine when compared to a control procedure.

DISCUSSION: The choice of anaesthetic technique for airway topicalization when maintenance of protective reflexes is desired has received little attention in the literature. Guiffrida (1960) and Walts (1965) both recommend against laryngeal anesthesia in this situation[1,5]. Thomas (1969) recommends only against transtracheal anesthesia. The role of the superior laryngeal nerve in the maintenance of airway protection has not been previously studied in humans[4].

The use of inhaled nebulised citric acid as a quantifiable stimulus to cough has been shown to be both consistent, reliable, and reproducible[2,3]. Citric acid acts on the surface liquid layer of the airway mucosa where it displaces chloride from cell surface receptors, a mechanism similar to that by which decreasing pH stimulates cough.

Every attempt was made to maintain blinding in this study. However, when asked on a post test questionnaire, six out of seven subjects correctly identified the day on which they had received lidocaine, usually by the presence of difficulty swallowing. Successful laryngeal anaesthesia was confirmed in 2 subjects by probing the larynx with a fiberoptic bronchoscope. After lidocaine injection, laryngeal probing produced no response while after saline injection, probing produced a brisk response.

CONCLUSION: Using a controlled protocol, we have shown no significant change in the airway protective reflexes with anesthesia of the superior laryngeal nerve, as measured by cough threshold to citric acid. We therefore accept the hypothesis of the experiment, and report that there is no effect of superior laryngeal nerve block on protective airway reflexes. This suggests that laryngeal receptors do not play a significant role in cough stimulated by citric acid and that such a procedure is a safe method of topicalization of the airway in the patient with a full stomach.

TABLE:

Subject	A	B	C	D	E	F	G
Day Rec'd lidocaine	1	1	2	2	2	2	1
Cough threshold* after lidocaine	10%	5%	20%	10%	20%	50%	10%
Cough threshold* after saline	10%	10%	20%	20%	20%	35%	10%

* recorded as % citrate at which cough interrupted inhalation
mean (± SEM) concentration after lidocaine: 18% ± 7
mean (± SEM) concentration after saline: 18% ± 7

REFERENCES:

1. Guiffrida et al. Anesthesia and Analgesia 1960; 39: 201-210.
2. Higenbottam. Bull. Eur. Physiopathol. Respir. 1984; 20: 553-562.
3. Rees PJ, Clark JH. Br. J. Dis. Chest 1983; 77: 94-97.
4. Thomas JL. Anaesthesia 1969; 24: 28-35.
5. Walts LF. JAMA 1965; 192: 121-122.

NEW INSIGHTS INTO THE IMPORTANCE OF ARTERIAL OXYGEN DESATURATION IN PATIENTS PRIOR TO CABG SURGERY.

B Kavanagh MB, D Cheng MD, A Sandler MB ChB, S Lawson RN, F Chung MD, D Ong MD.
Department of Anaesthesia, University of Toronto, The Toronto Hospital (General and Western Divisions), Toronto, Ontario.

INTRODUCTION: Preoperative myocardial ischemia has been reported to occur in up to 30% of patients prior to coronary artery bypass graft (CABG) surgery, and has been associated with adverse outcome[1]. Premedication with benzodiazepines and narcotics is aimed at reducing myocardial O_2 demand. These medications are potent respiratory depressants. However, no study has yet continuously monitored and correlated both O_2 saturation and ECG changes in this population. This prospective study was designed to document the impact of premedication on the incidence, magnitude and duration of arterial O_2 desaturation and it's time relationship to myocardial ischemia before CABG surgery.

METHODS: Following institutional ethics committee approval, written consent was obtained from 45 patients scheduled for CABG surgery. Exclusion criteria included prior use of sedatives, narcotics, O_2 or digoxin, significant valvular disease, or conduction disorders. Patients were monitored continuously with modified V4 and V5 electrodes (Q-MED MONITOR-1) and a digital pulse oximeter ('In-Vitro': Biomedics Ltd). Both monitors produce real-time hard-copy records of all events. Monitors were applied for 2 hours prior to premedication and remained in place under supervision for 4 hrs. Lorazepam was given sublingually, and Morphine and Perphenazine were given intramuscularly. The study was divided into 3 intervals (table 1). O_2 desaturation was defined as saturation <90% for >15 seconds. Myocardial ischemia was defined as ST segment depression >1mm (horizontal or downsloping from the J-point), and lasting >60 msec. Postoperative myocardial infarction was defined by CPK-MB > 35 U/L or new Q-waves.

RESULTS: Prior to premedication (Interval A), 27% of patients desaturated. With the exception of older age, none of the following were associated with desaturation during this interval: sex, LV function, ASA class, presence of COPD, severity of coronary disease or preoperative cardiac medications. The incidence of desaturation was 29% following Lorazepam (Interval B) (ns); however following Morphine (Interval C), the incidence increased to 51% ($p<0.05$). Duration of desaturation in intervals-A,B and C was 48 ± 27(mean$\pm$SEM), 47 ± 27 and 236 ± 95 sec respectively ($p<0.05$) (Fig 1). The mean minimum level of O_2 saturation was similar in all intervals A(86 ± 0.6%), B(87 ± 0.6%) and C(86 ± 0.6%). The only predictor of desaturation following premedication was the occurrence of desaturation before premedication ($p<0.02$).

Myocardial ischemia occurred in 4%, 2% and 11% in intervals A,B and C respectively (ns), and was not associated with episodes of O_2 desaturation. However, the mean maximal heart rate increased from 62 ± 2.3 before desaturation to 70 ± 2.3 following desaturation ($p<0.001$).

The incidence of postoperative myocardial infarction was 7%, and was not significantly associated with preoperative desaturation.

DISCUSSION: In preoperative CABG patients, there was a 2-fold increase in incidence and 5-fold increase in duration of O_2 desaturation following narcotic premedication. Such desaturation was predicted by the occurrence of desaturation prior to premedication.

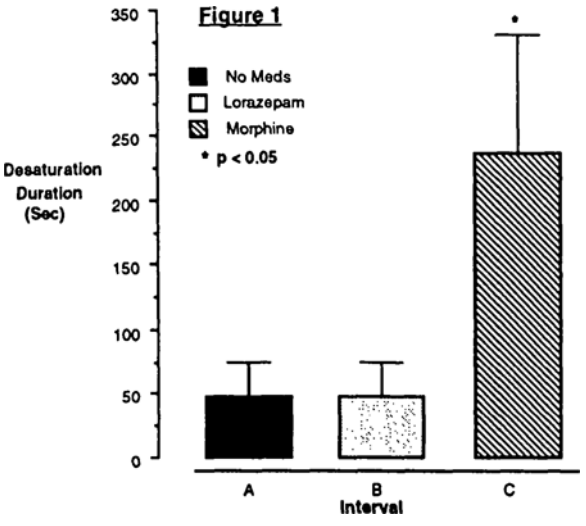
Desaturation was not associated with myocardial ischemia, and a possible explanation is the compensatory increase in heart rate following desaturation, thus maintaining myocardial O_2 supply.

Preoperative O_2 desaturation is not associated with an increased incidence of postoperative myocardial infarction.

REFERENCE:1. Anesthesiology 62:107-114,1985.

Table 1.

INTERVAL	A	B	C
DURATION	2hr	1hr	1hr
DRUG (mg/kg)	nil	Lorazepam (0.03)	Morphine (0.15) Perphenazine (0.05)



DOES GASTRIC ASPIRATION REDUCE POSTOPERATIVE NAUSEA AND VOMITING IN OUTPATIENTS?

L. Isabel M.D., C.A. Trépanier M.D., FRCP
Département d'anesthésie, Hôpital de l'Enfant-Jésus, Université Laval, Québec

Nausea and vomiting are frequent complications of general anaesthesia. Their incidence still remains around 35% in spite of the improvement of anaesthetic agents and techniques. Both are particularly ennoying in outpatient surgery where they represent one of the most frequent cause of unexpected hospital admissions[1]. In an attempt to prevent postoperative nausea and vomiting (N&V), insertion of a gastric tube with emptying of the stomach has been recommended[2]. However, this recommendation is based on older studies that did not specifically investigate this variable in a controlled manner. The goal of this study was to investigate the influence of aspiration of the stomach content with a gastric tube on the incidence of N&V in outpatients undergoing general anaesthesia.

METHODS:

After institutional approval and informed consent, 264 ASA physical status I, II and III patients were prospectively studied. They were schedulled to undergo a day surgery procedure under general anaesthesia. Patients with upper digestive tract pathologies or taking antiemetic drugs were excluded. Patients fasted overnight and did not receive any premedication. Anaesthesia was induced with fentanyl 2 ugkg-1 and thiopentone 4 to 6mgkg-1. Succinylcholine 1.5mgkg-1 preceded by d-tubocurarine 0,05mgkg-1 was given to facilitate tracheal intubation. Patients were ventilated by mask until complete relaxation was obtained. If the airway high pressure alarm set at 25 cm H_2O was activated, the patient was excluded from the study. Patients were divided in two groups by random allocation. In group 1, the study group, an orogastric tube (OGT) was inserted and the stomach content was aspirated. In group 2, the control group, no OGT was inserted. Anaesthesia was maintained with nitrous oxide in oxygen, isoflurane and fentanyl up to 5 $ugkg^{-1}$. At the end of surgery, in group 1 the OGT was aspirated then removed and in both groups the trachea was extubated and patients were taken to the recovery room where data on the occurrence of nausea, retching or vomiting were collected. The same data were also recorded at the day surgery unit and 24 hours postoperatively by phone, all in a double blind manner. Sample size was calculated considering a treatment effect of 50% chosen as minimal relevant difference and 0,10 as the upper limit for type II-error for an incidence of 35% of N&V. Statistical analysis was done with the X^2 test with Yates' correction and the Student's t test as appropriate. A p value <.05 was considered significant.

RESULTS:

The two groups were comparable with respect to age, weight, height, ASA physical status, sex, history of motion sickness or postoperative nausea, type and length of surgery. There was no difference in the overall incidence of nausea or retching and vomiting between the two groups (table). However, when the two groups were compared for each period of data collection, the incidence of nausea and retching plus vomiting was higher in group 1 (with OGT) when patients were called up 24 hours after surgery.

DISCUSSION:

This study shows that insertion of an OGT with aspiration of the stomach content not only does not reduce the incidence of N&V but actually increases it after patients leave the day surgery unit. It is particularly worrisome in the outpatient setting where patients are expected to quickly recover autonomy. Our overall results are comparable with those of Hovorka et al. who did not find any effect of gastric aspiration on postoperative N&V[3]. However, dividing the first postoperative 24 hours in six hours periods, they did not find any difference at any time. This discrepancy with our results can be explained by two factors. First, they studied inpatients having an abdominal hysterectomy and this population differs from our outpatients for many known causes of N&V (sex, analgesics, premedication, type of surgery, etc). Second, all their patients had an OGT, the stomach content being aspirated in only half of them. It is possible that the irritation to the pharynx, oesophagus or stomach caused by the OGT insertion may be by itself a cause of postoperative N&V. It has been reported that traumatic abrasions of the gastric mucosa increase gastric secretion[4], although the relationship of this phenomenom with N&V is speculative. We conclude that in outpatients, the aspiration of the gastric content with an OGT during general anaesthesia does not reduce the incidence of postoperative N&V but increases it after patients are discharged from the day surgery unit.

TABLE:

	% NAUSEA			% R & V		
	gr1	gr2		gr1	gr2	
RR	18.9	13,6		8.3	9.8	
DSU	18.9	25.8		16.7	12.9	
24H	26.5	12.1	*	16.7	6.8	**
TOT	41.7	36.4		28.8	22.0	

*p<.005
**p<.02
RR:recovery room
DSU:day surgery unit
24H:24 hours later

REFERENCES:
1 Anest Analg 1982;61: 961-6.
2 Semin in Anesth 1987;6: 300-308.
3 Anesth Intens Care 1990;18: 58-61.
4 Guyton: Medical Physiology 1986;7th ed, pp 770.

EVALUATION OF AN INFUSION SYSTEM CAPABLE OF NORMOTHERMIC RAPID VOLUME REPLACEMENT IN HEMORRHAGIC SHOCK

David C. Campbell, M.D., Thomas E. Randall, M.D., Gershon H. Growe, M.D., Irene Scarth, ART.

Department of Anaesthesia and Department of Haematology, Faculty of Medicine, University of British Columbia and Vancouver General Hospital, Vancouver, B.C.

INTRODUCTION: Immediate, aggressive volume resuscitation is critical in the successful treatment of severe hemorrhagic shock due to trauma or intraoperative bleeding.[1] Emphasis is placed upon normothermic volume replacement in an attempt to avoid the adverse consequences of hypothermia.[2,3] The provision of normothermic fluid replacement has been impaired by the inability of conventional blood warmers to function at the required high flow rates (>100 mL/min).[4,5,6] The Level I™ H-500 Fluid Warmer (Level I Technologies) uses a single-channel countercurrent heat exchanger to achieve adequate fluid warming at high flow rates by incorporating large bore tubing and an Alton Dean™ pressure infuser (Alton Dean Manufacturing Co.).

The purpose of this study was to evaluate the efficiency of this infusion system, particularly with respect to the effects of rapidly warming and infusing refrigerated (4-6°C) packed red blood cells (PC's). The infusion of 5 to 10 consecutive units of PC's through the system can cause blockage of the 170 micron pore filter of each tubing set. In an attempt to prevent this problem 300 micron pore PF1 pre-filters (Level I Technologies) were developed. In this study, the efficiency of the PF1 pre-filters was also evaluated.

METHODS: To ensure clinical relevance, in-dated, fully-tested, undiluted units of PC's were utilized. The Level I™ with the D-300 tubing set and the Alton Dean™ pressure infuser box were assembled as per the operator manual instructions. The infuser box was then placed 100 cm above the floor and set at a pressure of 300 mmHg.

Part I: Forty units of ABO compatible PC's were divided into 4 groups. Each group (10 units) was then assigned to one of the 4 cannula sizes (18, 16, 14, 8) to be evaluated. Each unit was then weighed and samples were collected for hematocrit and plasma free hemoglobin (P.F.H.) analysis. Each D-300 tubing set was purged with 500 cc of normal saline before and after each unit was infused. Only 5 units were infused through each D-300 tubing set. Infusion time, volume infused and maximum temperature were recorded. Following the infusion of each unit, post-infusion samples were collected for hematocrit and P.F.H. analysis.

Part II: 80 units of ABO compatible PC's were divided into 4 groups of 20 units. In Part II, only 1 large bore tubing set was used for each group and only the 14 gauge cannula was evaluated. 2 of the groups were infused using the PF1 pre-filters and the other 2 groups were infused without the pre-filters. 20 PF1 pre-filters were required for each group as only 1 pre-filter was used with 1 unit of PC's. 20 consecutive units were then infused through the system. Data and samples were collected as per Part I.

Two-factor Anova statistical analysis was used to assess the efficiency of the infusion system. Data was expressed as mean ± SD. $P < 0.05$ was considered significant.

RESULTS:

Part I: The 4 groups did not differ significantly with respect to weight, hematocrit or P.F.H. levels (Table I). The infusion system did not produce a significant decrease in mean hematocrit nor a significant increase in mean P.F.H. levels. The mean flow rates ranged from 584.6 cc/min (8.0 COOK) to 135.0 cc/min (18 CANNULA). Each cannula size produced a significant difference in flow rate. Infusion times were calculated using the flow rate and a constant volume (250 cc) for a unit of PC's. The mean temperatures recorded ranged from 32.7 to 35.1°C. Results are summarized in Table II.

Part II: The infusion times of the two groups in which the pre-filters were not used were significantly increased following infusion of the fifteenth consecutive unit (Figure I). Infusion times continued to increase until the system was completely blocked prior to infusion of the twentieth consecutive unit. Infusion times of the groups utilizing the PF1 pre-filters were not significantly increased following infusion of the twentieth consecutive unit. The PF1 pre-filters did not significantly decrease hematocrit nor increase P.F.H. levels.

DISCUSSION: The ability to transfuse a unit of relatively normothermic PC's in less than one minute is a critical factor in the successful treatment of severe hemorrhagic shock. This study indicates that this system is capable of delivering undiluted PC's rapidly at relatively normothermic temperatures. In this study, a unit of PC's was infused through an 8.0 Cook cannula in <25 seconds.

Most importantly, this system was capable of rapidly warming and infusing PC's without causing significant hemolysis. Although post-infusion plasma free hemoglobin levels were increased, the levels remained well below values reported to cause transient changes in renal function (675-750 mg/dL).[7,8]

The PF1 pre-filters were developed to remove large microaggregates and, therefore, prevent premature blockage of the 170 micron pore filter of the D-300 tubing sets. In the clinical setting, changing of the tubing sets is both time consuming and increases the risk of air embolism. Without the PF1 pre-filters it was not possible to transfuse 20 consecutive units of PC's through a single D-300 tubing set. To maintain adequate flow rates the tubing sets should be changed following infusion of the fifteenth unit of PC's, if the pre-filters are not used.

In conclusion, this infusion system provides an efficient method of rapidly delivering normothermic undiluted packed cells without causing hemolysis. Further similar studies are required to evaluate the potential complications of rapid volume replacement.

REFERENCES:
1. Archives of Surgery 1987;122:1044-47.
2. Anesthesia 1961;22:559-63.
3. Surgical Rounds 1984;7:57-84.
4. Canadian Journal of Anaesthesia 1986;33:516-27.
5. Journal of Trauma 1984;24:428-31.
6. Annals of Emergency Medicine 1989;18(2):355-59.
7. Blood 1951;6:1152-8.
8. Anesthesiology 1973;39:650-1.

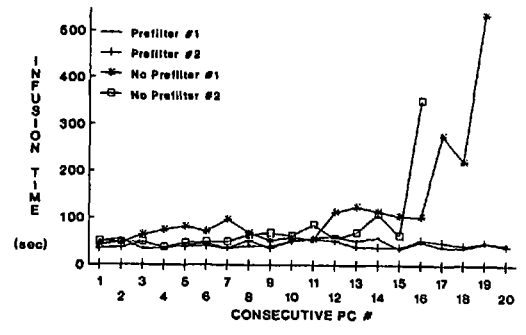
Table I. Preliminary Data

Cannula Size	Number of PC's	Age (Days)	Weight (Grams)	Pre Hct	Pre P.F.H. (mg/dL)
18	10	30±2.3	307.4±33.7	0.67±0.05	212±95
16	10	30±0.5	284.6±32.0	0.72±0.03	255±81
14	10	23±0.9	292.8±32.0	0.68±0.06	196±114
8	10	31±2.4	292.2±36.9	0.66±0.07	199±114

Table II. Effects of infusion through four cannula sizes

Cannula Size	Post Hct	Post P.F.H. (mg/dL)	Flow Rates (cc/min)	Infusion Time (sec)	Max Temp (°C)
18	0.65±0.05	329±132	135.0±15.2	112.4±12.8	35.1±0.4
16	0.70±0.04	291±163	190.4±18.2	79.4±7.6	34.1±0.1
14	0.68±0.06	217±131	343.3±56.4	44.7±6.9	33.0±0.2
8	0.65±0.05	321±139	584.6±30.0	25.7±1.4	32.7±0.6

Figure I. Infusion times with and without PF1 pre-filters



COMPARISON OF THORACIC AND LUMBAR EPIDURAL FENTANYL INFUSIONS FOR POST-THORACOTOMY PAIN

Sawchuk C.W.T.,M.D., Ong B., M.D.,FRCPC, Unruh H.,M.D.,FRCSC, Horan T.,M.D.,FRCSC, Greengrass R.,M.D.,FRCPC.
Departments of Anesthesia and Thoracic Surgery, Health Sciences Centre, University of Manitoba, Winnipeg, Manitoba

INTRODUCTION

Both thoracic and lumbar epidural fentanyl infusions can provide analgesia after thoracotomy, but, there is still controversy as to whether one is better than the other[1]. Therefore, we performed a prospective randomized trial to compare the two techniques in terms of pain relief, dose requirements, postoperative pulmonary function and side effects in patients who had undergone posterolateral thoracotomies.

METHODS

With institutional approval and patients' informed consent, 25 patients participated in the study. Preoperative pulmonary function and CO_2 response (CO_2r) curves were obtained as baseline values. Pain was measured by visual analogue scale (VAS, 0 = no pain, 10 = worst pain ever). Patients were prospectively randomized to receive a lumbar (L2-3,3-4)(N=12) or thoracic (T7-8)(N=13) epidural catheter. Catheter placement was tested with 3mL of 1.5% Lidocaine with 15ug epinephrine before anaesthetic induction. All patients received a standard anaesthetic induction with thiopentone(3-5mg/kg), fentanyl(5ug/kg), vecuronium (0.1 mg/kg) or succinylcholine and maintenance of anaesthesia with isoflurane, nitrous oxide, and vecuronium. No other narcotics or sedatives except epidural fentanyl solutions (10ug/mL) were given during the 72h study period. Postoperatively, patients received epidural fentanyl in titrated doses every 15min until the VAS was < 4 or until a maximum dose of 15mL bolus and 15mL/h infusion rate was reached. Epidural fentanyl infusions were maintained for 72h and managed according to established guidelines. Patients were reassessed at 4, 24, 48 and 72h postop for pain with VAS. Infusion rates were titrated according to VAS and symptoms. Spirometry (FEV_1, FVC) and CO_2 response were measured at 24,48, and 72 h postop. Data were analyzed using ANOVA and Fisher's exact test. $P<0.05$ was considered statistically significant.

RESULTS

The patients in the thoracic (THOR) and lumbar (LUMB) groups are similar (Table I). Data are presented as mean ±SEM. All patients had excellent pain relief (VAS <4) except for 1 patient in the lumbar group. Thoracic patients required significantly smaller mean total doses at 1 and 4 h postop to achieve similar levels of pain relief (Fig 1). There was no statistically significant difference between the two groups in postop FEV_1, FVC or CO_2 response. The incidence of somnolence and naloxone administration is higher in the lumbar group (TABLE II).

DISCUSSION

Thoracic and lumbar epidural fentanyl infusions provide good pain relief after thoracotomy. Thoracic epidural infusions required smaller doses and were associated with fewer major side effects. Of the patients who had lumbar epidural infusions, three required naloxone to treat somnolence and slow respiratory rates. We were unable to measure CO_2 responses when patients developed problems, and this may account for the similar CO_2 responses in the two groups. These initial results suggest that thoracic epidural infusions are superior to lumbar epidural fentanyl infusions for post-thoracotomy analgesia.

REFERENCE

1. Reg Anesthesia 1989;14(2S):26.

Figure 1

FENTANYL DOSE AND PAIN SCORES

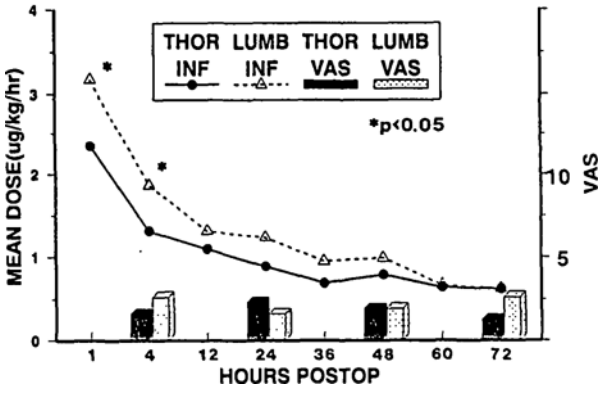


TABLE I

VARIABLES	LUMB (n=12)	THOR (n=13)
AGE (years)	60 ± 16	56 ± 19
SEX (M:F)	8:4	6:7
WEIGHT (Kg)	73 ± 20	68 ± 26
FEV_1 (l)	2.1 ± 0.8	2.1 ± 0.7
FVC (l)	3.0 ± 0.8	2.7 ± 1.0
CO_2r (l/mmhg)	1.4 ± 0.65	0.92 ± 0.34

TABLE II

VARIABLES	LUMB	THOR	P
SOMNOLENCE	5	1	P < 0.06
SOMNOLENCE & NALOXONE	3	0	P < 0.09

Effect of Neostigmine Administered After Complete Spontaneous Recovery From Intermediate-Duration Muscle Relaxants

D Mark,M.D., JB Kitts,M.D., FRCPC, MJ Curran,M.D., FRCPC, P Lindsay,R.N., T Polis,M.D.
Department of Anaesthesia, Main Division, University of Ottawa, Ottawa Civic Hospital, C-3, 1053 Carling Ave., Ottawa, Ontario, Canada, K1Y 4E9

INTRODUCTION:

With the introduction of intermediate-duration nondepolarizing muscle relaxants such as atracurium and vecuronium into clinical practice, routine administration of anticholinesterase agents at the end of a surgical procedure has become controversial. Some experts recommend that reversal of intermediate-duration muscle relaxants should be done on indication rather than as a routine because neostigmine itself may produce a neuromuscular block.[1,2] Others recommend administration of anticholinesterases at the end of every case where a nondepolarizing muscle relaxant has been used because monitors used clinically to assess depth of neuromuscular blockade may be unreliable.[3] The neuromuscular effect of an anticholinesterase agent administered after complete spontaneous recovery of neuromuscular function has occurred has not been described. Therefore this study was designed to determine the neuromuscular effect of neostigmine administered after complete spontaneous recovery from an intermediate-duration neuromuscular blockade.

METHODS

After approval from our ethics committee and informed consent, 22 adult (ASA I or II) patients undergoing elective orthopedic procedures were studied. After premedication with diazepam, 0.1-0.2 mg/kg p.o., 60-90 min. pre op, anaesthesia was induced with thiopental, 3-7 mg/kg i.v. and maintained with isoflurane, 0.7-0.9% and nitrous oxide, 60-70% end-tidal concentration. Fentanyl supplements were administered i.v. in intermittent boluses to control increases in heart rate and blood pressure. End-tidal carbon dioxide concentration and nasopharyngeal temperature were maintained between 30-35 mm Hg and 35-37°C, respectively.

Supramaximal train-of-four stimuli, at a frequency of 2 Hz were delivered to the ulnar nerve every 20 sec, via needle electodes placed subcutaneously at the wrist. The evoked twitch response of the adductor pollicis muscle was measured using a Grass FT-10 force transducer and recorded on a polygraph. After induction of anaesthesia and prior to administration of a muscle relaxant, control values for the first twitch (T_1) and train-of-four (TOF) ratio were established. Twelve patients received atracurium 0.2 mg/kg i.v. and 10 patients received vecuronium 0.03 mg/kg i.v. to facilitate endotracheal intubation. When the surgery ended and full spontaneous recovery from the muscle relaxant had occurred neostigmine 0.035 mg/kg and atropine 0.015 mg/kg were administered. The T_1 and TOF values were recorded for at least 10 min after administration of neostigmine and compared to values obtained just prior to administration of neostigmine. In seven patients a tetanic burst (50 Hz for 5 seconds) was administered.

RESULTS

All patients had fully recovered (TOF > 90%) prior to administration of neostigmine. Time from full recovery of neuromuscular function to administration of neostigmine ranged from 6-99 min (44.3 +/- 8.1 min, mean +/- SEM) in the vecuronium group and 12-66 min (34.25 +/- 6.5 min) in the atracurium group. No patients developed neuromuscular blockade after neostigmine administration. However, six patients in the atracurium group developed an increase in T_1 immediately after neostigmine administration without any change in T_4. This resulted in an apparent decrease in the TOF ratio (range of 73-90%). There was no fade demonstrated with tetanic burst in these patients. No patient exhibited any clinical evidence of residual neuromuscular blockade on arrival in recovery room.

CONCLUSION

These results suggest that administration of neostigmine to patients who have recovered spontaneously from neuromuscular blockade induced by either vecuronium or atracurium does not in itself result in deterioration of neuromuscular function.

REFERENCES

1. Payne JP, Hughes R, Al Azawi S: Neuromuscular Blockade by Neostigmine in Anaesthetized Man. Br J Anaesth 52:69-76, 1980
2. Astley BA, Katz RL, Payne JP: Electrical and Mechanical Responses after Neuromuscular Blockade with Vecuronium, and subsequent Antagonism with Neostigmine or Edrophonium. Br J Anaesth 59:983-988, 1987
3. Viby-Mogensen J, Jensen NH, Engbaek J et al: Tactile and Visual Evaluation of the Response to Train of Four Stimulation. Anesthesiology 1985; 63:440-443

SPINAL ANAESTHESIA WITH THE 27 GAUGE NEEDLE

Sylvain Coté, M.D., Maria Socci BSc, Saul Wiesel, M.D.

Departments of Anaesthesia, Jewish General Hospital and McGill University, Montreal, Quebec, Canada H3T 1E2

INTRODUCTION: Spinal anaesthesia appears to be enjoying renewed interest despite the well known complication of postdural puncture headache (PDPH). Using the 25 gauge needle in young male outpatients, both the PDPH rate (37.2%) and the dissatisfaction rate (31.4%) were high[1]. Although the incidence of PDPH with a 29 gauge needle was zero, it is difficult to use and has a significant failure rate[2].

We examined the BD 27 gauge Quincke type point needle in order to answer the following questions: 1) What is the incidence and severity of PDPH and does it vary with age or gender? 2) Is it a difficult needle to use? 3) Does a PDPH diminish the patient's satisfaction with the anaesthetic?

METHOD: Institutional approval was obtained. The study prospectively involved 262 consecutive patients undergoing elective or emergency surgery. Spinal anaesthesia was administered by all attending anaesthesiologists and the residents under their supervision who decided on the bevel orientation, patient position and local anaesthetic to suit the clinical situation.

Patients were divided into three groups according to age: <40 yrs; 40-60 yrs; >60 yrs. Patients were followed up for a minimum of three and a maximum of five postoperative days. A headache was defined as post-spinal if it fulfilled criteria described by Driessen[3]. Severity of symptoms of PDPH were rated by the patients as mild, moderate or severe. The Chi square test was used with $p < 0.05$ considered significant.

RESULTS: Of the 262 patients included in the study, the 27 gauge needle was abandoned in 19 patients (7.2%). Of the remaining 243 patients where the 27 gauge needle was successful, 20 patients could not be reached for follow-up, leaving 223 patients for a 92.4% follow-up rate. Of these 142 were males (63.7%) and 81 were females (36.3%). Twenty-three patients developed a PDPH for an overall incidence of 10.3%. The breakdown by age group is shown in the Figure. A statistically significant decrease in the incidence of PDPH with increasing age is seen ($p < 0.05$). The incidence of PDPH in males was 7.0% and in females 16.0% ($p < 0.05$).

Patient satisfaction with the anaesthetic decreased from 91% to 78.2% (not significant) with the occurrence of a PDPH (n=23). Patient's desire to have another spinal anaesthetic for a similar procedure decreased from 90% to 73.9% if the spinal anaesthesia was complicated with a PDPH ($p < 0.05$).

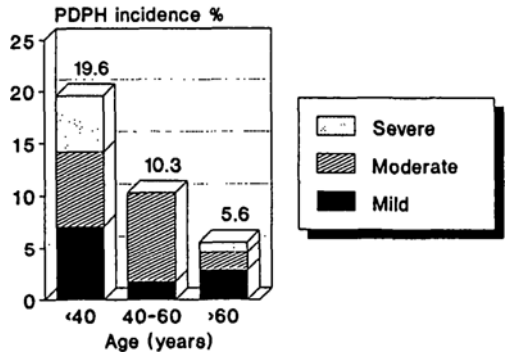
DISCUSSION: The overall incidence of PDPH with the 27 gauge needle was found to be 10.3% in the present study. A comparable study[4] of outpatients found an incidence of only 2.1%. We found that the incidence of PDPH was particularly high (19.6%) in patients under 40 years of age. The majority of PDPHs in all age groups were described by the patients as of mild or moderate intensity.

The incidence of PDPH was significantly higher in females in the present study. This is supported by other studies in young adults[5]. Despite the incidence of PDPH, 78.2% of patients were satisfied with the conduct of their anaesthetic and 73.9% would choose the same technique for a similar procedure.

This study suggests that spinal anaesthesia using the 27 gauge BD spinal needle is an acceptable alternative to general anaesthesia despite the occurrence of PDPHs. Care must be taken to explain the increased risk of PDPH to all patients less than 40 years of age, particularly females.

REFERENCES:
1. Anaesthesia 40: 1108, 1985
2. Anaesthesia 44: 147, 1989
3. Regional Anesthesia 3:38, 1980
4. Anesthesiology 73: A2, 1990
5. Anaesthesia 42: 202, 1987

PDPH: Incidence and Severity



OUTPATIENT ANAESTHESIA CONSULTATION SERVICES - A NEW TREND

J.B. Conway MD., C. Seyone MD., J. Goldberg MD FRCPC., F. Chung MD FRCPC

Department of Anaesthesia, Western Division, The Toronto Hospital, University of Toronto, Toronto, Ontario.

INTRODUCTION: Traditionally, anaesthetists have had no opportunity to see their patients before admission. This has led to inconveniences and unnecessary expenses for those patients admitted early, usually the day before surgery, to allow anaesthesia consultation. In addition, there has been a recent shift towards an increased use of same day ambulatory surgery facilities. There has also been a trend towards acceptance of more medically ill patients in these centres which enhances the necessity of a thorough pre-operative evaluation. These factors have helped to contribute to a high incidence of surgical delays and cancellations which represent a significant impediment to the efficient use of hospital beds and operating room time.

METHODS: We prospectively studied our newly established Outpatient Anaesthesia Consultation Clinic to determine its pattern of case referral and efficiency. Surgeons were requested to refer medically complex patients requiring special pre-operative evaluation or preparatory measures. Each patient was then evaluated at the clinic by a staff anaesthetist who was asked to record additional data on a separate form. In addition to relevant data concerning the patient's pre-operative status the anaesthetist documented which, if any, additional investigations or consultations were necessary, and whether or not the consultation was considered appropriate. The patient returned for surgery after the necessary measures were instituted. Peri-operative delays or cancellations were documented by the anaesthetist caring for the patient during the case. Patients were also questioned regarding their satisfaction with the clinic visit.

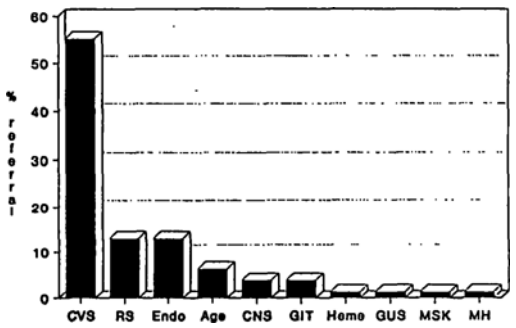
RESULTS: One hundred referrals were received during the initial three month period, of which 73% were female. The mean age was 62.2 years and 13% were graded ASA I, 71% ASA II, and 16% ASA III. Referrals were obtained mainly from orthopaedic and ophthalmological surgeons and overall, 77% of referrals were considered appropriate by the consulting anaesthetists. 43% of patients referred required additional investigations, while 10% were sent for additional consultations (Table 1).

TABLE 1

	%
Appropriate Consultations	77
Inappropriate Consultations	23
Additional tests	43
Additional Consultations	10
Total delays	8
Cancellations	1

The primary reason for referral was related to the cardiovascular system in 55% of cases, and to the respiratory and endocrine systems respectively in 13% of cases. More specifically, 23% of referrals were related to coronary artery disease, 21% to hypertension, 9% to diabetes mellitus, and 8% to asthma (Figure 1).

FIGURE 1



90% of patients indicated that their clinic visits had contributed to better hospital care.

A total of 8 cases were delayed on the operative day. One was delayed because of unexpected significant hypertension, and a second patient was deemed inadequately prepared because of new and unexpected laboratory results. In the remaining 6 cases, tests which had been ordered in the clinic had not been done. In each case, the problem was rectified and the patient underwent surgery the same day. One case was cancelled, due to a failure to have a thallium scan ordered in the clinic. The test was re-scheduled as an outpatient, and the patient returned and underwent surgery without incident.

CONCLUSION: The Outpatient Anaesthesia Consultation Clinic represents a new and effective means of evaluating higher risk surgical patients. The majority of delays and cancellations resulted from inadequacies in organizing outpatient laboratory tests and a failure on the part of the surgeons to wait for completion of tests before scheduling surgery. The high incidence of unnecessary referrals indicates that education of surgeons is needed. This system has the potential to decrease the incidence of operative delays and cancellations to as low as 2% and 1% respectively and thus also to decrease hospital costs by making more efficient use of available facilities and personnel in a manner which is well accepted and appreciated by patients.

IS RECOVERY ROOM MORBIDITY RELATED TO THE SURGICAL PROCEDURE?

D Keith Rose, MD, Marsha M Cohen, MD, Kent H Rogers, MD
Dept. of Anaesthesia, St. Michael's Hospital; Clinical Epidemiology Unit, Sunnybrook Health Sciences Centre; University of Toronto, Ontario

INTRODUCTION It is well established that the type of surgical procedure is predictive of postoperative mortality.[1,2] However, the impact of the type of surgical procedure on early postoperative morbidity has not been well researched. In order to examine this relationship, we prospectively documented adverse events (defined as events which were less than ideal) occurring in all patients admitted to the recovery room (PAR) over a 4½ month period (n=4617).

METHODS After receiving ethics approval, we studied all patients admitted to the PAR at our hospital (thus excluding those requiring elective ICU admission). A list of 30 adverse events with treatment modalities and physiological boundaries was transcribed directly on the PAR record to aid data collection. PAR nurses were trained to recognize and record events when they occurred. Procedures were coded by the ICD.9.CM system with specific reference to anaesthetic trespass where this coding system was inadequate. All data were reviewed by a clinical anaesthetist prior to computer processing. The patient's unique identifying number, date and time of surgery as well as the PAR events and procedure were entered into a customized dBase IV program and analyzed using the SAS statistical package. The Relative Risk (RR) and 95% C.I. for having an adverse event was computed for each procedure.[3] That is, the proportion of patients having an adverse event for each surgical procedure was compared to the proportion of patients having that adverse event among cases not having that surgical procedure.

RESULTS Adverse events were common in the recovery room (Fig. 1). No cardiac arrests or deaths occurred during this time period. However, when the frequency of each event was determined for different types of surgical procedures, very different patterns were identified. Fig. 2 shows the surgical procedures having the highest overall frequency of events. The procedures included upper abdominal, arthroplasty, hysterectomy/myomectomy, back surgery, vitrectomy/buckle and craniotomy. In addition, these different procedures were identified with different types of adverse events. For example, craniotomies were associated with airway problems (RR=4.1) and hypertension (RR=5.2). Following hysterectomies and myomectomies hypovolemia was common (RR=6.7).

Not surprisingly the procedures having the fewest adverse events were minor procedures including ECT, breast biopsy, arthroscopy, and minor gynecological procedures.

DISCUSSION: Knowledge of morbidity based on type of surgical procedure has several advantages; preventative strategies for optimum anaesthetic management during specific procedures can be instituted to avoid these outcomes; recovery room personnel can be informed of common adverse events following a procedure; and criteria for post-surgery management, eg. length of recovery stay, acuity of medical and nursing care, and patient postoperative discharge placement can be efficiently planned. Risk management and resource allocation based on the type of surgical procedure has strong support due to the large variation in outcome dependent on procedure demonstrated in this study.

REFERENCES

1. JAMA, 1988; 260: 2859
2. American Geriatrics Society, 1979; 28: 433
3. Statistical Methods in Epidemiology, 1989

FIGURE 1 Rate of adverse events (n=4617)

Any Event:	25.5%	
N & V:	7.5%	(wretching, antiemetic)
Desaturation:	7.3%	(SpO_2 <90)
Airway Problem:	3.2%	(hypovent., intubation, etc.)
Excessive Pain:	3.6%	(writhing, groaning)
Hypovolemia:	2.4%	(req'd. fluid bolus)
Hypotension:	2.4%	(<20% normal)
Hypertension:	1.0%	(>20% normal)
Bradycardia:	1.0%	(<50 bpm)
Tachycardia:	0.7%	(>120 bpm)

FIGURE 2 Relative risk of having an event (only values >2, and p<.05 are shown)

PROCEDURE	EVENT										
	n	% Pts with Events	N&V	A/W	PAIN	↓VOL	↓BP	↑BP	↓HR	↑HR	↓SAT
Upper Abdominal	101	51.5%	2.2		2.6	3.0					3.0
Arthroplasty	114	48.0%			3.4	4.4	4.9			4.3	3.7
Hyster/Myomectomy	187	44.9%	2.1			6.7	2.4				
Back Surgery	126	41.5%			4.4						2.1
Vitrectomy/Buckle	237	38.2%	2.6						6.6		
Craniotomy	85	35.3%		4.1			2.5	5.2			
ECT	94	2.1%									

CANADIAN FOUR-CENTRE STUDY OF ANAESTHETIC OUTCOMES: I. DESCRIPTION OF METHODS AND PATIENT POPULATION

Cohen MM, Duncan PG, Pope WDB, Tweed WA, Biehl D
From the Universities of Manitoba, Saskatchewan and Western Ontario

INTRODUCTION: The measurement of outcomes from health care is the basis upon which the quality of that care must be ultimately assessed. However there are few outcome studies in anaesthesia and these have focused on mortality reviews (1,2) or morbidity surveys from one institution (3). The purpose of this investigation was (a) to develop and validate a methodology for the study of anaesthetic outcomes and (b) to test the application of such methods in multiple clinical environments.

METHODS: The basic design of the study was "occurrence screening" that is follow-up of all patients who were attended by an anaesthetist at one of four Canadian teaching hospitals in 1988. After ethics review, a series of meetings were held to finalize the variables included as well as definitions used. For each patient, the anaesthetist completed a check-off form which included a series of patient, surgical and anaesthesia related items including a rating of preoperative medical conditions and physical status score. Following the operative procedure, the form accompanied the patient to the Recovery Room where the nursing staff noted any untoward events. Within 72 hours of the surgical procedure, a research nurse conducted a standardized interview with in-patients to assess nonlifethreatening problems and satisfaction with the anaesthetic experience. In addition, the hospital chart, hospital death logs and anaesthesia records were reviewed and any adverse events were added to the data collection instrument. To ensure reproducible data, nurses were trained at one hospital and similar forms were used for data collection in all centres. In addition, data were sent to the coordinating centre each month for data quality checks and to correct missing data. Final data collection began after a period of familiarization with the instruments and a series of multiple inservice orientations.

RESULTS: A parallel system of outcome surveillance was introduced into the four departments despite differences in hospital form requirements and physician attitudes. Overall data was collected on 37,665 anaesthetics. Table 1 shows some of the characteristics of the four hospitals which varied in several aspects. Compliance with the research protocols varied with hospital C having the highest proportion of patients interviewed and charts reviewed. Patient populations also differed across the four centres with Hospital A having the highest proportion of female patients. Hospital B had the most elderly cases and the most patients rated physical status III or more or having one or more serious preoperative medical conditions. Hospital A had the highest proportion of day surgery cases whereas hospitals B and D performed more complex surgical cases with 12% or more procedures over 4 hours in duration. Hospital C performed the most emergency procedures.

CONCLUSIONS: There were a number of problems identified in establishing a comparable outcome surveillance system in four very different settings. These included problems with institutional protocols, definition of variables and the number of items being collected. Hospitals varied considerably with regard to the types of patients seen and the procedures performed; variations in hospital protocols were reflected in the proportion of patient data we were able to capture. Thus the interpretation of outcome surveillance data must include corrections for institutional and case-mix variables.

REFERENCES

1. Br J Anaesth 1987;59:834.
2. Report of the Confidential Enquiry into perioperative Deaths. Nuffield provincial hospital trust London 1987.
3. Can Anaesth Soc J 1986;33:22

Table 1: Variations across hospitals

	Hospital			
	A	B	C	D
% Interviewed	45.6	30.7	71.9	44.3
% Charts Reviewed	95.8	82.7	99.8	98.8
% Female	63.8	56.7	49.4	49.9
% Age >70	16.3	24.6	18.8	14.2
% ASA III+	18.9	30.8	23.8	28.1
% 1+ serious condition	9.8	15.8	8.8	10.1
% Day surgery	35.8	22.1	18.6	28.2
% 2+ postop nights	54.1	55.8	73.6	68.2
% Emergency	12.5	12.1	15.6	8.2
% < 30 min.	16.2	4.8	1.5	4.3
% > 240 min.	8.2	12.3	8.0	13.1

CANADIAN FOUR CENTRE STUDY OF ANAESTHETIC OUTCOMES: II. ASSESSING THE CONTRIBUTION OF ANAESTHESIA TO PERIOPERATIVE MORBIDITY/MORTALITY.

Cohen MM, Duncan PG, Biehl D, Tweed WA, Pope WDB
From the Universities of Manitoba, Saskatchewan and Western Ontario.

INTRODUCTION: A major concern with anaesthesia morbidity/mortality studies is the determination of the relative contribution of anaesthesia as opposed to surgical, patient or other factors. One method which has been used is the Edwards Classification (1). This classification scheme has been used by the New South Wales Committee on Mortality (2) to review all perioperative deaths. In a large Canadian study of anaesthetic outcomes, we were interested in determining the extent to which anaesthesia contributed to perioperative morbidity as well as mortality. In order to do this, we first tested, then used, the Edwards classification in determining its usefulness in ascribing morbidity to anaesthesia.

METHODS: This classification assigns one of 8 categories to each reviewed case (Table 1). For purposes of analyses these categories were collapsed as follows: I-II anaesthesia, III-IV surgery, V-VI patient disease, VII-VIII cannot decide. In order to assess the usefulness and reliability of this instrument, 9 anaesthetists rated 10 fictional cases (prepared by the principal investigators) and interobserver agreement was determined using the Kappa Statistic (3). The Kappa statistic is similar to a correlation coefficient having a value of 0 to 1; an increasing value implies higher agreement across raters.

Data on 37,665 anaesthetics were collected from 4 Canadian teaching hospitals in 1988. From each hospital, a random sample of 30 cases was drawn from a list of all cases experiencing a death, cardiac arrest, postoperative myocardial infarction, stroke, neurologic deficit, malignant hyperthermia, aspiration or awareness. For each case a detailed report was prepared by a research nurse using original hospital charts and anaesthesia records. These cases were then reviewed using the Edwards classification by an audit committee consisting of three anaesthetists at each hospital.

RESULTS: There was an acceptable degree of interrater reliability for the 10 hypothetical cases. Overall there was a statistically significant agreement ($k=0.38$) but within the four categories, the kappa values were 0.42 for anaesthesia, 0.51 for surgery, 0.30 for patient disease and 0.07 (N.S.) for 'cannot decide'.

For the 120 true records selected for review, two reviews were not completed, and four events could not be confirmed when the hospital charts were examined (2 cases of awareness and 2 of neurologic deficit). This left 115 events in 114 patients in the review. Of these, 15 (13.0%) were judged to have an anaesthetic component. Of 43 deaths reviewed, none were attributed to anaesthesia and preexisting patient disease was the major factor. Eight cases (7.0%) were judged as not having sufficient information to make a decision. When the first three Edwards classifications are considered together (I-III), 21 events (18.3%) were judged to have varying degrees of anaesthetic involvement.

DISCUSSION: Anaesthetists as raters using the hypothetical exercises did not appear to have hesitancies about ascribing the adverse outcome to anaesthesia. The degree of agreement across raters was reasonably good and was considered sufficient for the review of actual cases.

Anaesthetists found the classification system relatively easy to use as they were unable to classify only 7% of cases. Due to confidentiality concerns, the three raters reviewed cases arising in their own hospitals. For the actual cases, 13% of major events were judged attributable to anaesthesia the majority being aspiration and awareness (10/15).

CONCLUSIONS: Interrater reliability among anaesthetists was fairly high using the Edwards Classification and while not without limitations, this classification was found to be useful in reviewing morbid occurrences. Using this scheme to classify events in a multicentre study, suggests that only a minority of adverse events are likely to be ascribable to the quality of the anaesthetic administered.

REFERENCES:

1. Anaesthesia 1956;11:194.
2. Br J Anaesth 1987;59:834.
3. Fleiss JL. Statistical methods for rates and proportions, Wiley 1982.

Table 1

Category	Definition
I.	Where it is reasonably certain that the event was caused by the anaesthetic agent or technique of administration, or in other ways coming directly within the anaesthetist's province.
II.	Similar cases, but in which there is some element of doubt as to whether the agent or technique was entirely responsible.
III.	Cases in which the event was caused by both the anaesthetic and surgical technique.
IV.	Events entirely referable to surgical technique.
V.	Inevitable event eg. cases of severe general peritonitis, but in which the anaesthetic/surgical techniques were apparently satisfactory.
VI.	Fortuitous event e.g. pulmonary embolism.
VII.	Cannot be assessed despite considerable data.
VIII.	An opinion could not be formed on account of inadequacy of data.

CANADIAN FOUR CENTRE STUDY OF ANAESTHETIC OUTCOMES: III. RESULTS FOR INPATIENTS.

Duncan PG, Cohen MM, Tweed WA, Pope WDB, Biehl D. From the Universities of Manitoba, Saskatchewan and Western Ontario.

INTRODUCTION: The accompanying abstract discusses the methodology and patient population from a multicentre study of 37,665 anaesthetics administered over a one year period at four university affiliated hospitals in Canada. Since the patient case-mix was influenced by the presence of large outpatient populations at some hospitals, in order to achieve a better comparison between the four hospitals, this report is confined to inpatients (n=27,184). The purpose of the study was to determine if outcomes from anaesthetic care could be measured and whether such measurements reflect the quality of care provided.

METHODS: Data on 27,184 inpatients (defined as any case with at least one postoperative night stay) was collected during the intraoperative, recovery and postoperative time periods (up to 72 hours). First, the crude rate of occurrence per 1000 anaesthetics was computed for 70 adverse events by hospital. Then, in order to control for differences in patient populations, five case-mix adjustors were used: age, gender, physical status score, emergency case, and anaesthesia time. These variables were entered into a multiple logistic regression model for each complication and the adjusted relative odds for having that complication was determined. For the comparisons hospital A was used as the reference hospital. A p value of 0.05 was used to determine statistical significant differences in the relative odds as compared to hospital A.

RESULTS: The four institutions varied with respect to the number of patients include and their age, gender, physical status and proportion of emergency cases (Table 1). Follow-up was high in all hospitals with no systematic error identified in the patients lost to follow-up.

Due to space limitations, only some of the results are presented (Table 2). The rates of occurrence of adverse outcomes varied considerably between hospitals even after case-mix adjustment; no hospital had consistently the highest or lowest rates. For example out of 13 adverse events measured in the operating room, hospital D had the highest rate for four and the lowest for seven events. Variations across hospitals in adjusted rates was twofold for OR events; for the PACU the range was 1.5 to five fold while events occurring on the ward varied up to six fold depending upon the event sought. The in-hospital adjusted mortality rate was similar for three hospitals but less than half for hospital D. With regard to major events (cardiac arrest, myocardial infarction, stroke or deaths), the rate for hospital D was higher but still less than for the other three hospitals.

CONCLUSIONS: The possible reasons for the major variations in rates of adverse outcomes in four teaching hospitals include, degree of compliance in reporting among staff, inadequate case-mix adjustment, difference in interpretation of variables, institutional differences, or physician practice patterns. While each may have contributed to the study results, it is clear that extensive variations exist across hospitals with regard to outcomes of anaesthetic care. Furthermore the conclusions derived from outcome data will be highly dependent upon the events chosen to be surveyed. If we accept that these relatively homogeneous university hospitals are offering anaesthetic care of equal quality, then the incidence of adverse outcomes may not be valid reflections of quality of care.

Table 1: Inpatient populations in the 4 hospitals

	Hospital			
	A	B	C	D
# Patients	9213	6610	6133	5229
% Charts reviewed	95.8	82.7	99.8	98.8
% Female	51.2	50.7	46.3	45.3
% Age 70+	23.6	30.4	21.7	18.9
% ASA III+	28.0	38.3	28.5	38.1
% 240+ min.	12.8	15.8	9.7	18.1

Table 2: Adjusted relative odds of adverse events
As compared to hospital A:

	A	B	C	D
O.R.				
Hypotension	1.00	1.18*	0.67*	0.56*
Hypertension	1.00	2.18*	1.41*	2.33*
Ventricular arrhythmia	1.00	1.28	1.42	0.55*
Difficult intubation	1.00	1.65*	0.98	0.90
PACU:				
Nausea/vomiting	1.00	1.68*	1.54*	2.23*
Hypotension	1.00	0.58*	0.64*	2.08*
Respiratory	1.00	1.19	0.88	1.10
Intensive care:				
Hypotension	1.00	1.16	1.23	1.75*
Pneumonia	1.00	1.84*	0.23*	0.96
CNS deficit	1.00	1.81	0.78	1.36
First 72 hours on ward:				
Nausea/vomiting	1.00	0.74*	0.99	0.46*
Headache	1.00	1.43*	1.57*	0.40*
Pneumonia	1.00	1.10	0.27*	1.04
Decreased LOC	1.00	0.32*	0.14*	0.37*
Deaths	1.00	0.97	0.93	0.42*
Major events	1.00	0.97	0.95	0.70*

--*$p<0.05$

IDIOPATHIC POSTOPERATIVE DELIRIUM IS ASSOCIATED WITH LONGTERM COGNITIVE IMPAIRMENT

R.L. Knill, M.D., T.V. Novick, B.A., M.I. Skinner, B.A.
Department of Anaesthesia, University of Western Ontario, London, Ontario, Canada

INTRODUCTION The most common complication of anaesthesia and major surgery in the elderly is idiopathic postoperative delirium (IPD).[1] Its clinical manifestations onset typically in the first to third postop nights and wax and wane over the subsequent one to three days or nights. Since IPD is a mental disturbance, we wondered if it might be associated with mental sequellae - in particular longterm cognitive impairment. The purpose of this study was to assess the cognitive outcome of elderly patients who suffer IPD after anaesthesia and surgery and to compare it to the outcome of elderly surgical patients who do not.

METHODS The subjects were selected from patients 70 years or older undergoing elective anaesthesia and abdominal or orthopaedic surgery. Exclusion criteria included less than a grade 8 education and a history of a neurologic or psychiatric disorder. No attempt was made to interfere with anaesthetic or surgical care. All patients were followed through the first postop week for the development of idiopathic delirium, as previously defined.[1] To assess cognitive outcome, we performed the Mini-Mental State examination (MMS) on three occasions: just before operation, one week after operation and during the sixth postop week. (The MMS is a reliable and widely accepted method of grading cognitive function. Eleven individual functions are scored. The maximum score is 30.) We also obtained data on (1) personal characteristics - e.g. age, gender, medical history and concurrent medication; (2) the anaesthetic/surgical procedure - e.g. type of anaesthesia, type of surgery, anaesthesia duration, intraop blood pressure change; and (3) the postoperative course - e.g. the use of sedatives and the doses of opioids (expressed as morphine equivalents). Potential differences between the patients who suffered IPD and the remainder were assessed with a Student's t-test, an analysis of variance or Chi square test, as appropriate.

RESULTS Amongst the 61 patients studied, 12 (20%) developed IPD. The clinical manifestations appeared on the first to fifth postop nights and had dissipated by the sixth postop day. The IPD patients were not detectably different from the remainder in any of the personal, procedural or postoperative factors assessed - except for having a longer duration of anaesthesia. (Table).

The preoperative MMS scores in the IPD patients were not detectably different from those of the remaining patients but the MMS scores one week after operation were significantly less (Table). In 3 of the 12 IPD patients, substantive MMS score reductions (i.e. decrements of 3 points or more, reflecting performance deficits in two or more functions) appeared at both one and six weeks after operation (Table). Such substantive score reductions occurred in only one of the 49 remaining patients (p=.009).

VARIABLE	IPD GROUP n=12	OTHERS n=49	p
PATIENT			
Age (yrs)	76.8±4.7	75.3±3.3	
Gender: F/M (n)	5/7	26/23	
PROCEDURAL			
Anaesthesia type: gen/sp (n)	8/4	31/18	
Anaesthesia duration (min)	153±68	114±43	0.019
Surgery type: gen/ortho (n)	5/7	4/45	
POSTOPERATIVE			
Total morphine, to 48 hrs postop (mg)	70.3±43.9	54.6±28.1	
Sedative use, to 48 hrs postop (n)	3 (25%)	23 (47%)	
MINI-MENTAL STATE SCORES			
Preop	27.4±2.5	27.7±1.9	
Postop, 1 week	26.0±2.8	27.8±2.2	0.013
Postop, 6 weeks	26.6±2.6	27.7±2.2	
Substantive score reductions, 1 and 6 weeks (n)	3 (25%)	1 (2%)	0.009

(n) values indicate number of subjects
Values other than (n) indicate mean ± SD

DISCUSSION The patients who suffered IPD had normal preoperative MMS scores,[2] suggesting that IPD does not relate to preoperative cognitive dysfunction. One week after operation, however, the IPD group had slightly reduced MMS scores and, within this group, there was a greater rate of substantive MMS score reductions (as defined above), which persisted. The magnitude of these reductions would not be expected to develop in normal elderly patients over a six week period.[2,3] This implies a linkage of IPD to the development of cognitive impairment.

We conclude that idiopathic postoperative delirium is associated with persistent moderate decrements in cognitive performance in some elderly patients. Whether this association is due to the IPD itself, the pathophysiologic events underlying it or some other related factor(s) remains to be determined.

REFERENCES

1. Can J Anaesth, 1989; 36:S90.
2. J Psych Res, 1975; 12:189-198.
3. J Neurol Neurosurg & Psych, 1984; 47:496-499.

METHODOLOGICAL REPORTING IN ANAESTHESIA LITERATURE

Alix Mathieu MD, Edith Villeneuve MD, Charles H. Goldsmith PhD
McMaster University, Dept. of Clinical Epidemiology & Biostatistics
Hamilton, Ontario, L8N 3Z5

INTRODUCTION: The purpose of this study is to assess the extent to which articles in five anaesthesiology journals contain sufficient information for their methodological evaluation. This study is inspired by previous reports of the surgical[1] and general medical[2] literature which have shown less than adequate reporting of a number of methodological issues. These aspects of design and analysis are essential to critically appraise the methods as well as understand and potentially accept the results from published clinical reports. It is important to note that the main focus of our study is the enumerative rather than qualitative aspects of reporting.

METHODS: Anaesthesiology, Anesthesia Analgesia, the British Journal of Anaesthesia, the Canadian Journal of Anaesthesia and the Annales Francaises d'Anesthésiologie were selected on the basis of their citation ranking[3]. All 1989 issues of these five journals were reviewed by two authors (AM & EV) to identify eligible clinical trials defined as prospective, comparative evaluations of an intervention on human subjects. We excluded: abstracts, analytical cohort studies, follow-ups on previously reported work, articles on prognosis and diagnostic procedures and pharmacokinetic studies. After stratification to journals and issues throughout the year, 100 articles were randomly sampled. Selected articles were labelled from 1 to 100 and divided randomly in two groups of fifty, designated "block A" and "block B". Each reader scored all articles from both blocks according to a randomized reading sequence. Then readers were randomly assigned one of the blocks for a second scoring. Hence, intra- and inter-rater agreement could be measured. Random numbers were obtained through a software package. All articles were scored as the sum of presence (1) or absence (0) according to 10 criteria: 1) subject eligibility criteria, 2) method of allocation, 3) description of the allocation method, 4) subjects' blindness to intervention, 5) blind assessment of outcome, 6)adverse effects, 7) loss to follow-up, 8) statistical analysis, 9) statistical methods, and 10) power/sample size calculations. **Statistical considerations.** A sample size of 20 articles per journal was determined to achieve a power of 90% for the detection of a "clinically" important absolute difference of 20% when comparing the mean journal scores with ANOVA. A two-tailed α of 0,05 was chosen as the level of statistical significance. The inter- and intra-rater agreement beyond chance will be calculated using the kappa statistic.

RESULTS: The following results were obtained from a preliminary survey conducted to establish the naturally occurring variance for the purpose of sample size calculation. Mean (SD) reporting score, based on a convenience sample of 33 articles from three of the five journals, was 6.1 (1.4) out of a possible score of 10 (Table 1). A one-way ANOVA on these articles was not statistically significant which is not surprising given the small sample size used for this pilot study ($p=0.3$).

DISCUSSION: Although based on preliminary data, the results seem to suggest that: 1) there is no significance difference in the mean level of reporting of those 10 criteria among these journals; 2) some items are reported more than others eg, eligibility criteria, method of allocation, statistical analysis and methods. In contrast, power or sample size considerations were usually lacking (present in 2 out of 33 articles). As for the remaining items, they could benefit from improved reporting. This emphasis on the application of sound epidemiologic principles and critical appraisal skills to our specialty will underscore the pioneering efforts of others[4] in that field. It is reasonable to expect that this concern about methodological quality of our literature will positively impact on the "effective development of individual anaesthesia practice"[4].

REFERENCES:

1. Emerson JD, McPeek B, Mosteller F. Reporting clinical trials in general surgical journals. Surgery. 95:572-9, 1984.
2. DerSimonian R, Charette LJ, McPeek B et al. Reporting on methods in clinical trials. N Engl J Med. 306:1332-7, 1982.
3. Garfield E. Science Citation Index: Sci Journal Citation Reports. Philadelphia, PA: ISI Inc; Vol 19:363, 1988.
4. Duncan PG, Cohen MM. The literature of anaesthesia: what are we learning? Can J. Anaesth. 35:494-9, 1988.

Table 1. Preliminary scores for three journals

Journal	n	Mean, SD	95% CI
Can J Anaesth	13	5.7, 1.6	2.5-8.9
Anaesthesiology	7	6.7, 1.1	4.5-8.9
Anesth Analg	13	6.1, 1.3	3.5-8.7
Total	33	6.1, 1.4	

Dantrolene Availability in Eastern Ontario Hospitals

Gregory C. Allen, MD, FRCPC
Malignant Hyperthermia Investigations Unit, Ottawa Civic Hospital, Ottawa, Ontario

INTRODUCTION

"How do you prepare for the only real disease that is solely your responsibility?" Duncan asked this question [1], in discussing the problem of stocking intravenous (IV) dantrolene for the treatment of malignant hyperthermia (MH). He concluded that at least 3 mg/kg of dantrolene should be immediately available, and 10 mg/kg "within reasonable time" (10-15 min). Paasuke and Brownell agreed, suggesting that 12 vials (240 mg) should be the minimum amount immediately available [2]. A survey of 183 U.S. hospitals has shown that while 53% stocked at least 36 vials of dantrolene , 9% stocked none or fewer than 12 vials [3]. Of 73 ambulatory surgical centres, 22% stocked no dantrolene, and 26% had less than 12 vials. Because of these statistics, a survey was made of dantrolene availability in Eastern Ontario Hospitals.

METHODS

We surveyed the pharmacy directors of 33 general hospitals in Eastern Ontario. They were asked how many vials of IV dantrolene they stocked, in what locations, and how long it would take to make them available in the operating room. Directors were also asked about their access to additional dantrolene from other hospitals, and how often in the last 5 years IV dantrolene had been used. The survey questionnaire was sent to the pharmacy director, who was later called by telephone to confirm information. Hospitals were grouped according to the number of available acute care beds (0-100, 101-250, >250).

RESULTS

Of the 33 hospitals contacted, three were dropped from the study because their operating room facilities were now closed. Seventeen hospitals had 36 vials of dantrolene available within 5 min in their operating rooms (Table 1). One hospital kept only ten vials of dantrolene; their backup supply was at another hospital 50 miles away. Of the 12 hospitals stocking 12-24 vials of dantrolene, 9/12 stated additional dantrolene was within 15 min, either from the hospital pharmacy (2), or from another hospital (7). One hospital required 30 min to obtain additional dantrolene available to them. Sixteen directors reported that IV dantrolene had been used in their hospitals in the last 5 years (Table 2). In 9/16 cases, IV dantrolene had been used to treat a suspected MH episode.

DISCUSSION

The results of this survey show that 97% of hospitals in Eastern Ontario have at least 12 vials of IV dantrolene available within 5 min, but 13% of centres cannot guarantee that 36 vials would be available within 15 min.

A common complaint about stocking IV dantrolene is its cost (approx. $41.00/vial) relative to its infrequent use. Pharmacists complain that the vials often reach their expiration date, and must be discarded. However, 16/30 hospitals surveyed had used dantrolene in the last 5 years, most often for the treatment of a suspected MH episode.

Dantrolene is a resuscitation drug; it is the only specific therapy available for MH. Therefore, a comparison with other resuscitation measures is warranted. Twelve vials of dantrolene should be immediately available [2], costing $492.00. Bretylium is an anti-arrhythmic drug that costs $84.00 for 500 mg bag. If only 15% of patients who receive it survive a cardiac arrest, the cost of bretylium is $560.00 per survivor. A cardiac defibrillator may cost $10,000.00. Although it may never be used, it costs approx. $1,000.00 per year to have one available. Yet no one would question its purchase. The "prohibitive" cost of dantrolene cannot be used as an argument for not stocking it. Thirty-six vials of dantrolene, amortized over its 3 year shelf life costs $41.00 per month.

The results of this study suggest that more specific guidelines on the amount of IV dantrolene stocked may be needed.

TABLE 1 - Number of vials of dantrolene available within 5 min vs number of beds

No. of beds	0-100	101-250	>250	Total
36 vials	6	4	7	17
12-24 vials	4	7	1	12
<12 vials	0	1	0	1
Total	10	12	8	30

Table 2 - Dantrolene utilization in last 5 years

No. of beds	0-100	101-250	>250	Total
Never used	7	5	2	14
Prophylaxis	2	3	2	7
Treatment	1	4	4	9
Total	10	12	8	30

REFERENCES

[1] Duncan PG. Can Anaesth Soc J 1985;32:205.
[2] Paasuke R, Brownell AKW. Can Anaesth Soc J 1986;33:567.
[3] Hein HAT. Anesthesiology 1986;69:A726.

RISK FACTORS FOR HYPOXAEMIA IN THE RECOVERY ROOM

Charles E. Smith MD FRCPC, Alfred C. Pinchak MD PhD, Joan F. Hagen BA

Department of Anaesthesia, MetroHealth Medical Center, Case Western Reserve University, 3395 Scranton Rd, Cleveland, Ohio, USA

Introduction: The occurrence of postoperative hypoxaemia has been well documented (1,2). This study was designed to determine patient and anaesthesia related risk factors for hypoxaemia on arrival to and discharge from the postanaesthesia recovery room (PARR).

Methods: Approval by the institutional human research committee was obtained. Candidates for this non-randomized prospective study were any patient undergoing elective operation requiring general, regional or monitored anaesthesia care (MAC) and admission to the PARR. Anaesthetic and PARR care were at the discretion of the anaesthetist, surgeon and PARR personnel. Measurements consisted of oxygen saturation (SpO2- Nellcor 100), blood pressure, pulse, respiratory rate and temperature. Level of consciousness, activity, colour and respirations were scored using a standard recovery scale. No attempt was made to blind anaesthesia and PARR personnel from SpO2 results. After the initial SpO2 reading, supplemental oxygen (O2) was administered. O2 was removed prior to discharge in all but 9 patients at the nurse's discretion using our usual PARR criteria (awake, normal strength and vital signs). Measurements were recorded on arrival to the PARR, 30 min after arrival and 5 and 10 min after cessation of O2. If hypoxaemia (SpO2 < 91%) occurred following O2 cessation, O2 was resumed, adequate SpO2 confirmed, and supplemental O2 ordered for at least 12 hrs afterwards. Patient-related (age, body mass index (BMI= weight in kg/height^2 in m), smoking, heart, lung and vascular disease) and anaesthesia-related (duration, technique, agents, dose) risk factors for hypoxaemia were analyzed using Chi-Square and Fisher's Exact test. A p value < 0.05 was considered significant.

Results: The incidence of hypoxaemia on arrival to the PARR was 20% (46 of 227 patients) vs 3.5% (8 patients) after O2 cessation prior to discharge (Figs 1,2). The use of general anaesthesia (vs regional and MAC), muscle relaxation (vs none), vecuronium (vs atracurium) and obesity (BMI >30) were associated with hypoxaemia on arrival to the PARR (Table 1). The duration of anaesthesia and dose were (mean ± SEM) 203±11 v 156±12 min, p < 0.05, t - test, and 0.06±0.01 v 0.37±0.03 mg/kg/hr for vecuronium and atracurium, respectively. We could not identify any factor associated with hypoxaemia after O2 cessation.

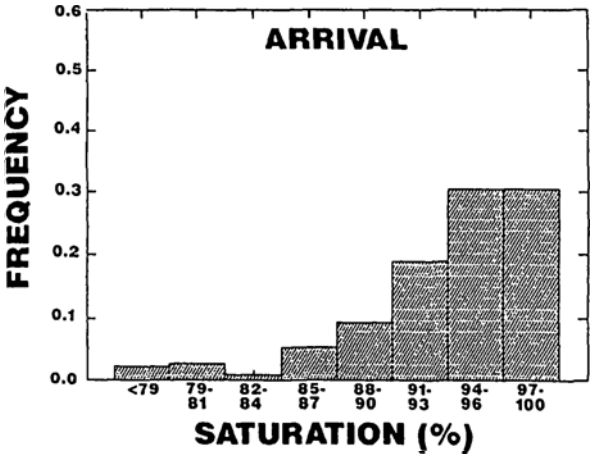
Discussion: The study suggests that obesity and residual effects from general anaesthesia and intermediate muscle relaxants such as vecuronium may be associated with hypoxaemia in the immediate recovery period.

References:
1. Anesthesiology 1990;73:890-5
2. Can J Anaesth 1990;37:S135 (abstract)

Table 1. Risk factors for hypoxaemia on arrival to the PARR.

		Number of Pts	SpO2 <91% (% of pts)	P*
Obesity	Yes	54	37	0.0005
	No	140	14	
General Anaesthesia	Yes	187	24	0.002
	No	40	2.5	
Relaxant	Yes	173	24	0.002
	No	54	9	
Vecuronium		99	30	0.002
Atracurium		61	10	

*Chi-square test



Figures 1. Frequency histogram of SpO2 values on arrival to PARR.

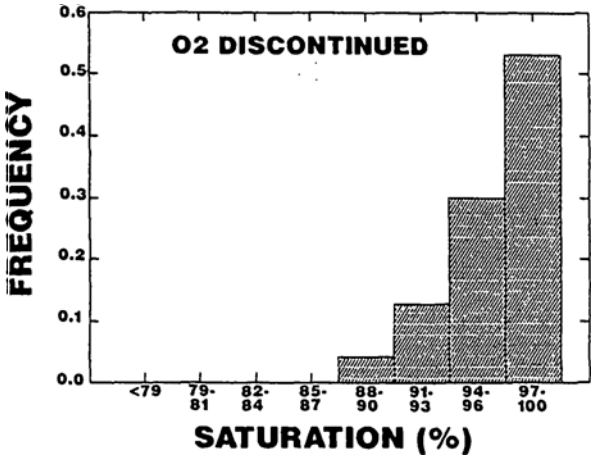


Figure 2. Frequency histogram of SpO2 values 5 min after cessation of oxygen.

ARE INTRAOPERATIVE COMPLICATIONS RELATED TO THE PATIENT'S CONDITION AT THE END OF THE CASE AND CONDITION AT DISCHARGE?

JC Hudson,M.D., C Gennings,Ph.D.,* BL Tyler,R.N., RL Keenan,M.D.
Departments of Anesthesiology and Biostatistics*, Medical College of Virginia, Virginia Commonwealth University, Richmond, VA 23298, U.S.A.

INTRODUCTION

At the conclusion of surgery and anesthesia most patients are awake, extubated and responsive. Some patients, however, remain sedated, intubated, and are occasionally unstable. We wanted to investigate the relationship of these two outcomes with the frequency of intraoperative events or complications. Furthermore we wanted to compare the complication rates of those patients who survived hospitalization with those that died.

METHODS

Since 1983, every patient having surgery in our main operating rooms has had an intraoperative data form prepared by the primary anesthetist. Data from every record was verified and entered into a Digital VAX-750 data base. Intraoperative complications were categorized in four groups: cardiac (C), respiratory (R), metabolic (M) and other (O). A case was considered as having a complication if the primary anesthetist identified one or more problems within the category. The status of the airway, the respiratory, cardiovascular and central nervous system was documented as the patient left the operating room. The patient was considered as normal (N) if they were all of the following: spontaneously breathing, extubated or never intubated, verbally responsive and stable. The patient was considered as abnormal (Abn) if they were any of the following: intubated, unresponsive or responsive only to pain, hemodynamically unstable or had a new tracheostomy. 20,720 patients with completed data sets were evaluated. The condition (N or Abn) was evaluated by the chi-square test with the presence or absence of each of the four complication categories (C,R,M,O) $p \leq 0.05$ was considered significant. In addition, for 16,721 patients, we had condition (dead or alive) on discharge from the hospital. Discharge conditions (dead or alive) was evaluated by chi-square with the presence or absence of the four intraoperative complication categories (C.R.M.O).

RESULTS

Out of 20,720 patients, 92.31% were normal in all functions at the end of surgery. 7.69% were abnormal in at least one of the assessed functions (C.R.M.O.).

The overall rate of intraoperative complications was: cardiac 11.97%, respiratory 5.77%, metabolic 3.48% and other 2.76%.

The complication rates by category for the normal and abnormal at the end of surgery are shown in Table 1.

Table 1
Intraoperative complication rates according to condition at end of surgery. (N = 20,720)

	OPERATIVE OUTCOME		
	NORMAL	ABNORMAL	
All patients	92.31%	7.69%	
complication rates			p value
cardiac	9.83%	37.64%	<0.001
respiratory	5.85%	4.77%	NS
metabolic	2.76%	12.12%	<0.001
other	2.13%	10.29%	<0.001

The complication rates by category in those patients who were discharged (dead or alive) from the hospital is shown in Table II.

The overall mortality rate was 4.32% in the 16,721 patients in whom we have hospital discharge data. The mortality rate of those who were normal at the end of the case was 1.16% while the mortality rate of those who were abnormal was 18.48%.

Table II
Intraoperative complication rates according to condition at discharge. (N = 16,721)

	DISCHARGE OUTCOME		
	ALIVE	DEAD	
All patients	95.68%	4.32%	
complication rates			p value
cardiac	14.65%	37.12%	<0.001
respiratory	6.90%	11.63%	<0.001
metabolic	4.71%	14.68%	<0.001
other	3.49%	14.27%	<0.001

DISCUSSION

There is a correlation between the occurrance of intraoperative complications in the cardiac, metabolic and other categories and the condition of the patient at the end of surgery. The patients who arrive in the recovery room intubated, obtunded, or unstable (Abn) are more likely to have experienced during surgery a complication in the cardiac, metabolic or other category than those who arrived in the normal condition. The occurrance of a respiratory complication does not seem to influence this outcome probably because the majority of problems in this category reflect difficulties in establishing the airway.

The patients who died during their hospitalization are more likely to have experienced a complication in any group (C,R,M, or O) during their surgery than those patients who survived hospitalization. However, the clinical relevance of this is unknown. Preoperative patient information and surgical factors are needed before cause and effect can be examined.

VALIDATION OF AN OBJECTIVE AMBULATORY SURGERY DISCHARGE SCORING SYSTEM

F. Chung MD FRCPC., C. Seyone MD., N. Mati MD., D. Ong MD., P. Powell BA. RN., V. Chan MD FRCPC

Toronto Western Division, The Toronto Hospital, University of Toronto, Toronto, Ontario

INTRODUCTION: The postanaesthetic scoring system used in the recovery room immediately after anaesthesia determines patient's recovery but does not evaluate home readiness of ambulatory surgery patients. Clinical discharge criteria (CDC) are usually used. No objective scoring system exists which systematically determines home readiness. In this study, a new Post Anaesthetic Discharge Score (PADS), which uses numerical values in assessing patient recovery and discharge readiness, is compared against the existing CDC in outpatient surgery of approximately 1 hr duration.

METHODS: Following institutional approval and informed consent, 96 patients scheduled for outpatient ambulatory surgical procedures of approximately 1 hr duration under general anaesthesia were studied. All were seen by an investigator every 30 min postoperatively commencing 1 hr after the operation up until discharge. At each postoperative visit, all patients were scored using both the PADS and CDC. PADS consists of the following criteria.

1. Vital signs
   - 2 = Within 20% of preoperative value
   - 1 = 20-40% of preoperative value
   - 0 = >40% preoperative value
2. Activity and mental status
   - 2 = Oriented x3 AND has a steady gait
   - 1 = Oriented x3 OR has a steady gait
   - 0 = Neither
3. Pain, nausea and/or vomiting
   - 2 = Minimal
   - 1 = Moderate, having required treatment
   - 0 = Severe, requiring treatment
4. Surgical bleeding
   - 2 = Minimal
   - 1 = Moderate
   - 0 = Severe
5. Intake and output
   - 2 = Has had PO fluids AND voided
   - 1 = Has had PO fluids OR voided
   - 0 = Neither

The total score is 10 with patients scoring 9 or above being considered fit for discharge.

The CDC used in our hospital are: stable vital signs, alertness and orientation, absence of nausea and/or vomiting, a steady gait and no significant bleeding. The time taken to obtain a PADS ≥ 9 and to fulfill all CDC were recorded. These results were not made known to those directly involved in the care of the patients nor any influence exerted on the actual discharge time. The time that the patients were actually discharged from the ambulatory surgical unit were noted. All patients were contacted by telephone one day postoperatively for follow up. Data was analyzed using absolute relative differences among variables. Results are expressed as Mean ± SD.

RESULTS: The mean age and weight of the 96 patients studied were 38.3 ± 11.84 yrs and 72.5 ± 17.5 kg respectively. 79.6% of the patients were ASA I while 20.4% were ASA II. The mean duration of anaesthesia was 62.0 ± 25.9 min. The majority of patients studied underwent arthroscopies (60.4%), while 20.8% of the patients had laparoscopies and another 18.8% had other minor surgical procedures (Table 1).

TABLE 1:

		%
Arthroscopy		60.4
Laparoscopy		20.8
Other:	Minor orthopaedic surgery	8.3
	Minor general surgery	6.3
	ENT/Face surgery	4.2

Patients required 139.4 ± 50.26 min postoperatively to achieve a PADS ≥ 9 as compared to 145.2 ± 53.03 min needed for a satisfactory CDC.

88.5% of the patients were judged suitable for discharge using PADS at 3 hr postoperatively as compared to 86.5% of patients using the CDC. 95.8% at 3.5 hr postoperatively were fit to be discharged using either PADS or CDC (Figure 1).

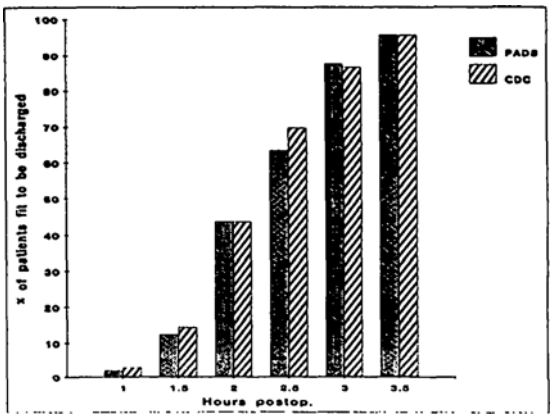


FIGURE 1:
PADS = Post Anaesthetic Discharge Score
CDC = Clinical Discharge Criteria

There was a close correlation noted between the time taken to become fit for discharge using either PADS or the CDC from the end of anaesthesia (Pearson's Correlation Coefficient r = 0.96, Figure 2).

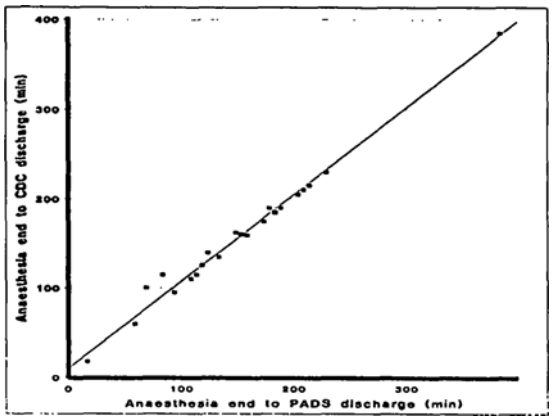


FIGURE 2:

Notwithstanding, the actual postoperative discharge time was 232.3 ± 70.59 min, which was significantly longer than the time needed to achieve either a PADS ≥ 9 or satisfactory CDC ($p < 0.0001$). All patients discharged did well, with no re-admission being needed.

CONCLUSION: The new PADS is a simple, time effective and objective measurement of ambulatory surgery patients. We have validated a close correlation between this new post anaesthetic discharge scoring system and the existing clinical discharge criteria. Using the new score can ultimately speed up the discharge of these patients.

NITROUS OXIDE LEVELS IN THE OPERATING ROOM: THE EFFECT OF SCAVENGING THE OHMEDA 5200 CAPNOMETER

MJ TESSLER, M.D. SJ KLEIMAN, M.D. S WIESEL, M.D.
Departments of Anaesthesia, Jewish General Hospital and McGill University, Montreal, Quebec, Canada

INTRODUCTION: Exposure to trace anaesthetic agents remains a concern to Operating Room (OR) personnel[1]. With the wide use of gas scavenging devices, the risk of exposure to harmful levels of anaesthetic agents should be markedly reduced. The Ohmeda 5200 Capnometer samples anaesthetic gases from circuits and releases this gas effluent into the ambient air. It is possible to return the capnometer effluent to the anaesthetic circuit from where it will be scavenged.

This study was designed to determine if returning the capnometer effluent to the anaesthesia circuit significantly decreases the level of nitrous oxide OR pollution.

METHODS: The measurements were made in a vacant standard OR (3330 cubic feet) over five consecutive days. Non-recirculating ventilation in this OR accomplishes 18.6 air changes per hour. Anaesthesia circuits were connected via a passive scavenging device to the central ventilation which provides a negative pressure of 0.1 mmHg. An Ohmeda 8000 anaesthesia machine was used with a circle system and a Fraser Harlake Model 701 anaesthesia ventilator set to deliver a 600 ml tidal volume at a rate of 10 breaths/minute to an artificial lung. Flowmeters were set to deliver 2 l/min of nitrous oxide and 1 l/min of oxygen with a vaporizer set at 1% isoflurane. Measurements of OR nitrous oxide levels were made at least hourly using an infrared spectrophotometer at a wavelength of 4.5 microns. The spectrophotometer was zeroed daily in an area remote from the OR block. In order to sample gases that would represent the exposure to an Anaesthetist, measurements were made directly in front of the anaesthetic machine at a point 5 feet (1.5m) above the floor.

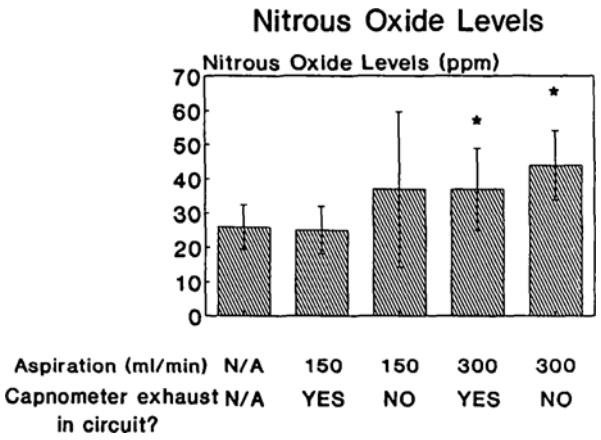
Operating room nitrous oxide levels were measured under the following conditions - 1) no capnometry, 2) Ohmeda 5200 capnometer with aspiration set at 150 ml/min and effluent returned to the circuit or 3) open to the OR and 4) with aspiration set at 300 ml/min and effluent returned to the circuit or 5) open to the OR. The anaesthetic circuit itself was scavenged at all times. Each group was measured through the course of one day. Data was analyzed using the Fisher t-test with p 0.05 considered statistically significant.

RESULTS: Nitrous oxide was not detectable in the OR before the start of any of the daily readings. When capnometry was not used at all, the concentration of nitrous oxide was 26 +/- 6.5 ppm (mean +/- SD). With the capnometer functioning at a withdrawal rate of 150 ml/min, the concentration of nitrous oxide rose from 25 +/- 6.9 ppm-effluent returned to the circuit- to 37 +/- 22.7 ppm- effluent open to the OR. When capnometry was used at a withdrawal rate of 300 ml/min, the concentration of nitrous oxide rose from 37 +/- 12.0 ppm to 44 +/- 10.1 ppm. There is a trend to increasing mean concentrations of nitrous oxide with either the avoidance of scavenging or the use of capnometry, particularly at the higher aspiration rate of 300 ml/min. Compared with control (no capnometry), there is a statistically significant increase in the concentration of nitrous oxide OR pollution when capnometry is used at a sampling rate of 300 ml/min whether or not the effluent is scavenged. (see Figure)

DISCUSSION: Controversy remains as to whether chronic low levels of nitrous oxide in the OR pose a serious health hazard to OR personnel[2]. Since capnometry is a highly useful monitor which will almost certainly be used with increasing frequency in the future, its contribution to OR nitrous oxide levels is important. It is therefore recommended that when the Ohmeda 5200 Capnometer is used, circuit gases should be aspirated at 150 ml/min and the capnometer effluent returned to the circuit in order to achieve the lowest level of ambient OR nitrous oxide.

REFERENCES:

1. Anaesthesia and Intensive Care; 15: 1987; 411-20.
2. Clinical Anesthesia. Philadelphia, Penn; JB Lippincott 1989; 69-74.



Alkalinization of Mepivacaine for Epidural Anaesthesia Decreases the Incidence of Tourniquet Pain

John E. Tetzlaff, M.D., Helen J. Yoon, M.D., Bruce Baird, M.D., Michael Walsh, M.D., Gregory Hondorp, M.D.

Dept. of General Anesthesia, The Cleveland Clinic Foundation, Cleveland, OH 44195

Introduction: Pneumatic tourniquets used for extremity surgery are known to induce pain during otherwise adequate regional blocks. This pain is known to occur with different incidence during spinal anaesthesia, depending on the agent and baricity.[1-3] Recently, considerable attention has been directed toward the effect of alkalinization of local anaesthetics on the latency to onset of regional block. Capogna [4] demonstrated a more rapid onset with mepivacaine for epidural anaesthesia. Whether this influences the quality of the block has not been reported. This study was conducted to evaluate the influence of alkalinization on the incidence of tourniquet pain.

Method: Institutional Review Board permission and written informed consent was obtained from 40 patients. They were randomized to receive lumbar epidural anaesthesia with 2% mepivacaine 1:200,000 epinephrine with or without bicarbonate (1 meq/ml) 1 ml per 10 ml. The procedures were lower extremity orthopaedic procedures with tourniquet time greater than 60 minutes. Pain free-tourniquet time less than 60 minutes was an exclusion. 20 cc were injected and level identified. If below T10, further agent was injected. Sedation was provided, but no narcotic analgesics were given unless tourniquet pain was reported. Patients were questioned every 15 minutes about pain and answers recorded. If pain was reported, the level was checked to distinguish tourniquet pain from inadequate sensory level. Time of pain was recorded and fentanyl 1 cc was administered intravenously as necessary. Amount of fentanyl was recorded. Data was evaluated with Fischer's Exact Test and considered significant at $p<0.05$.

Results: The pH of the adjusted mepivacaine was 7.31. Six procedures were excluded for tourniquet time (pain-free) less than 60 minutes. Both groups were comparable for age, height, weight, ASA status and level. There was a significant decrease in tourniquet pain in the alkalinized group (Table one).

Discussion: The exact etiology of tourniquet pain is unclear. The differential advantage of bupivacaine over tetracaine for spinal anaesthesia for tourniquet pain may lie in a differential sensitivity in C-fibers or by an increase in the frequency-dependent block produced by different agents. It may be that alkalinization facilitates penetration of the nerve of a higher concentration of the agent initially, leading to a denser or differentially more effective block with epidural anaesthesia.

Table One

Tourniquet Pain	Alkalinized	Plain	Total
Yes	1	8	9
	6.67	42.11	26.47
No	14	11	25
	93.33	57.89	73.53
Total	15	19	34
	100.00	100.00	100.00

Fischer's Exact Test, p=0.047

References:

1. Anesthesia and Analgesia 67:828-832.
2. Anesthesia and Analgesia 65:1181-1185.
3. Anesthesia and Analgesia 67:833-837.
4. Regional Anesthesia 15:242-244.

ENHANCEMENT OF ANALGESIC POTENCY OF MEPERIDINE BY DIAZEPAM AND DROPERIDOL

Medhat R. Wassef, M.B.,B.CH., D.A., F.F.A.R.C.S.
Department of Anesthesiology, Mount Sinai School of Medicine, New York, U.S.A.

INTRODUCTION: Techniques in general anesthesia employing nitrous oxide and an opioid have established considerable popularity. An ideal opioid should provide profound analgesia with minimal side effects. The purpose of this work is an endevour to reduce meperidine requirement while enhancing its analgesic potency.

METHODS: Forty five ASA 1-2 patients were scheduled for upper or lower extremity procedures. All were comprable in age and weight. Patients were divided into three groups. Control group A (N=19), patients were adminstered meperidine 0.50 $mgKg^{-1}$ followed by thiopental 5.0 $mgKg^{-1}$; and were maintained with nitrous oxide-oxygen 4:2 $L.Min^{-1}$, and breathing spontaneously. Group B (N=13), patients were pretreated with diazepam 0.10 $mgKg^{-1}$. Group C (N=13), patients were pretreated with droperidol 0.08 $mgKg^{-1}$. Both groups were followed by the same technique applied to group A patients. No premedication was adminstered to any patient in the three groups.
Increments of meperidine of 0.50 mKg^{-1} were given as determined by reflex responses of cardiovascular, respiratory, and motor systems. This was determined by a standardized end point denoting a significant quantitative change in each parameter. Scoring points were given to each specified quantitative change in each parameter.
Cumulative hourly meperidine dose requirement ($\mu Kg^{-1}Min^{-1}$) and the corresponding scores, expressed as (Score/Min.), were calculated, and plotted on a graph for the three groups.
Student's t-test was used for comparison between groups, with level of significance of $P < 0.05$.

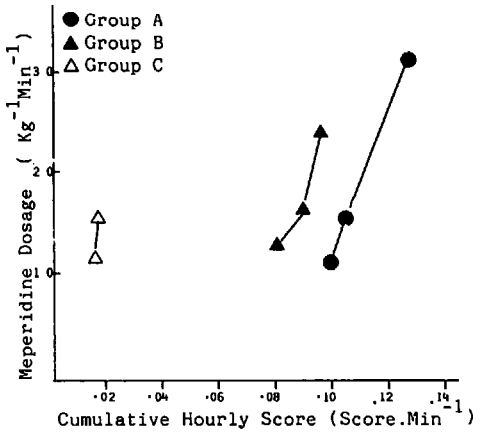
Table shows patients characteristics, meperidine dose requirement, and reflex response score for the three groups. Data are expressed as mean ± SEM.

Group	Age (Years)	Weight (Kg.)	Dosage ($Kg^{-1}Min^{-1}$)	Score
A	40.0 ± 4.3	66.7 ± 3.8	23.08* ± 2.37	11.05 ± 1.26
B	36.6 ± 6.5	66.5 ± 4.3	14.59* ± 1.15	11.39 ± 1.62
C	27.2 ± 3.6	61.7 ± 2.9	11.46* ± 0.77	1.39* ± 0.31

* = Student's t-test significance level, P 0.05

RESULTS: Table showed a significant decrease in meperidine overall dose requirement after pretreatment with diazepam. Meanwhile, droperidol pretreatment resulted in a much significantly lower dose requirement. There was no significant difference, in the overall reflex response score, between the control group and diazepam pretreated group, which required less meperidine. This could be explained by the simultaneous occurance of increase in more than one parameter which warranted only one meperidine incriment. However, droperidol pretreatment resulted in an extremely low reflex response score.
Figure depicts the relationship between the cumulative hourly meperidine dose requirement and the corresponding score for the three groups. It demonstrates a progressive shift to the left, first by diazepam and more by droperidol.

DISCUSSION: Various conflicting reports were published regarding opioid analgesic requirement in terms of enhancement by diazepam and droperidol, in animal and man. Evidence of potentiation is rather inconclusive.
In this study meticulous monitoring of reflex responses, of various parameters, to surgical stimuli together with concomitant adminstration of meperidine helped quantification of meperidine dose requirement.
The significant decrease of dosage and progressive shift of the score/dose relatioship to the left by diazepam and more by droperidol proved the efficacy of these agents in attenuating meperidine dose requirement.
In conclusion, this study showed that diazepam and, to a larger extent, droperidol effectively reduce meperidine requirement by enhancing its analgesic potency in nitrous oxide-oxygen anesthesia for upper or lower extremity procedures.



OXYGEN SATURATION MONITORING DURING GASTROINTESTINAL (G.I.) OUTPATIENT PROCEDURES UNDER INTRAVENOUS (I.V.) SEDATION

C. Munshi, M.D., J. Brooks, R.N., N. Nimphius, M.S.
Deptartment of Anesthesiology, Medical College of Wisconsin, Milwaukee, WI 53226

Introduction

Outpatient procedures are routinely done under intravenous sedation in the GI clinic. This study was undertaken to monitor O_2 saturation and determine incidence of oxygen desaturation during these procedures.

Methods

Oxygen saturation was monitored in 23 patients (13 females and 10 males) during GI procedures under intravenous sedation with meperidine and midazolam. A desaturation episode was defined as any decrease in O_2 saturation of 3% or more from baseline saturation until the value returned to normal.

Data were analyzed for significant differences between age (over vs. under 60 years) and gender for desaturation and dosages by one-way analysis of variance and Scheffe's test. A level of $p \leq 0.05$ using a 2-tail test was considered statistically significant. Data are presented as mean ± SD.

Results

The procedures included 14 colonoscopies, 7 esophagoscopies, and 2 sigmoidoscopies. The procedures varied in length from 30 to 120 minutes, mean 60±16 minutes. The patients' ages ranged from 29 to 88 years, mean age 59±17 years.

Desaturation occurred in 21 of the 23 patients (91.3%) (Table 1). All patients over 60 years of age desaturated. Desaturation varied from 4% to 9% below baseline. Average desaturation was 5.3±2.1%, with patients over 60 years desaturating 5.7±1.7% and patients under 60 years desaturating 4.8±2.5% ($p>0.05$).

Meperidine and midazolam were administered as deemed necessary by the physician. The mean dose for midazolam was 2.7±1.7 mg and for meperidine was 55±24 mg. Females under 60 years were administered significantly more midazolam (4.7±1.5 mg) than both males and females over 60 years. Although females under 60 years also were administered more meperidine (74±18 mg) than the other three groups of patients, this difference was not significant. No significant changes in heart rate or blood pressure were noted.

Discussion

The results indicate that significant oxygen desaturation can occur in patients undergoing GI procedures with IV sedation (e.g. midazolam, meperidine) even without significant changes in heart rate and blood pressure.

Patients over 60 years of age exhibited more severe and higher incidence of desaturation (statistically not significant) even though they received less midazolam ($p=0.02$) and meperidine ($p>0.05$) than patients under 60 years. Severity and frequency of desaturation in older patients (>60 years) may be related to increased sensitivity to CNS depressants and is especially significant in the presence of cardiovascular or respiratory diseases, which are prevalent in this age group. Our results suggest that all patients receiving IV sedation (midazolam and meperidine) for GI procedures should be monitored by pulse oximetery. Supplemental oxygen and airway mangement equipment should be available, if necessary.

Table 1. Severity of Desaturation and Doses of I.V. Sedation

	N	Mean Desaturation (%) ($p>0.05$)	Dose of Midazolam (mg) ($p=0.02$)	Dose of Meperidine (mg) ($p>0.05$)	Number that Desaturated ≥3%
Under 60 yrs	10	4.8±2.5	3.6±1.9	62±21	8
Over 60 yrs	13	5.7±1.7	2.0±1.1	50±25	13
All patients	23	5.3±2.1	2.7±1.7	55±24	21

PROLONGING INSPIRATORY TIME DOES NOT IMPROVE GAS EXCHANGE DURING ANAESTHESIA

W.A. Tweed FRCPC, T.L. Lee FFARACS
Department of Anaesthesia, National University Hospital, Lower Kent Ridge Road, Singapore 0511

INTRODUCTION

In patients with respiratory failure pulmonary O_2 exchange is improved by PEEP, CPPV, and pressure controlled-inverse ratio ventilation (PC-IRV). It is thought that their effects on gas exchange are mediated primarily by an increase in mean airway pressure (mean AWP)[1], although the shape of the respiratory waveform may also be important. Impaired O_2 exchange is also observed during anaesthesia. In order to differentiate between the effects of mean AWP and respiratory waveform, we compared time cycled-inverse ratio ventilation (TC-IRV), without PEEP, with conventional ratio ventilation (CRV) in anaesthetized patients. With TC-IRV the inspiratory flow rate is reduced and inspiratory time is prolonged, but the expiratory waveform is unaffected. We hypothesized that modifying only the inspiratory waveform with TC-IRV would increase mean AWP and improve gas exchange, while avoiding the detrimental haemodynamic effects of PEEP.

METHODS

We compared TC-IRV with CRV in 24 low risk patients having orthopaedic operations. Under total IV anaesthesia they were paralysed and their lungs were ventilated with air/O_2 by a non-rebreathing circuit and a Siemens 900-C servo ventilator. Two randomized levels of TC-IRV (I:E ratios of 60/40 and 77/23) were bracketed by control periods with CRV (I:E ratio of 35/65). Inspired O_2 fraction, O_2 uptake and CO2 elimination, arterial blood gases, pulmonary ventilation and mechanics, heart rate and blood pressure were measured. From these data alveolar and dead space ventilation and four oxygen tension-based indices of gas exchange were calculated.

RESULTS

During TC-IRV mean AWP was significantly increased (from 3 to 7 cm H_2O), but end expiratory pressure was not elevated above 1 cm H_2O. There were no changes in the oxygen exchange indices, pulmonary mechanics, HR or BP. A sub-set of the sample with moderately impaired oxygen exchange, defined as the upper quartile for (A-a) DO_2 (134-166 mm Hg), was examined separately with identical results.

DISCUSSION

We have shown that prolonging inspiratory time by TC-IRV increased mean AWP without causing a PEEP effect, but pulmonary mechanics and oxygen exchange did not benefit. This strongly suggests that mean AWP, when determined solely by the shape of the inspiratory waveform, does not regulate gas exchange during anaesthesia. We suggest that improvement in gas exchange requires concurrent alteration of the expiratory waveform and pressure.

REFERENCES

[1] J Pediatr 94:114, 1979

TIME CYCLED-INVERSE RATIO VENTILATION : POOLED DATA (n=24)

I : E Ratio	35/65	60/40	77/23	35/65
mean AWP cm H_2O	3.0 ± .2	4.7 ± .3*	7.0 ± .3*	3.2 ± .2
Compliance mL.cm H_2O^{-1}	49 ± 2	49 ± 2	54 ± 3	48 ± 2
(A-a) DO_2 mm Hg	83 ± 11	91 ± 12	84 ± 13	88 ± 12

* Indicates P < 0.0001 compared to control

HIGH TIDAL VOLUME VENTILATION DOES NOT IMPROVE GAS EXCHANGE DURING LOWER ABDOMINAL SURGERY

W.A. Tweed FRCPC, W.T. Phua M.Med, K.Y. Chong M.Med, E. Lim M.Med, T.L. Lee FFARACS
Department of Anaesthesia, National University Hospital, Lower Kent Ridge Road, Singapore 0511

INTRODUCTION

Impaired pulmonary O_2 exchange is a common complication of general anaesthesia, particulary during abdominal and thoracic surgery and alternative positioning. Both high tidal volume (HV_T) ventilation and manual hyperinflations (HI) have been claimed to ameliorate these changes in some circumstances [1-3]. To assess the effectiveness of these interventions in anaesthesia practice we have compared HV_T with conventional tidal volume (CV_T) ventilation in a randomized control trial.

METHODS

We studied 14 patients scheduled for lower abdominal gynaecologic surgery under general anaesthesia. Pulmonary gas exchange was estimated during four steady states : awake control (AC) just prior to induction of anaesthesia, after 30 min of ventilation with CV_T and HV_T, introduced in random order, and 5 min after manual HI of the lungs. Patients lungs were ventilated with air/O_2 (fresh gas flow 10 $L.Min^{-1}$) by an Ohmeda 7000 volume controlled ventilator via a circle system with soda-lime absorber. The F_IO_2 was controlled at 0.5, while PCO_2 was controlled by adding dead space during HV_T. At the end of each study period we measured peak airway pressure (peak AWP), tidal volume (V_T), and arterial blood gases. Four oxygen tension-based indices of gas exchange were then calculated.

RESULTS

During CV_T ventilation, $V_T$was 7 ± 1 $mL.kg^{-1}$ and peak AWP was 21 ± 4 cm H_2O; during HV_T ventilation, V_T was increased to 12 ± 1 $mL.kg^{-1}$ (+72%) and peak AWP to 29 ± 5 cm H_2O. There were no changes in $PaCO_2$ or pH. In the AC state (A-a)DO_2 was 84 ± 30 mm Hg. After induction of anaesthesia, incision of the lower abdomen, placement of packs and retractors, and Trendelenberg positioning there was a marked deterioration of O_2 exchange, and average (A-a)DO_2 increased to over 150 mm Hg. There was no difference in O_2 exchange between CV_T and HV_T. Gas exchange improved after HI, but not to control values (see illustration).

DISCUSSION

In this clinical model of impaired O_2 exchange during anaesthesia there was no improvement attributable to HV_T ventilation. Although HI was superior to both HV_T and CV_T, it did not restore gas exchange to control values, and the duration of improvement remains uncertain. Both HV_T and HI produce alterations in the inspiratory phase of the respiratory cycle, increasing both inspiratory volume and pressures. We suggest that the expiratory waveform and pressure may have a greater effect on gas exchange than the inspiratory volume, waveform, or airway pressure.

REFERENCES

[1] Anesthesiology 24:57, 1963
[2] New Eng J Med 269:991, 1963
[3] Anesthesiology 39:285, 1973

PULMONARY VENTILATION AND GAS EXCHANGE (n=14)

Mean ± SD

	AC	CV_T	HV_T	HI
Tidal Vol. mL.		440 ± 90	740 ± 110	
Peak AWP* cm H_2O		21 ± 4	29 ± 5	
(A-a)DO_2** mm Hg	84 ± 30	158 ± 44	145 ± 49	116 ± 47

* $p < 0.001$ by paired t-test
** $p < 0.001$ by ANOVA

THE FUNCTIONAL EFFECTS OF ADENOSINE IN ISOLATED PERFUSED WORKING RAT HEARTS

B.A. Finegan, FRCPC, C. Coulson, Ph.D., G.D. Lopaschuk, Ph.D., A.S. Clanachan, Ph.D.

University of Alberta, 8440 - 112 Street, Edmonton, Alberta T6G 2B7

INTRODUCTION: Adenosine (ADO) is an endogenous nucleoside that is involved in the regulation of the balance between energy supply and energy demand in the heart by dilating coronary resistance vessels, inhibiting atrial and ventricular automaticity and inhibiting the effects of beta-adrenoceptor stimulation. The intravenous administration of ADO causes profound and rapid relaxation of vascular smooth muscle and ADO is used clinically to induce controlled hypotension. Adenosine 5'-monophosphate (AMP), a soluble ADO prodrug, reduces systemic vascular resistance (SVR) and is more effective than sodium nitroprusside (SNP) in increasing cardiac output (CO) both in normal dogs and in dogs with acute ischaemic LV dysfunction (1, 2). To clarify the mechanism responsible for this beneficial effect, we investigated the effects of ADO on mechanical function in isolated perfused working rat hearts. This model allows fine control of experimental conditions and facilitates assessment of function.

METHODS: Hearts were excised from anaesthetized male Sprague Dawley rats (250-300g), cannulated and perfused as described in detail elsewhere (3). When perfused as working hearts, the Krebs-Henseliet buffer contained 11mM glucose, 2.5mM free Ca^{++} and physiological concentrations of fat (0.4mM palmitate pre bound to 3% bovine serum albumin). The perfusate was gassed with 95% O_2 - 5% CO_2. Left atrial filling pressure was maintained at 11.5mmHg and work was performed against three hydrostatic afterloads (50mmHg, 80mmHg and maximally attainable afterload). Heart rate (HR), peak systolic pressure (PSP), CO, coronary flow (CF) and O_2 consumption were monitored throughout the perfusion period. Measurements were obtained in spontaneously beating hearts and hearts paced at 280 beats·min^{-1} and in the absence or presence of ADO (100μM).

RESULTS: In spontaneously beating hearts, ADO markedly decreased HR at each of the three afterload levels (by 40%, 60%, and 60%, respectively) and increased PSP at afterloads of 50 mmHg and 80mmHg (by 13% and 11%, respectively). CO and CF were unchanged, but work performed per μmole of O_2 consumed (efficiency) was increased by approximately 60% at each of the three afterload levels. In paced hearts ADO had no effect on the measured variables and efficiency was unaltered.

DISCUSSION: ADO increased the efficiency of spontaneously beating working hearts, but this effect was abolished once the heart rate was controlled. Similar increases in efficiency have been observed in catecholamine-stimulated isolated hearts and again the predominant action of ADO was to slow HR (4). Despite the reductions in HR in the unpaced hearts, CO was not changed. There was no evidence of ADO-induced depression of mechanical function in paced hearts. A shift in substrate preference (glucose *vs* fatty acid) by the heart in the presence of ADO may also be a factor in increasing efficiency and this is currently being investigated.

REFERENCES:

1. Anesth Analg 1990;70:44-52.
2. Can J Anaesth 1990;37:S149.
3. Am J Physiol 1986;250:H351-H359.
4. Pflugers Arch 1989;413:354-358.

BAROTRAUMA IN CONGENITAL DIAPHRAGMATIC HERNIA: THE KILLER?

Fournier L FRCP(C), Cloutier R FRCS(C), Major D B.Sc.

Centre Hospitalier de l'Université Laval, 2705 boul. Laurier, Québec, G1V 4G2

INTRODUCTION

Congenital diaphraghmatic hernia (CDH) can be a challenge for every anesthesiologist even more for those who do not work as pediatric anesthetists. Every one of us is susceptible to take care of one of those small patients, sometimes only to transfer him to a specialized center. The challenge exists also in these pediatric centers since mortality rate for this kind of affliction varies between 50% and 100% depending on the severity of the disease.

Between 1971 and 1990 we treated 55 cases of high risk CDH i.e. those showing symptoms in the first six hours of life. Before 1979 our survival rate was only 29%. This kind of statistics prompted us to try to find a way to improve our treatment. The course of the deterioration was almost always the same: after a brief period of relatively good evolution post-reduction of the hernia, the babies on the ventilator began to deteriorate inexorably till they died. We knew that reversal to fetal circulation was a factor in this outcome (1) and fetal circulation can be obtain if we increase pulmonary vascular resistance. According to Macklin, malignant interstitial emphysema can bring about an increase in pulmonary vascular resistance (2). From that we hypothesized that barotrauma was creating perivascular emphysema in the agenetic lung of our babies suffering from CDH and that barotrauma was the main factor in the fatal outcome in a vast majority of our small patients. We also assumed that ventilation which is a factor in creating barotrauma is not the only culprit and that suctioning the thoracic cavity or putting a drain even without suctionning was also responsible for causing barotrauma in the lungs (3).

METHOD:

To verify our impression that draining the thoracic cavity was causing barotrauma in the neonates, we compared all patients treated before 1979 with those treated after this date when we stopped draining after reduction of the hernia.

Concurrently we submitted to various transpulmonary pressure gradient the lungs of newborn lambs on which a diaphragmatic hernia had been surgically created in utero. The diaphragmatic hernia was repaired at birth and a tube left in place in the thoracic cavity. This tube was kept closed in some lambs in others it was connected to an underwater seal, with or without suction. Since these lambs were also intubated we could vary the transpulmonary pressure at will.

Subsequently we tested the hypothesis that barotrauma induces pulmonary interstitial emphysema which increase pulmonary arterial pressure by extrinsic compression of the pulmonary vasculature and so is the main cause of death in neonates operated for CDH. To induce barotrauma, either right or left pneumonectomy was done in eight lambs and various degrees and duration of suction applied on an underwater drain left in place after surgery. In two lambs barotrauma was induced by introducing an urethral catheter into the main bronchus and air forced through at a pressure of 40 cm H2O for a period of two minutes. We then measured maximal variation occurring in the ratio of pulmonary artery pressure over blood pressure.

In all lambs, lungs were fixed with formalin solution for morphometric grading in a blinded manner by an independant pathologist.

RESULTS:

When we stopped draining the thoracic cavity in our patients, survival first improved from 29% to 65%. Which was a significant improvement.

In the lambs with induced diaphragmatic hernia we found a significant relation between pulmonary pressure gradient employed and the pulmonary interstitial emphysema found at post-mortem. So to much pressure can give interstitial emphysema.

In the lambs with induced barotrauma there was a very significant correlation between pulmonary arterial hypertension and the index of perivascular emphysema (% of perivascular emphysema / % of pulmonary vessels). So interstitial emphysema can cause pulmonary arterial hypertension.

DISCUSSION:

These experimental results led us to conclusions that modified some aspects of the treatment of our neonates suffering from CDH.

The negative pressure applied to a thoracic drain is additive to the positive pressure coming from the ventilator. One is pulling on the hypoplastic lung and the other is pushing in. Removing one of these two forces diminishes the chances of barotrauma. So we do not drain anymore.

If we also reduce to a minimum the inspiratory pressure of the ventilator we further increase the chances of survival in our small patients. Inserting a gastric tube will help to attain that goal.

These precautions dramatically improved our survival rate up to 83% instead of 29%.

REFERENCES:

1. Cloutier R, Fournier L, Levasseur L: Reversion to fetal circulation in CDH: J. Pediatr Surg 1983, 18:551-554

2. Macklin CC, Impediment to circulation occasioned by pulmonic interstitial emphysema and pneumomediastinum. J Mich State Med Soc 1940, 39: 756-59

3. de Luca H, Cloutier R, Laberge JM et al: Pulmonary Barotrauma in Congenital Diaphragmatic Hernia: experimental study in lambs. J Pediatr Surg 1987, 22:311-316

HIGH OXYGEN CONCENTRATION ADMINISTRATION IS REQUIRED IN VENTILATED POST-OP THORACIC/ABDOMINAL SURGICAL PATIENTS

M.D. Sharpe MD, H.R. Wexler, MD
Departments of Anaesthesia/Critical Care,
University Hospital, University of Western Ontario,
London, Ontario, N6A 5A5

INTRODUCTION

All patients are at risk of developing hypoxemia following major thoracic/abdominal procedures. Factors predisposing to hypoxemia may include decreased cardiac output, ↑ respiratory shunt (Qs/Qt), reduced lung volume, and ↑ V/Q mismatch as well as mishaps during transfer from the operating room (OR) to the ICU. Also, the patient who has appeared to have had adequate oxygenation in the OR may be hypoxemic on arrival in the ICU. Given these possibilities, we noted that neither the incidence of inadequate oxygenation nor the optimal inspired oxygen concentration (FIO_2) upon initiation of positive pressure ventilation (PPV) in the ICU has been addressed. We therefore examined initial blood gases and FIO_2's following institution of PPV in post-op ICU patients.

METHODS

73 patients following either coronary artery bypass grafting (CABG) or mitral or aortic valve replacement (VR) or liver transplantation (Tx) were sequentially entered in our study. At the time of ICU admission the initial ventilating parameters were ordered at the discretion of the attending anaesthetist and the following parameters were recorded: age, arterial and mixed venous (mv PO_2) blood gases, cardiac index (CI), and FIO_2; Qs/Qt was calculated. Data between groups was analyzed using ANOVA and Student-Newman-Keuls tests. All patients were then allocated to a $FIO_2 \leq .50$ or $FIO_2 > .50$ group according to the initial FIO_2 ordered. Their corresponding PaO_2's were then recorded and allocated to either a PaO_2 less than or greater than 100 mmHg group.

RESULTS

Mean Qs/Qt was high in all groups (Table I). 2/73 (3%) patients were hypoxemic (defined as PaO_2 <60mmHg); one patient was receiving a FIO_2 of .50 (PaO_2 = 57) and the other patient was receiving a FIO_2 = 1.0 (PaO_2 =43). This patient was known to be hypoxemic in the OR and was administered 100% O_2 throughout the case.

46/73 or 63% of all patients were administered a $FIO_2 \leq .50$ and ten of these patients had PaO_2's <100 (range 57-95, mean = 84 ± 12) while only 1/27 patients in the FIO_2>.50 group had a PaO_2 < 100 ($p<.05$, Chi square analysis) and this was the patient who was hypoxemic intraoperatively with a post-op PaO_2 of 43. The mean FIO_2 administered to the FIO_2>50 group was .92 ± 13

CONCLUSIONS

1) Post-op thoracic and abdominal surgical patients are at significant risk to develop hypoxemia as demonstrated by their high Qs/Qt. 2) administration of a $FIO_2 \leq .50$ predisposes these patients to develop hypoxemia, therefore, 3) we suggest administration of 100% O_2 upon initiation of PPV in the ICU until assessment of oxygenation has been performed either by blood gas sampling or oximetry.

TABLE I

	n	Qs/Qt	CI
Liver Tx	20	.50±.23	5.57±1.40*
VR	12	.54±.23	2.26±.55
CABG	35	.51±.20	2.25±.67

(mean±SD)

(* $p<.001$ vs VR + CABG groups)

POST-OPERATIVE HYPOTHERMIA: COMPARISON OF A HOT AIR SYSTEM TO A HEATED WATER BLANKET FOR PATIENTS IN THE POST ANESTHESIA CARE UNIT

Charul A Munshi, M.D. and M. Saeed Dhamee, M.D.
Dept. of Anesthesiology, Medical College of Wisconsin, Milwaukee, WI 53226, USA

Introduction

Postoperative hypothermia is not an uncommon occurrence in spite of efforts at prevention. Several methods have been used for treatment of hypothermia in the Post Anesthesia Care Unit (PACU). We compared a hot air system (Bear Hugger) to a heated water blanket for post-operative rewarming.

Methods

All patients (n=52) with an axillary temperature of 96°F or less on arrival in the PACU were monitored in two hospitals. In one hospital, a heated water blanket (Normo-O-Therm Hyper-Hypothermia Machine, Cincinnati Subzero Products Inc., Cincinnati, OH) (GR-I) at 105°F is routinely used, and a hot air system (Bear Hugger, Augustine Medical Inc., Eden Prairie, MN) (GR-II) at 105°F is routinely used on the other hospital. Axillary temperatures were recorded on arrival in the PACU and every 15 minutes thereafter for 90 minutes. Oxygen saturation and incidence of shivering were also recorded every 15 minutes.

In GR-I (n=29), the patients were placed on the heated water blankets and in GR-II (n=23), the hot air blankets were placed on top of the patients.

Changes in axillary temperatures as a function of time were analyzed for the first 90 minutes using regression analysis. The significance of differences in temperature rise from baseline between the two groups at each time interval were analyzed using Student's unpaired t-test.

Results

Average initial axillary temperature for GR-I was 94.8±1.1°F and GR-II was 92.9±1.1°F. The slopes of the regression lines were 1.94×10^{-2} and 2.87×10^{-2} for GR-I and GR-II, respectively, indicating that rise in body temperature was faster in the GR-II patients. After 90 minutes, the mean axillary temperature increased 2.2±1.4°F in GR-I patients and 3.0±1.1°F in GR II patients (P=0.02) (Figure 1). There were no significant differences in shivering between the the two groups even though the mean initial temperature of GR-II patients was lower than GR-I patients. At the end of 90 minutes, the temperature rise was significantly greater in GR-II patients. Although statistically not significant at every 15 minute interval, temperature rise was greater in GR-II patients. There were no differences in oxygen saturation as measured by pulse oximeter between the two groups at any time interval.

Discussion

Prompt treatment of hypothermia is needed to prevent detrimental effects of shivering, increased oxygen consumption, acidosis, delayed recovery from anesthesia, and prolonged neuromuscular blockade.

The hot air warming system resulted in a faster rate of warming compared to the heated water blankets. Unlike the water blankets, in which a few minutes are needed to warm the water, the hot air system can be used immediately and also there is no danger of water leakage.

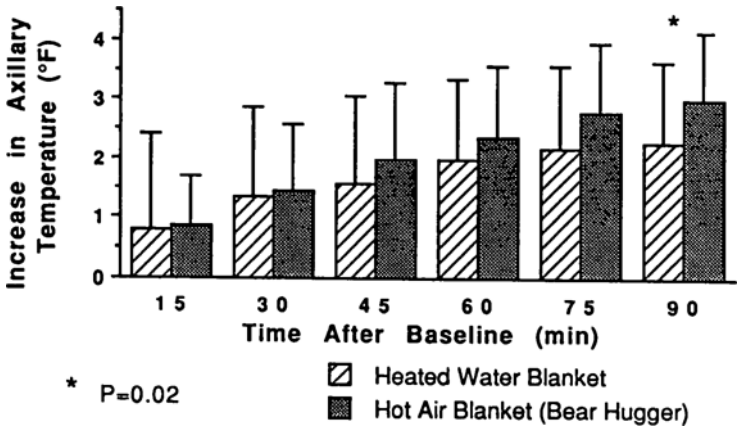


Figure 1. Increase in Axillary Temperature From Baseline in Post Anesthesia Care Unit Patients Warmed with Heated Water Blankets and Hot Air Blankets (Bear Hugger).

EFFECTS OF LOW-DOSE DOPAMINE AND DOPEXAMINE ON RENAL FUNCTION DURING CARDIO-PULMONARY BYPASS

R. Rooney FFARCSI, SK Ong, E. O'Leary FFARCSI, M. McCarroll FFARCSI, D. Phelan FFARCSI.
Department of Anaesthesia & Intensive Care, Mater Misericordiae Hospital, Dublin 7, Ireland.

INTRODUCTION

Studies have shown that dopamine provides protection against renal dysfunction in major surgical operations (1). Dopexamine hydrochloride, a dopamine analogue, is a potent dopamine receptor agonist. However, it is a more potent beta 2 agonist than dopamine and by increasing renal blood flow to a greater extent than dopamine, should be a better agent for renal protection (2). The aim of this study was to compare the renal effects of prophylactic infusions of dopamine and dopexamine. By studying renal function during cardiopulmonary bypass (CPB) the indirect renal effects which might result from changes in cardiac output were eliminated.

METHODS

Nineteen patients presenting for coronary artery bypass surgery were chosen and randomly assigned to one of three groups. After induction of anaesthesia, Group 1 (control) received normal saline, Group 2 received dopamine (2 ug/kg/min) and Group 3 received dopexamine (2 ug/kg/min). Haemodynamic parameters were maintained within normal limits during CPB. Creatinine clearance, urinary sodium excretion and urine output output were measured at 20 minute intervals throughout CPB. Statistical analysis was performed using one way analysis of variance and Student's t test where indicated. A probability of less than 0.05 was considered significant.

RESULTS

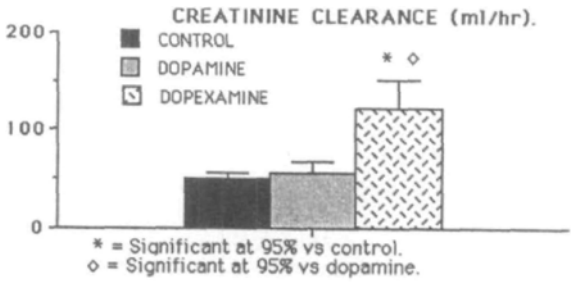
Sodium excretion and urine flow were highest in the dopamine group compared with the dopexamine and control groups, but this did not reach statistical significance. Creatinine clearance was significantly higher in the dopexamine group than in the dopamine or control groups.

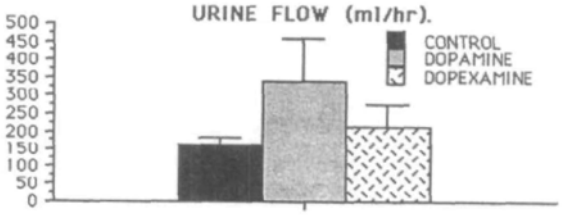
CONCLUSION

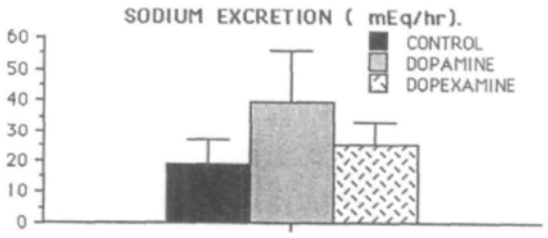
The increase in sodium excretion and urine output induced by dopamine are in keeping with its known diuretic effect (3). However, dopexamine hydrochloride appears to exert a more beneficial effect on renal function, as evidenced by a significant increase in creatinine clearance. This effect is probably related to its beta2 agonist properties.

REFERENCES

(1) Annals of the Royal College of Surgeons of England, 70, 9-12 : 1988.
(2) British J. Pharmacology, 85, 599 : 1985.
(3) Proc. Soc. Exp. Biol. and Med., 129, 210-13 : 1968.







CHANGES IN COAGULATION PROFILE ASSOCIATED WITH PNEUMATIC TOURNIQUET RELEASE

T. Young FFARCSI, D. Coghlan, E. O'Leary FFARCSI, W.P. Blunnie FFARCSI.
Department of Anaesthesia & Intensive Care, Mater Misericordiae Hospital, Eccles St., Dublin 7, Ireland.

INTRODUCTION

Pneumatic tourniquets are widely used in limb surgery to provide a bloodless surgical field. The associated ischaemia may induce coagulation changes on tourniquet release. This study investigated the change in coagulation profile associated with the use of a thigh tourniquet for an intermediate period during knee arthroscopies.

METHODS

Ten consecutive ASA Class 1 adults scheduled for routine arthroscopy under general anaesthesia were studied. Blood for a coagulation profile (P.T., P.T.T.K., Platelet count, Plasminogen and Factor VIII levels) were taken via peripheral vein prior to induction of anaesthesia. Repeat assays were performed 3 and 15 minutes post tourniquet release on samples taken via the femoral vein on the operated side. Statistical analysis was performed with Fisher's exact probability test and the Wilcoxon Rank Sum Test.

RESULTS

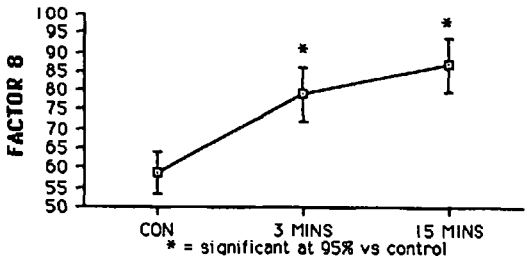
The mean tourniquet time was 56 minutes. There was a statistically significant fall in P.T.T.K. at 3 and 15 minutes post tourniquet release compared to the pre-induction value ($p < 0.05$). Factor VIII levels were significantly elevated at 3 and 15 minutes post tourniquet release ($p < 0.05$). The remainder of the coagulation profile did not change significantly post tourniquet release.

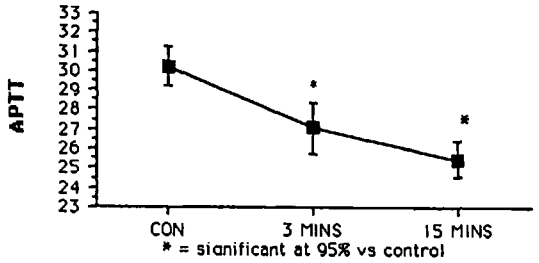
CONCLUSION

A short period of fibrinolysis without rebound has been previously reported following release of an occlusive tourniquet (1 - 3). Our study failed to show the occurrence that a hyper-coagulable state may be present following tourniquet release.

REFERENCES

(1) Lancet, 971 : 1977.
(2) Thrombosis Research, 11, 817-25 : 1977.
(3) The Journal of Bone and Joint Surgery, 63 (3), 461-5, 1971.





THE PEAK EFFECT OF FENTANYL IN CHILDREN

W.M. Splinter, MD, FRCP(C)
Children's Hospital of Eastern Ontario and University of Ottawa, Ottawa, Ontario.

INTRODUCTION: Fentanyl (F) supplementation of an IV anaesthetic induction with sodium thiopental blunts the pressor response to laryngoscopy and tracheal intubation. The optimal time to administer F before laryngoscopy is unknown. The peak effect of F given to adults is about 2 minutes after administration.[1] To determine the optimal time to inject low-dose F we investigated children administered F at 1, 2, 3 or 4 minutes before tracheal intubation.

METHODS: After the study was approved by the Hospital Ethics Committee, we obtained consent from the parents of 120 healthy children, ages 2-12 years undergoing elective surgery. Subjects were excluded from study if they had cardiac or respiratory disease, or a study drug was relatively or absolutely contraindicated. The subjects were randomly assigned to one of four groups. On arrival in the operating room the patient's HR, SBP, mean blood pressure (MBP), and DBP were monitored q1min with a Dinamap^{R} non-invasive blood pressure monitor (NIBP). During the first minute of study, subjects were sedated by inhaling a mixture of 70% N_2O and 30% O_2 and an IV catheter was inserted. Subsequently the N_2O was discontinued and patients were offered 100% O_2 for the remainder of the induction. Fentanyl, 3 mcg/kg, was administered IV 4.1, 3.1, 2.1 or 1.1 minutes before laryngoscopy and intubation. Vecuronium (0.1 mg/kg) and thiopental (4 mg/kg) were administered 2.0 minutes and 1.8 minutes prior to intubation, respectively. The trachea was intubated within 15 seconds by an experienced anaesthetist or anaesthesia resident. After intubation, anaesthesia was maintained for 2 minutes with 70% N_2O, 30% O_2 and 1.5% halothane delivered through a coaxial circuit and ventilation was controlled to maintain normocapnia. Subjects were not stimulated during the observation period. (The observation period was 7 minutes long, from the start of induction to 1.9 minutes after intubation.)
The data was analyzed using the Minitab^{R} General Linear Model Procedure and ANCOVA (covariates were baseline values and patient age). All results were accepted as significant if $P<0.05$.

RESULTS: There were no significant differences between the groups with respect to age, weight, gender and baseline haemodynamic variables. HR was significantly increased immediately after intubation, $P<0.001$. HR was not significantly different between the groups (Figure). Although SBP was significantly increased immediately after intubation, the increase was less among the subjects administered F at 2 and 3 minutes before intubation when compared to those administered F 1 minute before intubation. By 2 minutes after intubation, SBP, DBP and MBP were significantly less than baseline, $P<0.01$.

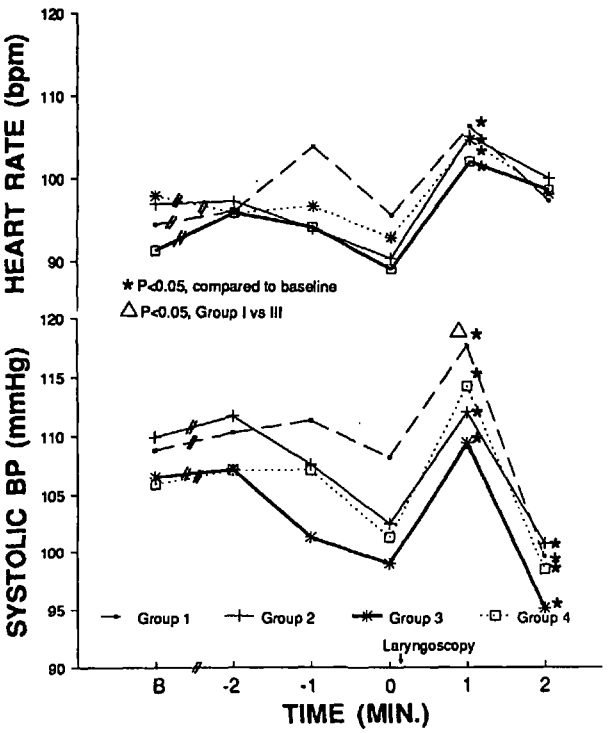


Figure: The heart rate and systolic blood pressure at rest (time=B, baseline), during induction of anaesthesia and after tracheal intubation among subjects administered fentanyl one (Group 1), two (Group 2), three (Group 3) or four (Group 4) min before intubation.

DISCUSSION: The optimal time to administer low-dose F to children is to 2 to 3 minutes before intubation. This is consistent with adult studies of the speed of onset and EEG responses to F.

References: 1. Bowdle TA, Ward RJ. Anesthesiology 1989; 70: 26-30.

THE PEAK EFFECT OF ALFENTANIL IN CHILDREN

W.M. Splinter, MD, FRCP(C)
Children's Hospital of Eastern Ontario & University of Ottawa, Ottawa, Ontario.

Introduction: Alfentanil (Alf) supplementation of an IV anaesthetic induction with sodium thiopentone (STP) blunts the pressor response to laryngoscopy and tracheal intubation. The optimal time to administer Alf before laryngoscopy is unknown. To determine the optimal time to inject low-dose Alf we investigated children administered A at 1, 2, or 3 minutes before tracheal intubation.

Methods: After the study was approved by the Hospital Ethics Committee, we obtained consent from the parents of 93 healthy children, ages 2-12 years undergoing elective surgery. Subjects were excluded from study if they had cardiac or respiratory disease, or a study drug was relatively or absolutely contraindicated. The subjects were randomly assigned to 1 of 3 groups. On arrival in the operating room the patient's HR, SBP, mean blood pressure and DBP were monitored q1min with a Dinamap^{R} non-invasive blood pressure monitor (NIBP). During the first minute of study, subjects were sedated by inhaling a mixture of 70% N_2O and 30% O_2 and an IV catheter was inserted. Subsequently the N_2O was discontinued and patients were offered 100% O_2 for the remainder of the induction. Alf, 20 mcg/kg, was administered IV 3.1, 2.1 or 1.1 minutes before laryngoscopy and intubation. Vecuronium, 0.1 mg/kg, and STP, 4 mg/kg, were administered 2.0 minutes and 1.8 minutes before intubation, respectively. The trachea was intubated within 15 seconds by an experienced anaesthetist or anaesthesia resident. After intubation, anaesthesia was maintained for 2 minutes with 70% N_2O, 30% O_2 and 1.5% halothane delivered through a coaxial circuit and ventilation was controlled to maintain normocapnia. Subjects were not stimulated during the observation period. (The observation period was 7 minutes long, from the start of induction to 1.9 minutes after intubation.) The data was analyzed using the Minitab^{R} General Linear Model Procedure and ANCOVA (covariates were baseline values and patient age). All results were accepted as significant if $P<0.05$.

Results: There were no significant differences between the groups with respect to age, weight, gender and baseline hemodynamic variables. Alf had a rapid effect on haemodynamic variables. Within 1 minute of administration there was a significant decrease in HR and BP among the patients administered Alf (FIGURE). The subjects who received Alf 3 min before intubation had greater increase in HR immediately after intubation when compared to the other two groups and when compared to baseline values, $P<0.05$. SBP immediately after intubation was similar when compared to baseline and similar among the groups studied. By 2 minutes after intubation, SBP, DBP and MBP were significantly less than baseline, $P<0.05$.

Discussion: In children, there is a rapid decrease in heart rate and blood pressure following Alf administration. Low-dose Alf blunts the haemodynamic responses to intubation of children when administered 1 to 2 minutes before the stress. This is consistent with adult studies of the speed of onset of Alf.

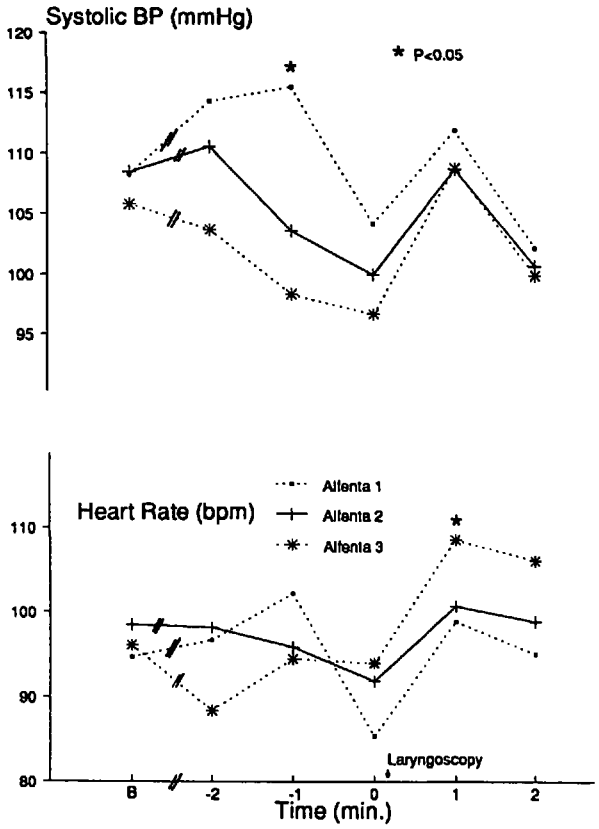


Figure. The heart rate and systolic blood pressure at rest (time=B, baseline), during induction of anaesthesia, and before and after tracheal intubation in children treated with alfentanil, 20 mcg/kg, 1(Alfenta1), 2(Alfenta2) or 3(Alfenta3) min before tracheal intubation.

TRANSOESOPHAGEAL ASSESSMENT OF LEFT VENTRICULAR FUNCTION DURING ABDOMINAL AORTIC ANEURYSM RESECTION

RYAN T, FFARCSI, MAGUIRE M, BOUCHIER-HAYES D, FRCSI CUNNINGHAM A.J., FRCPC

DEPARTMENT OF ANAESTHESIA, BEAUMONT HOSPITAL, DUBLIN, IRELAND.

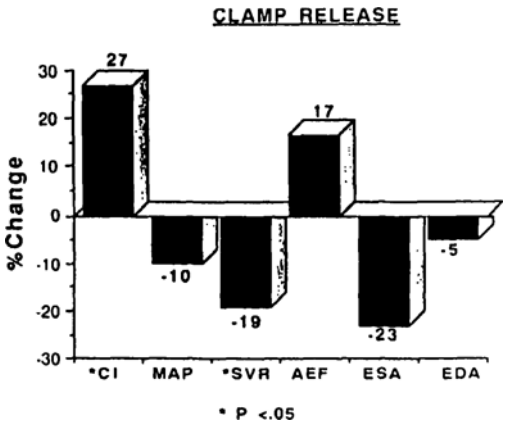
Introduction:
Aortic clamping and release may be associated with significant haemodynamic changes.[1] Transoesophageal echocardiography (TOE) provides a method of measuring ejection fraction and estimating left ventricular perload intraoperatively.[2] Echocardiographic assessment of ventricular function was compared with standard methods of assessment.

Methods:
Following Ethics Committee approval, 10 patients scheduled for infrarenal aortic aneurysm resection were studied. Preoperative cardiac status was assessed by physical examination, electrocardiogram, chest x-ray, Goldman Risk Index (CRI) and left ventricular ejection fraction determined by radionuclide ventriculography (RNAEF). Prior to induction of anaesthesia, radial and pulmonary artery catheters were inserted under local anaesthesia. A standardised anaesthetic technique included premedication with oral diazepam, induction with fentanyl 3-6 $\mu g/kg^{-1}$, thiopentone 1-3 mg/kg^{-1} and vecuronium 0.1 mg/kg^{-1}. Hypertension >25% of baseline was treated with iv infusion of nitroglycerin and incremental bolus of fentanyl. A 5 mHz TOE probe was inserted to view the short axis of the left ventricle at the mid papillary muscle level. Haemodynamic data, including heart rate, blood pressure, pulmonary artery occlusion pressure (PAOP), thermodilution, cardiac output (CO) and systemic vascular resistance (SVR) were collected pre and post aortic clamping and release. TOE data, including left ventricular areas at end systole (ESA) and end diastole (EDA), were recorded on videotape and analysed later. Three consecutive sinus beats at end expiration were averaged to obtain each value of ESA and EDA. Area ejection fraction was calculated by %AEF = (EDA-ESA)(EDA) x100. Student's t test, Kendal Rank correlation coefficient were used to analyse data. P <.05 was considered significant.

Results:
All patients were CRI Class I - II. Preoperative ejection fractions ranged from 21% to 70%. Three patients required nitroglycerin infusion for control of hypertension and one required inotropic support. Aortic clamping was not associated with any significant change in cardiac index (CI), MAP, SVR and PAOP. At clamp release significant changes in cardiac index (CI) (3.0±0.8 $L/m^2/min$ to 3.8±1.0 $L/m^2/min$) and SVR (1270±491 $dy/cm/sec^2$ to 999±317 $dy/cm/s^2$) occured. MAP decreased (89±19.1 mmHg to 85.4±19.8 mmHg) but this was not significant.

Preload, as assessed by LVEDA and PAOP, was unchanged peroperatively. %AEF was unchanged at aortic clamping. At clamp release LVESA decreased (8.3±9.0 cm^2 to 6.5±6.8 cm^2) and %AEF increased (52.7±17.7% to 62.3±18.4%). These changes were not statistically significant. The percent changes in haemodynamic and echocardiac values at clamp release are presented in Figure I.

Figure I



* P <.05

The correlation between LVEDA and PAOP was poor in all patients, even those with preoperative RNAEF>50%. None of the correlation coefficients were significant at the 5% level.

Discussion:
In this patient population, the anaesthetic technique chosen resulted in cardiovascular stability as judged by both haemodynamic and TOE measurements. Clamp release decreased blood pressure and SVR. Concurrent increases in both cardiac index and %AEF indicated that declamping hypotension was due to vasodilation and not to myocardial contractility depression. There was no significant correlation between LVEDA and PAOP thus emphasising the limitations of PAOP as an index of preload in this patient population. Intraoperative TOE improves the ability to quantify left ventricular function.

References:
1. Can J Anaes 1989; 36: 426-44
2. Br J Anaesth 1990; 64: 331-6

POWER SPECTRAL CHANGES IN HEART RATE VARIABILITY DURING ACUTE ISCHEMIA

W.S. BEATTIE, M.D., M.V. KAMATH, Ph.D., E.L. FALLEN, M.D.
Department of Anaesthesia, McMaster University Medical Centre, 1200 Main Street West, Hamilton, Ontario, Canada L8N 3Z5

Introduction:

Most episodes of ischemia are associated with increased O_2 demand. Many ischemic episodes have no hemodynamic precursors, last up to 5 times longer, and are difficult to eliminate. Power spectral analysis offers a unique chance to examine the autonomic changes during acute ischemia. The low frequency (LF) power signal has been equated with sympathetic activity and the high frequency (HF) has been associated with parasympathetic activity.[1] This study compared the power spectral changes of acute ischemia in hemodynamic to non-hemodynamic induced ischemia.

Method:

After institutional ethics approval and informed consent, 7 patients were monitored for 24 hours with a Holter Monitor, a base line HR was established. We defined ischemia ST depression of 1.5 mm as 80 msec after J point for more than 1 min. Hemodynamic ischemia was defined as those ischemic episodes occurring at a HR less than 90 with less than a 10% deviation from baseline HR. Auto regressive power spectra were computed by a previously described algorithm off line on a portable computer.[2] Mean power spectra were computed for the time periods 1 hr, and 30 min before ischemia, during ischemia and for 30 min and 1 hr after the ischemic episode.

Results:

Results are outlined in Table 1. the HF component is depressed during non-hemodynamic ischemia (Figure 1). There is also a rebound of the HF component in the 30 mins after the ischemic episode.

Discussion:

These date, while preliminary, suggest that non-tachycardia induced ischemia is mediated by a loss of parasympathetic/cholinergic tone.

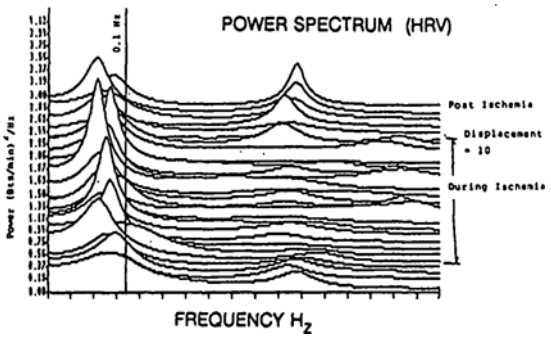
Ischemic episodes which are not associated with tachycardia also lose the LF component. Since the LF is associated cholinergic tone these changes may reflect a loss of cholinergic tone during non-tachycardia ischemia.

Table 1

POWER SPECT. COMP. $(BPM)^2/Hz$

	HR	LF(.1 Hz)	HF(.25 Hz)	RATIO
HR CHANGE n=4				
1 hr pre-ischemia	92.3	65.9	22.3	3.2
1/2 hr pre-ischemia	94.2	64.8	20.8	3.3
ischemia	115.8	67.5	21.3	3.4
1/2 hr post-ischemia	95.9	73.5	22.0	3.5
1 hr post-ischemia	91.8	79.7	21.7	3.9
NO CHANGE n=3				
1 hr pre-ischemia	68.7	76.0	25.6	3.4
1/2 hr pre-ischemia	66.0	73.6	28.4	2.9
ischemia	74.8	92.5	19.4	5.5
1/2 hr post-ischemia	65.2	63.8	37.1	2.0
1 hr post-ischemia	62.7	72.6	27.3	3.5

Figure 1



References:

1. Circ Res 1986;59:178-93.
2. Clin Invest Med 1988;11:331-40.

HIGH-DOSE APROTININ DECREASES BLOOD PRODUCT USAGE IN CARDIAC PATIENTS UNDERGOING REPEAT STERNOTOMY

J.M. Murkin MD, FRCPC, N.A. Shannon RN
Department of Anaesthesia, University Hospital,
University of Western Ontario, London, Ontario.

INTRODUCTION:
The primary observations of Royston and Bidstrup et al[1], reporting significantly decreased bleeding and transfusion requirements during administration of aprotinin in patients undergoing cardiac surgery using cardiopulmonary bypass (CPB), have been corroborated in several other reports during a variety of cardiac surgical procedures.[2,3] To date, no studies examining the efficacy of aprotinin usage in North America, or with usage of a membrane oxygenator for repeat sternotomy, have been reported.

METHODS:
After identification of all 38 cardiac patients undergoing repeat median sternotomy and CPB over the past 18 months in whom the Royston/Bidstrup aprotinin regimen (2×10^6 KIU load to patient and to CPB circuit, followed by 0.5×10^6 KIU/hr during surgery)[2] was followed, an age/procedure/surgeon matched control group, operated on within a one year span, was identified and a chart review conducted. Specific variables examined included duration of CPB, and packed red cell (PRC), fresh frozen plasma (FFP), and platelet (Plt) transfusions administered both during CPB (CPB) and after CPB (post-CPB). Data were analyzed by unpaired two-tailed t-test, or Chi-square for nonparametric variables, with $p<0.05$ required for significance.

RESULTS:
There were 17 repeat coronary artery bypass procedures, and 21 repeat valve repair/replacement procedures in each group, all of whom underwent CPB using a membrane oxygenator and arterial line filter. There was no significant difference between aprotinin-treated and control groups with regard to duration of CPB, age, procedure, or PRC during CPB. Throughout the perioperative period, aprotinin patients were significantly more likely than the control group not to receive transfusions of any blood products, 8/38 vs 2/38 respectively ($p=0.036$), and also received significantly less FFP 2.3±2.3 vs 3.9±2.3 ($p=0.004$), and Plt 1.5±3 vs 4.2±4 ($p=0.002$) post-CPB. One patient in the aprotinin group and two in the control group were excluded from analysis of group mean blood product use since they developed an apparent coagulopathy, defined as blood product administration greater than group mean+2 s.d. One patient in each of the aprotinin and control groups required surgical re-exploration for postoperative bleeding.

DISCUSSION:
Aprotinin is a serine protease inhibitor, suppressing kallikrein generation and significantly decreasing plasmin formation, felt to be major factors in the genesis of excessive bleeding after CPB. While its use in North America had primarily been restricted to treatment of pancreatitis and pulmonary emboli, this study demonstrates aprotinin is efficacious in decreasing blood product administration in cardiac patients undergoing repeat sternotomy and CPB, even with use of a membrane oxygenator.

REFERENCES:
1. van Oeveren W, Jansen NJG, Bidstrup BP, Royston D, Westaby S. Effects of aprotinin on hemostatic mechanisms during cardiopulmonary bypass. Ann Thorac Surg 1987;44:640-5.
2. Royston D, Bidstrup BP, Taylor KM, Sapsford RN. Effect of aprotinin on need for blood transfusions after repeat open heart surgery. Lancet 1987;ii:1289-91.
3. Reduction in blood loss and blood use after cardiopulmonary bypass with high-dose aprotinin (Trasylol). J Thorac Cardiovasc Surg 1989;3:364-72.

Assessment of Behaviour During Mask Induction in Paediatric Patients

C. J. Montgomery MD, FRCPC, H. W. Karl MD
Department of Anesthesiology, Children's Hospital and Medical Center,
4800 Sand Point Way N.E., P.O. Box C5371, Seattle, WA U.S.A. 98105

INTRODUCTION:

An important issue in the design and evaluation of clinical studies assessing the efficacy of pre-medication in children is the subjective nature of behaviour assessment. Previous investigators have used a descriptive ordinal scale.[1] During preliminary investigation of oral transmucosal triazolam, an ordinal behaviour score[2] was used and assessed for ease of use and reliability.

METHODS:

After informed consent, twenty-five outpatients who had selected mask induction of anesthesia were studied without blinding or randomization. Thirteen patients received 5-15 µg/kg of oral transmucosal triazolam 10 to 40 minutes prior to induction. The remaining 12 patients had no premedication. Behaviour was scored by 3 raters using a 5 category behaviour score in which single word descriptors were supplemented with behavioural criteria. The first rater was always the principal investigator, the second was the attending anesthesiologist or the resident and the third was an anesthetic nurse. All patients underwent a standardized mask induction with the parents present. Their behaviour was scored independently by each of the 3 raters at 4 times during induction: immediately before application of the pulse oximeter probe(Pre); after probe application (Post); at first placement of the mask(Mask); and the worst behaviour until loss of consciousness(Worst). The results were tabulated and interrater reliability evaluated using kappa statistics[3].

RESULTS:

The patients' ages ranged from 1 to 11 years, with a mean (+/- S.D.) of 4.6 (+/-2.6) years. There were 100 different observation points and 300 observations. The frequency distribution of behaviour scores is shown in Figure 1. There were no observation in category 1 and there was a higher incidence of scores 2 and 3 throughout induction All 3 raters agreed at 51 observation points (51%). Behaviour scores differed by one at 39 observation points (39%) and by two 10 times(10%). Kappa analysis showed rater agreement greater than that expected by chance($p<0.01$) at all observation points except the first.(Fig 2).

DISCUSSION:

The absence of scores at level 1(Drowsy/Asleep) reflects the minimal hypnotic effect of triazolam at these doses. The frequency of the scores 2-3 suggests that the behaviour score might be made more sensitive by expanding the categories in this area. Kappa analysis assesses agreement between raters beyond that expected to occur by chance, and does not require an interval scale. The low agreement between raters at the first observation point (Pre) and its increase over the following three may reflect a training effect. Alternatively, behaviour may become easier to judge as the stresses of induction accumulate. The reliability of three raters' evaluation of premedication efficacy has been assessed previously using a similiar behaviour scale with data analysis with ANOVA-based intraclass correlation coefficients.[2] Kappa analysis provides an advantage in that does not require assumption of an interval scale. Further study is needed to devise an optimum method to evaluate the effects of anxiolytic agents in infants and children.

REFERENCES:

1. Anaesthesia 45:427-35,1990
2. Anesthesiology 71:A932,1989
3. Statistics in Medicine 9:1103-1115,1990

Figure 1:

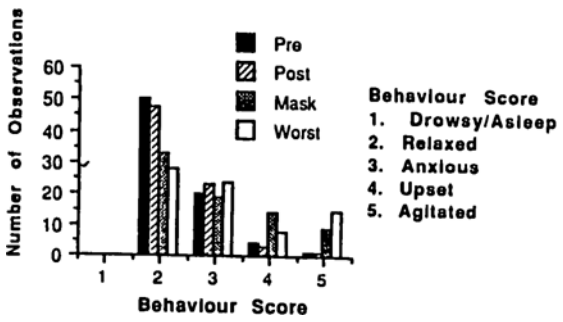
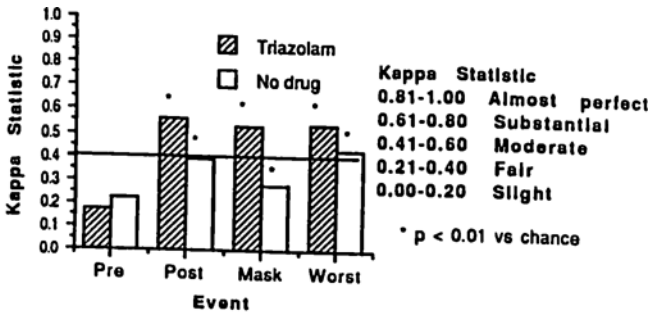


Figure 2:



Oxygen saturation during patients transfer: IS APNEA A BETTER ALTERNATIVE ?

Jacques Raymond MD, Pierre Drolet MD, FRCPC
Dept. of Anaesthesia, Maisonneuve-Rosemont Hospital, 5415 l'Assomption Blvd., Montreal, H1T 2M4

INTRODUCTION

It is a common practice in adult anaesthesia to increase the oxygen uptake of patients at the end of surgery and in the post-anaesthesia care unit (PACU). During transfer to the PACU, oxygen is not widely used because it seems unpractical to carry a cylinder. Most anaesthesiologists during transfer, have their patient breathing room air, spontaneously or with assistance (Ambu bag). However, this practice has been shown to involve a risk of hypoxaemia with children [1,2] as well as with adults [3,4].

The present study propose an alternative which alleviate the need for a cylinder and possibly offers a better oxygenation during transport: Apnea after ventilation with pure oxygen at the end of surgery.

METHODS

For a period of three months (oct. - dec. 1990), we studied 160 adult patients ASA class I, II or III who underwent surgery under general anaesthesia with intubation and who, in the opinion of the attending anaesthesiologist, did not need supplemental oxygen during transfer to the PACU. We did not control the choice of anaesthetic technique, except for the reversal of myorelaxant drugs which was necessary for the transfer of patients mode I (see below).

At least five minutes before being transferred from the operating room (OR) to the PACU; each patient was given 100% oxygen. In order to avoid coughing, 1 Mac % volatile anaesthetics was administered until it was time to leave the OR. If the patient coughed before transfer, xylocaïn 1-2 mg/kg IV was given. Patients were excluded from the study if they coughed or presented breath-holding during transfer.

They were divided between three mode of transfer. In Mode I we had the patients spontaneously breathing room air. In Mode II, patients were manually ventilated with room air and finally, in Mode III, patients remained completely apneïc during transfer. All patients' SpO_2 were monitored with an Ohmeda pulse oxymeter.

On arrival to PACU, all patients were allowed to complete a period of three minutes in the same mode of ventilation unless the SpO_2 reached 90 or less. Then, supplemental oxygen was given. $EtCO_2$ was also measured with a Datex capnograph when leaving the OR and three minutes later. We noted the time required for transfer and the different SpO_2 values (OR, PACU and three minutes after leaving the OR). Time to reach a SpO_2 below or equal to 90 was also noted if less than three minutes.

The study was approved by the ethics committee of our hospital who judged that an informed consent was not necessary.

For statistical analysis, ANOVA and Scheffe was used for continuous variables and the X^2-test was used for discrete variables.

RESULTS

The following is a preliminary analysis for the first 118 patients studied. There was no difference between the three groups regarding age, sex, ASA class, weight, body mass index, smoking history, hemoglobin, type of surgery, duration of anaesthesia and surgery, temperature, arterial pressure, presence of jaundice and use of methylene blue.
Variation of $EtCO_2$ during transfer was not clinically significant. Time elapsed during transfer ranged from 30 to 40 seconds (mean: 85.8 sec).

Mean SpO_2 before transfer was 98.8% for mode I and II and 99.5% for mode III which was statistically significant ($p<.01$).

On arrival to PACU, mean SpO_2 was 97.0% for mode I and mode II, and 99.0% for mode III showing a statistically significant difference only between the last and the first two ($p<.001$).

Mean SpO_2 values at three minutes was 95.0% for mode I, 95.5% for mode II and 97.7% for mode III again statistically significant if we separate only the last from the first two modes ($p<.001$).

A fall of 5% or more in SpO_2 was found in 17 of 38 pts (45%) with mode I, 11 of 38 pts (29%) with mode II and 6 of 42 pts (14%) with mode III ($p = .01$).

A fall of SpO_2 below 95% was found in 19 of 38 pts (50%) with mode I, 17 of 38 pts (45%) with mode II and 8 of 42 pts (19%) with mode III ($p<.01$).

A fall of SpO_2 below 90% was found in 6 of 38 pts (16%) with mode I, in 7 of 38 pts (18%) with mode II and in 3 of 42 pts (7%) with mode III but no statistically significant difference was found.

DISCUSSION

We find a fall of SpO_2 which was greater with mode I and II when compared to mode III. We also found that less patients in mode III reached a SpO_2 of 90 or 95%. A fall in SpO_2 of 5% or more was also less frequent in group III. All those differences have been shown to be statistically significant except for the fall to 90% or below.

It is also true there is a slight difference between inital SpO_2. Although statistically significant, we believe that this difference is hardly clinically relevant.

Apneic oxygenation has already been known to provide adequate oxygen without any ventilation. However, its safety has never been verified for the transfer of patient. This study shows that it is at least as secure as the common practice of using air for ventilation either artificially or spontaneously.

REFERENCES

[1] Canadian Journal of Anaesthesia 34: 5, 470-3, 1987
[2] Anesthesiology 69: 616-18, 1988
[3] Anesthesia and Analgesia 64: 1108-12, 1985
[4] Anesthesia and Intensive Care 15: 147-150, 1987

BENEFICIAL EFFECTS OF CLENTIAZEM ON POST-ISCHEMIC CORONARY FLOW IN ISOLATED RABBIT HEARTS

M. Tanguay, M.Sc., G. Blaise, M.D., D. Garceau, Ph.D., L. Dumont, Ph.D.

Dép. d'anesthésie et de pharmacologie, Hôpital Notre-Dame et Université de Montréal, Nordic Lab. Inc., Laval, Québec

Introduction:
During the last few years, researchers have attempted with more or less success to improve peroperative myocardial protection by adding many components to the cardioplegia, including calcium antagonists. Until now, this pharmacological class was beneficial to myocardial recovery when added to normothermic cardioplegia but seems to lose its benefial effect when added to cold cardioplegia (1). Clentiazem is a new benzothiazepine calcium antagonist that is more lipophilic than diltiazem, due its chlorine molecule (2). This physicochemical property could provide a better cellular penetration and thus better cytoprotective effect. The purpose of this study was to investigate the post-ischemic protective effect of clentiazem, when added to cold cardioplegia.

Methods:
Isolated rabbit hearts were perfused in a Langendorff apparatus with an oxygenated (95% O_2, 5% CO_2) Krebs-Ringer solution at a constant pressure of 85 cm of water. The coronary flow was monitored with an ultrasonic flowmeter probe placed in the pefusion line. The isovolumetric left ventricular pressure (LVP) was measured by a saline-filled latex balloon inserted in the left ventricle and connected to a pressure transducer. Hearts were rendered globally ischemic for 90 min by clamping the aortic line. A cold cardioplegic solution (St. Thomas Hospital), with or without clentiazem 10^{-6} M, was then allowed to flow through the coronary bed from a reservoir located 100 cm above the heart. Cardioplegic solution was infused in order to reduce myocardial temperature to 10-12° C. After 15 min of reperfusion, a starling curve of the left ventricle was obtained by increasing the volume of the intracardial balloon to change diastolic pressure from 5 to 25 mmHg in steps of 5 mmHg. Coronary flow and EKG were monitored before ischemia and following reperfusion (30 min).

Results:
Before ischemia, the left ventricular starling curve was similar in both groups and it decreased to a similar extent after the ischemic period (fig. 1). Basal coronary flow, obtained prior to the ischemic period, was equivalent in both groups (28.3 ± 2.4 ml/min in control group and 31.7 ± 3.6 ml/min in clentiazem group), but post-ischemic values were higher in the clentiazem group for the first 15 min of reperfusion (fig. 2). No arrhythmia was observed at reperfusion.

Discussion:
The experimental model used in this study reproduced clinical situations in which cold cardioplegia is used to protect the myocardium against global ischemia (peroperative cardioprotection). Our data suggest that the addition of clentiazem in cold cardioplegic solution provides improvement of coronary perfusion following a prolonged period of ischemia. No deleterious effects on myocardial contractility were observed when compared with the control group. Additional studies (metabolic, cellular) are needed to assess the cytoprotective properties of clentiazem in addition to its beneficial effects on post-ischemic coronary flow.

References:
1. Circulation 70 (suppl I):I-54, 1984.
2. Cardiovascular Drugs and Therapy 4:723-730, 1990.

Figure 1

EFFECT OF CLENTIAZEM ADDITION TO COLD CARDIOPLEGIA ON SYSTOLIC LEFT VENTRICULAR PRESSURE

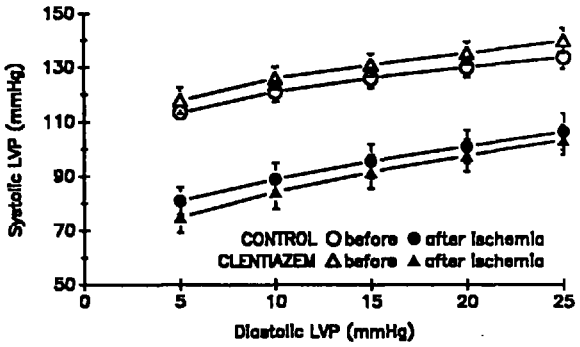
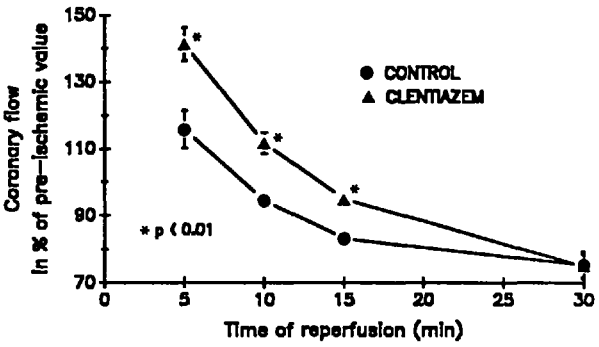


Figure 2

EFFECT OF CLENTIAZEM ADDITION TO COLD CARDIOPLEGIA ON POST-ISCHEMIC CORONARY FLOW



HALOTHANE ATTENUATION OF ACETYLCHOLINE INDUCED VASODILATION OF ISOLATED CANINE VESSELS: ARE ARACHIDONIC ACID METABOLITES INVOLVED ?

A. Omri, Pharm B, G.A. Blaise,MD, M. Sharkawi, PhD

Notre-Dame Hospital, University of Montreal, Depts. of Anesthesiology and Pharmacology, Montreal, Quebec

INTRODUCTION:

Several substances are vasodilators by releasing vasoactive compounds from the endothelium. The endothelial cells can release both vasoconstrictors and vasodilators (1). Acetylcholine (ACh) induces vascular dilation by releasing endothelium derived relaxing factor (EDRF) from endothelial cells. It has been observed that halothane attenuates the ACh-induced vasodilation (2), and increases the tension of precontracted intact rat vessels, this last effect was potentiated in the presence of indomethacin (3) suggesting that halothane has an effect on arachidonic acid metabolism. The objective of the present study was to determine if halothane's attenuation of ACh-induced vasodilation is due to the release of vasoactive intermediate of arachidonic acid metabolites by endothelial cells.

MATERIALS AND METHODS:

The experiments were performed on rings of femoral arteries taken from dogs of either sex (15-25 kg) anesthetized with sodium pentobarbital (30 mg/kg I.V.). The femoral arteries were dissected and cut into 5 mm rings. The rings were cleaned of fat and loose connective tissue and suspended on a pair of stirrups and introduced in 25 cc organ chambers filled with oxygenated Krebs-Ringer solution maintained at 37 oC and attached to an isometric force transducer and recorder. All vessels were brought to their optimum passive tension and allowed to relax for at least 30 min, then contracted with phenylephrine ($3X10^{-6}M$). In order to block selectively the different metabolic pathways of arachidonic acid, quinacrine (Q), $1X10^{-5}M$, a phospholipase A2 inhibitor, nordihydroguaiaretic acid (NDGA), $1X10^{-6}M$, a lipoxygenase inhibitor or indomethacin (I), $1X10^{-5}M$ a cyclo-oxygenase inhibitor was added the organ chambers, 10 min later, halothane (2.5%) was bubbled, after 5 min, the dose-response to ACh was carried out. Appropriate controls were run simultaneously.

RESULTS:

Ach-induced relaxation was not affected by quinacrine, $1X10^{-5}M$, NDGA, $1X10^{-6}M$ or indomethacin, $1X10^{-5}M$. Halothane at a concentration of 2.5%, significantly attenuated Ach-induced relaxation (fig 1). However indomethacin does not modify this effect (fig 2) while Q or NDGA (fig 3) slightly attenuates halothane's effect.

DISCUSSION:

Our data confirm the inhibitory effect of halothane on ACh-induced relaxation, a blockade of phospholipase A2 or lipoxygenase attenuates the effect of halothane on ACh response, this suggest that in presence of halothane the muscarinic stimulation of the canine femoral endothelial cells release a prostanoid vasoconstrictor which is a metabolite of the lipoxygenase pathway.

REFERENCES:

1. N Engl J Med 1990; 2: 27-36
2. Anesthesiology 1988; 68: 31-37
3. Anesthesiology 1989; 71: 126-132

Figure 1

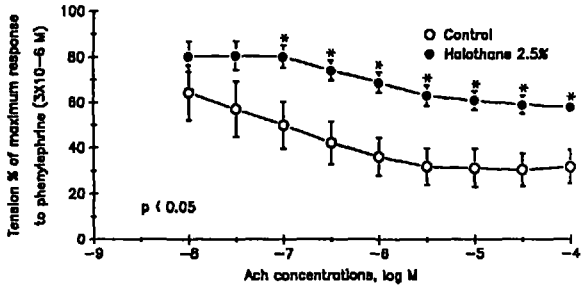


Figure 2

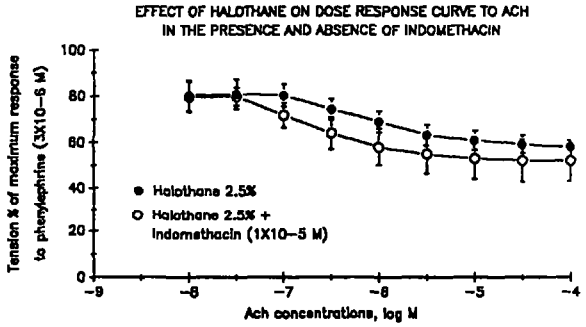
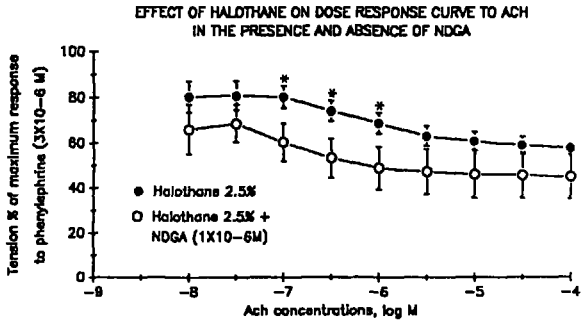


Figure 3



HYPERTENSION AFTER INTUBATION : HOW MUCH PROPOFOL CAN PREVENT IT ?

V. BILLARD, J.L. BOURGAIN

Institut Gustave-Roussy, 94805 Villejuif Cedex. France.

INTRODUCTION

For many years, haemodynamic stability after a noxious stimulus has been considered as one of clinical signs of an adequate depth of anaesthesia. It was even included in scoring system (1) used for adjusting a continuous supply of drug. Laryngoscopy and orotracheal intubation are particular stimulations whose direct haemodynamic consequences have been often mentionned but with discordant results (2, 3).
The purpose of this work was to study laryngoscopy and orotracheal intubation as a common noxious stimulation, and to compare blood pressure and heart rate changes, following induction and orotracheal intubation, in patients randomly allocated to receive variable doses of Propofol.

PATIENTS AND METHODS

Thirty two patients, ASA I or II, 18-65 years, were included. Patients with arterial hypertension, coronary artery disease or any kind of ischemic history were excluded.
Fentanyl 2 µg/kg was first administered ; five minutes later, anaesthesia was induced by a random dose of Propofol (2, 2.5, 3 or 3.5 mg/kg), and Vecuronium 0.1 mg/kg was given to facilitate orotracheal intubation. Patients were then manually ventilated with an FIO2 = 1. Intubation was performed 4 min after Propofol administration in each group and the patient lungs were mechanically ventilated for 3 min (FIO2 = 1, PETCO2 35 ± 2 mmHg).
Blood pressure and heart rate were recorded continuously from a radial artery catheter, inserted before induction under local anaesthesia.
Changes in systolic blood pressure (SBP), diastolic blood pressure (DBP), and heart rate (HR) after induction and intubation were expressed as percentages of pre-induction values. Significance of changes in all variables was assessed using an ANOVA. The data were then compared using a modified t test. $p<0.05$ was considered statistically significant.

RESULTS

Thirty two patients (eight in each group), aged 57 ± 9, weighting 59 ± 12 kg were included. Age, weight, initial blood pressure and heart rate were similar in all groups. The results are summarized in table 1 and Figure 1. In each dose group, SBP and DBP decreased significantly by the first minute after induction (Figure 1). SBP and DBP returned to baseline values after intubation (Table 1).
No significant change in heart rate was found. No difference relating to Propofol dose was found in any of the parameters measured. The duration of hypotension between induction and intubation was similar in all groups.

DISCUSSION

In the dose scale of Propofol, administered after Fentanyl, arterial blood pressure following intubation didn't exceed base line values. This is in agrement with published works (2) where Propofol was used in combination with opioids drugs.
Nevertheless, intubation was preceded by an early hypotension, more severe than in other works using Alfentanil (4) or Hydroxyzine-Ketamine (3) combination.
The lack of correlation between Propofol dose and magnitude of blood pressure changes suggests that Fentanyl interaction may be more important than hypnotic drug dose in haemodynamic stability after induction.

CONCLUSION

Increasing the dose of Propofol (2 to 3.5 mg/kg) did not change the haemodynamic response to tracheal intubation, nor did it raise the incidence of hypotension after induction.
In patients where hypotension may be especially deleterious, use of Propofol must be modified by means other than dose modifications.

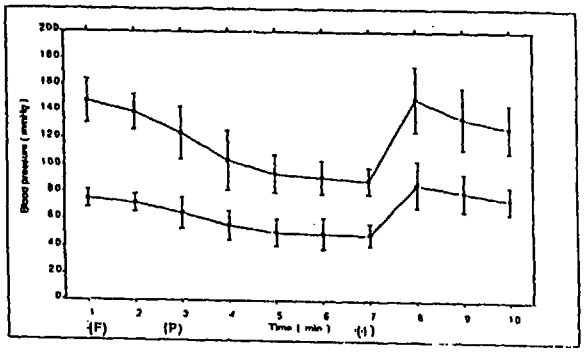
REFERENCES

1. EVANS JM. In Rosen M & Lunn JN. Consciousness, Awareness and Pain in General Anaesthesia, Butterworths, London, 1987.
2. HARRIS CE, MURRAY AM & Col. Anesthesia, Vol. 43, Suppl. 31-36, 1988.
3. RICHARDS MJ, SKUES MA. Br J Anaesth, 65, 157-163, 1990.
4. MANEGLIA R. COUSIN MT. Anesthesia, 43 Suppl. 109-111, 1988.

Table 1 : Haemodynamic changes following induction of anaesthesia

Propofol dose	2 mg/kg	2.5 mg/kg	3 mg/kg	3.5 mg/kg
SBP before induction (mmHg)	147 ± 28	140 ± 13	130 ± 16	129 ± 19
DBP before induction (mmHg)	72 ± 9	72 ± 7	69 ± 7	67 ± 8
Max SBP variation after induction (%)	-40 ± 13	-36 ± 6	-44 ± 8	-36 ± 8
Max DBP variation after induction (%)	-34 ± 10	-32 ± 8	-39 ± 11	-31 ± 12
HR before induction (bpm)	79 ± 11	79 ± 25	84 ± 19	87 ± 26
Max HR variation after induction	-16 ± 9	-11 ± 15	-13 ± 7	-9 ± 24
Max SBP variation after intubation (%)	-12 ± 27	+7 ± 19	-17 ± 16	-5 ± 20
Max DBP variation after intubation (%)	-4 ± 28	-20 ± 21	-5 ± 17	-14 ± 29
Max HR variation after intubation (%)	-6 ± 97	-0 ± 23	-2 ± 11	-1 ± 17

SYSTOLIC AND DIASTOLIC BLOOD PRESSURE CHANGES FOLLOWING INDUCTION OF ANAESTHESIA WITH FENTANYL, 2 µg/Kg (F), AND PROPOFOL, 2.5 mg/Kg (P).



EFFECT OF WARM HEART SURGERY ON PERIOPERATIVE MANAGEMENT OF PATIENTS UNDERGOING URGENT CARDIAC SURGERY.

BP Kavanagh MB, A Panos MD, CD Mazer MD, SV Lichtenstein MD PhD.
Dept. of Anaesthesia and Div. of Cardiovascular Surgery, St. Michael's Hospital; University of Toronto, Toronto, Canada M5B 1W8

INTRODUCTION: Hypothermia is frequently considered to be the most important component of cardioplegic myoprotection, as utilized during cardiopulmonary bypass[1]. The technique of "warm heart surgery" using continuous normothermic blood cardioplegia is a new approach to myocardial protection[2]. It was developed because of potential disadvantages of hypothermia at the level of myocardial cellular metabolism and enzyme function. Normothermic blood cardioplegia involves inducing cardiac arrest with a blood:crystalloid (4:1) high potassium solution (K conc. = 20 mmol/L), and then continuously perfusing the myocardium with a blood-crystalloid solution (K conc. = 7.0 mmol/L) at 37° C. To determine the effect of the introduction into clinical practice of warm heart surgery on perioperative anesthetic management, we compared patients undergoing urgent cardiopulmonary bypass using continuous normothermic blood cardioplegia to a similar group receiving cold blood cardioplegia.

METHODS: Ninety-three patients who underwent urgent or emergent cardiac surgery by the same surgeon over a three year period were included in the study. Group 1 (n=37) consisted of patients from July 1986 to November 1987, all of whom received continuous cold blood cardioplegia and systemic hypothermia. Group 2 (n=56, November 1987 to March 1989) received normothermic blood cardioplegia as described above, without systemic hypothermia. Demographic, perioperative anaesthetic management and outcome data were collected from chart review and compared with t-test or chi-squared tests where appropriate, with $p < 0.05$ being considered significant.

RESULTS: The groups were similar in terms of age, sex, ASA status, NYHA angina classification and pre-operative left ventricular function. No statistically significant differences were noted between group 1 vs group 2 with respect to total doses of fentanyl, diazepam, heparin, or protamine (table 1), or the percent of patients receiving supplementation with inhaled anesthetics (57% vs 52%). The number of patients requiring defibrillation after aortic crossclamp release was significantly lower in the warm group (2 of 56) compared to the cold group (31 of 37) $p<0.0001$. The following parameters did not differ significantly between the groups: aortic cross clamp time, transfusion requirements, blood loss, or inotrope administration. The groups were also similar in terms of ICU length of stay (41.1±5.3 hrs vs. 60.6±16.2), postoperative temperature, potassium, hemodynamics and blood loss. Group 2 patients had slightly lower incidence of post-op MI, low cardiac output syndrome (LCOS), intra-aortic balloon pump (IABP) insertion, and mortality within 30 days of surgery.

DISCUSSION: The use of normothermic cardioplegia dramatically reduced the occurrence of ventricular fibrillation on reperfusion, and eliminated the need for rewarming of patients prior to weaning from bypass. The warm heart surgery patients tended to have improved outcome with lower mortality and lower incidence of low cardiac output, although this did not reach statistical significance because of the limited numbers studied. The introduction of continuous normothermic blood cardioplegia did not produce any other significant change in anaesthetic technique or postoperative management of patients in the ICU. These results suggest that hypothermia is not an absolute requirement for cardioprotection, and that continuous normothermic blood cardioplegia is a useful and safe technique in high risk patients undergoing urgent cardiac surgery.

REFERENCES: 1. Circulation 57&58(suppl II):II3-II4, 1978. 2. Lancet 1:1443-1444, 1989.

TABLE 1

	Age	% Male	Total Fentanyl Dose (mg)	Total Diazepam (mg)	Total Heparin (units)	RBC Trans-fusions	Bypass Time (min.)	Max. Serum Potassium (mmol/L)
COLD n=37	61.7±1.7	81	5.2±0.3	15.3±1.8	29,333± 2,042	2.0±0.4	93.2±4.6	5.6±0.2
WARM n=56	62.6±1.4	82	5.4±0.2	14.5±1.5	33,267± 1,622	1.8±0.3	108±8.0	5.6±0.1

	Mortality	LCOS	IABP	Myocardial Infarction	Inotrope use (% of pts)	% of patients defibrillated
COLD n=37	5.4%	40%	16%	18.9%	43.2%	83.8% **
WARM n=56	3.6%	29%	9%	9.1%	42.9%	3.6% **

** $p < 0.0001$ cold vs. warm

ONSET OF SUCCINYLCHOLINE AND VECURONIUM NEUROMUSCULAR BLOCKADE IN CHILDREN DURING NARCOTIC ANAESTHESIA

JC Bevan MD, V Popovic MD, MRN Baxter MB, F Donati MD, DR Bevan MB.
Departments of Anesthesia, Montreal Children's Hospital & McGill University, Montreal, PQ.

PURPOSE:

Neuromuscular monitoring techniques using evoked responses to nerve stimulation allow a window of measurable blockade to be recognised. It has been estimated that approximately 70% of receptors must be occupied before any weakness is detected and the response is abolished when 90% are occupied with muscle relaxants. Consequently, the time to maximum effect at the junction should be measured using sub-paralysing doses. In addition, the clinical effect and timing should be measured using full paralysing doses.

The purpose of this study was to compare the onset times of equipotent sub-paralysing and paralysing doses of succinylcholine and vecuronium during narcotic anaesthesia in children.

METHODS:

Following institutional approval, 24 paediatric surgical patients (aged 3-10 yr and ASA physical status 1 or 2) were studied. They were randomized into four groups to receive succinylcholine 0.3 or 1.0 $mg.kg^{-1}$ IV and vecuronium 0.03 or 0.1 $mg.kg^{-1}$ IV to facilitate endotracheal intubation during thiopentone - fentanyl - oxygen anaesthesia. After induction of anaesthesia, the integrated EMG of the adductor pollicis in response to supramaximal stimulation of the ulnar nerve was recorded using a Datex NMT 221 neuromuscular transmission analyzer. The time to maximum blockade (from injection of drug to smallest response) and the intensity of maximum blockade was measured. The results for the two doses of each drug were compared using Students-t test.

RESULTS:

The small and large doses used for each drug produced similar neuromuscular blocking effects. Onset times were similar for both doses of succinylcholine and vecuronium, and three times faster for succinylcholine than vecuronium at low and high doses (Table).

DISCUSSION:

Onset of neuromuscular blockade depends on the muscle relaxant used. In children aged 3-10yr (anaesthetized using a barbiturate - narcotic sequence without nitrous oxide or inhalational agents which potentiate neuromuscular blockade) the use of doses of approximately 2xED95 produced no decrease in onset time of succinylcholine and only a small, statistically insignificant acceleration of the onset of vecuronium blockade compared with subparalyzing doses of the two drugs. The onset times for both drugs were shorter than previously reported values in adults[1,2].

REFERENCES:

1 Anaesthesia 1981;36:661-6.
2 Br J Anaesth 1984;55:119-24.

TABLE

	SUCCINYLCHOLINE		VECURONIUM	
Dose ($mg.kg^{-1}$)	0.3	1.0	0.03	0.1
n	6	6	6	6
Age (mth)	61.3±8.0	67.6±7.4	60.2±4.5	82.4±8.7*
Wt (kg)	17.6±1.1	21.9±2.1	17.6±1.4	27.8±3.6*
Max effect (sec)	51.7±9.1	63.3±8.8	190.0±13.7	153.3±28.5
Min twitch (%)	41.2±9.5	5.5±5.5*	37.0±14.3	0.16±0.16*

(Mean±SEM * $P<0.05$)

SELECTION CRITERIA FOR ANAESTHESIA RESIDENTS

C. Bachman,M.D.*; M. Kopelow,M.D.+; N.Donen,M.D.*
Department of Anaesthesia* and Department of Continuing Medical Education+,University of Manitoba, Winnipeg, Manitoba R3E 0W3

INTRODUCTION: Selection of residents for post-graduate Anaesthesia specialty training is a challenge facing all University programs. No uniform criteria or guidelines exist for selection committees. This qualitative study was undertaken to define the current selection criteria within Canadian university Anaesthesia residency training programs.

METHODS: A written mail survey of the university based accredited Anaesthesia residency programs across Canada was carried out. The program directors were asked to describe the process used in resident selection, criteria used in judging desirability or suitability of candidates, and how in-training evaluations are used to modify the resident selection process.

RESULTS: The response rate was 64% (9/14).
A) *Process of Resident Selection*: All programs required a written application and submitted references. All programs conducted personal interviews, with the number of interviewers seeing each candidate ranging from one to six. Six programs conducted a number of one-on-one interviews, one held a single group interview, and one did both. Seven programs included a resident as one of the interviewers.
B) *Criteria for Resident Selection*: All centres expressed difficulty in priorizing attributes as selection criteria. Three centres made some attempt to be systematic by formally ranking residents according to various characteristics. All programs considered both academic and psychosocial criteria. Academics were evaluated by premedical school grades in four centres, medical school grades and evaluation in seven, post-medical school grades in seven, and research background in seven. Two centres did not specify how they evaluated academic criteria. Psychosocial criteria were emphasized as being important by eight centres, though characteristics considered desirable varied across the country. Generally, attempts were made to select residents who demonstrated marked interest in Anaesthesia, and who were mature and stable. Two centres also looked for commitment to the geographic region of the country.

RESULTS (cont'd):

C) *Modification of Resident Selection Criteria by Resident In-Training Evaluation:* Two programs are attempting to correlate demographic information on residents with their evaluations and other measures of performance within the residency program. Results are not yet available.

DISCUSSION: There is no pattern or consistency between centres in selection criteria for candidates entering residency programs for Anaesthesia in Canada. All centres consider academic and psychosocial factors important but the relative weight given to each is not uniform. Academic criteria alone have been found to be inconsistent predictors of success in a residency program.(1,2) Psychosocial factors have been recognized as having a major impact upon resident performance. However, only sporadic evidence is available in the literature to date.(2,3,4,5) Personality characteristics of a sample of anaesthetists have been described,(3) and attempts have been made to elucidate predictors of success in candidates entering an Anaesthesia residency.(2,4) Further information on resident selection criteria and subsequent resident performance might prove extremely useful to both residency candidates and to Program Directors across Canada in more accurately predicting and evaluating resident success.

REFERENCES:
[1] Academic Medicine, Vol 65,page 36.
[2] Journal of Medical Education Vol 6, page 591.
[3] Anaesthesia Vol 35, page 559.
[4] Southern Medical Journal Vol 80, page 1031.
[5] Anesthesiology Vol 65, A472.

EFFECTS OF ALFENTANIL IN PAEDIATRIC PATIENTS UNDERGOING MINOR SURGERY

DT Limón, MD; S Kemp, MD; E Hartley, MD; N Sikich, RN; WL Roy, MD; J Lerman MD
The Department of Anaesthesia and The Research Institute, The Hospital for Sick Children and University of Toronto, Toronto

INTRODUCTION: Alfentanil is a rapid onset, short acting opioid analgesic chemically related to fentanyl.[1] Although the pharmacokinetics of alfentanil in children have been studied, few studies have reported the pharmacodynamics of alfentanil in children.[2] Thus, we evaluated alfentanil as a analgesia adjunct to anaesthesia in intubated pediatric patients undergoing tonsillectomy and adenoidectomy. Specific objectives included assessments of efficacy, safety and recovery.

METHODS AND MATERIALS: This study was approved by the Institutional Review Board and parental consent was obtained. Seventy-five patients were studied. All patients were ASA I-II, 3-12 years of age, fasted and unpremedicated. After an intravenous cannula was inserted, anaesthesia was induced with sodium thiopental 5 mg/kg, atropine 0.01 mg/kg, droperidol 0.015 mg/kg, and vecuronium 0.10 mg/kg. Alfentanil 100 µg/kg was infused over 60 seconds and the trachea was intubated. Anaesthesia was maintained with N_2O:O_2 (70:30) and vecuronium as necessary. Incremental intravenous boluses of alfentanil 5, 10, or 15 µ/kg were administered to maintain heart rate (HR) and systolic arterial pressure (SAP) within 20% of preoperative values. If the incremental dose of alfentanil exceeded 45 µg/kg, isoflurane 0.25-0.5%, was administered. At the end of surgery, N_2O and isoflurane were discontinued and neuromuscular blockade was reversed with atropine 0.025 mg/kg and neostigmine 0.05 mg/kg. When the patient was awake and breathing spontaneously, the trachea was extubated. During transport to the PACU, all patients were monitored with a pulse oximetry (SaO_2). Heart rate, SAP, SaO_2 and respiratory rate were recorded every 10 minutes for the 1st hour postoperatively. A PARR score analysis was completed for each patient at various times after arrival in the Recovery Room. Codeine 1.5 mg/kg IM, was given when the pain score exceeded 6.[3] The total dose of alfentanil in µg/kg was calculated for each patient. The number of patients requiring isoflurane and the number needing postoperative analgesia with codeine were also recorded. The time interval from the end of surgery to extubation was recorded. The anaesthetists' global assessments of induction, maintenance and recovery using this anaesthetic technique was also recorded. Statistical significance ($p<0.05$) was determined using unpaired t test and Fisher's exact test.

RESULTS: Thirty-four males (45.3%) and 41 females (54.6%) were enrolled. The mean age was 5.5±2.2 years; the mean weight was 23.0±9.3 kg. Although numerous hemodynamic values (HR, SAP, DAP, MAP) were statistically different from control values at various time points during surgery, these changes in hemodynamic status were not considered to be clinically disturbing.

The results of the key recovery assessments showed that patients recovered rapidly from alfentanil-N_2O anaesthesia (Table I). Results using a PARR scale based on motor performance, respiration and consciousness (0-2 for each) showed that the cumulative percentage of patients with a perfect (i.e. zero) PARR score was 96% by 60 minutes after the end of surgery. The mean time from end of surgery to discharge was 78.4±3.1 minutes.

Global assessments of induction, maintenance, and recovery performed by the anaesthetists are shown in Table II.

Sixteen disturbing adverse reactions were observed. Of these, 11 were considered to be possibly related to alfentanil. There was, however, a requirement for respiratory support in the postoperative period.

DISCUSSION: In this study, an alfentanil-N_2O anaesthetic technique produced suitable intraoperative conditions for paediatric patients undergoing tonsillectomy surgery. Postoperatively, recovery from anaesthesia was rapid, as indicated by recovery times and PARR scores. The need for respiratory support in the recovery room suggests that it may be advisable to utilize a 100 µg/kg bolus of alfentanil prior to intubation followed by isoflurane (rather than narcotic increments) for maintenance. This may provide optimal hemodynamic stability with rapid restoration of airway reflexes postoperatively.

REFERENCES:

1. Reitz J. Drug Int Clin Pharm 20:335, 1986
2. Casey W.F, Woodford RA, Martin WJ, et al. Anesth Analg 70:S52, 1990
3. Broadman LM, Rice LJ, Hannallah RS. Anesthesiology 69:A770, 1988

Table I

Perioperative Data (minutes)

	Mean ± SEM
Surgical time	18.8 ± 6.6
Anaesthetic time	27.0 ± 6.5
Time to awakening*	2.8 ± 1.9
Time to extubation*	6.1 ± 7.6
Time to response to verbal commands*	8.3 ± 10.8
Time to alertness*	15.2 ± 14.4

* from end of surgery

Table II

Evaluation of Anaesthesia

	Good %	Satisfactory %	Unsatisfactory %
Induction*	97.3	1.3	1.3
Maintenance*	62.6	24.0	13.3
Recovery*	53.3	33.3	13.3

* $p < 0.001$

Blood Pressure Contourography: A New Display Method

D. John Doyle
Department of Anaesthesia, Toronto General Hospital, Toronto

Introduction Blood pressure (BP) has always been of interest to clinicians as an indicator of a patient's cardiovascular state. Recently, interest has focused on the effect of respiration on the arterial blood pressure wave. For example, it is well known that systolic blood pressure varies with respiration and that an exaggeration of this effect ("pulsus paradoxus") can be indicative of a pathologic state (eg. asthma, cardiac tamponade) [1]. More recently, it has been noted that systolic blood pressure variation may be increased in hypovolemic patients [2]. Any indicator of hypovolemia in surgical patients would be potentially helpful in guiding fluid and blood repacement. We report here on some initial results in using computer-based graphical methods to analyze the arterial blood pressure wave. The intended use of this system is in studying the relationship between blood pressure and airway pressure in the intubated surgical patient.

Methods The system hardware consists of an IBM PC/AT compatible microcomputer equipped with a Data Translation DT-2801A 12-bit data acquisition system. A Tandy CGP-215 4-color graphics printer/plotter was used for waveform display. Patients studied were undergoing major surgery for which radial artery catheterization was employed as a standard part of their monitoring. After induction of anaesthesia and endotracheal intubation, the airway pressure was transduced by direct connection to the endotracheal tube. Both blood pressure and airway pressure was measured using Hewlett-Packard quartz transducers in association with a Tektronics model 414 monitor. The pressure signals taken from the monitor were then fed to the data acquisition system, where they were sampled at 1000 Hz at a resolution of 12 bits. Data acquistion was controlled by a program called AQ [3]. The analysis software was custom written in Microsoft FORTRAN.

Results Fig. 1 shows a typical tracing of blood pressure and airway pressure obtained from the system:

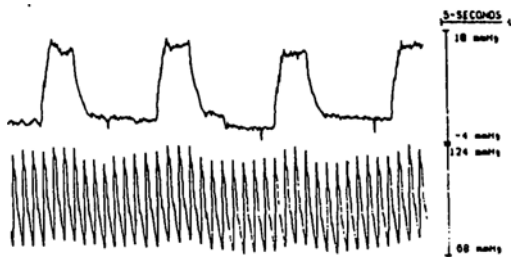


Fig 1: Airway pressure vs blood pressure plot

Fig. 2 shows how the relationship between the two variables can be better illustrated if the blood pressure data is processed so that only the systolic blood pressures are plotted with the airway pressure:

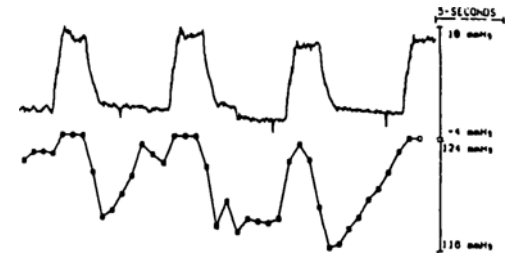


Fig 2: Airway pressure vs systolic blood pressure

Such a plot clearly shows the interdependence of the two variables, but the actual blood pressure wave is no longer present. Other plotting strategies showing the complete waveform were also investigated. To facilitate quick and efficient comparison of successive cardiac cycles, a "blood pressure contourogram" was developed. This is a single cardiac cycle plot of blood pressure, with subsequent cardiac cycles plotted directly above (Fig. 3). The resulting graph is compact, has a 3-dimensional appearance, and allows easy recognition of waveform trends.

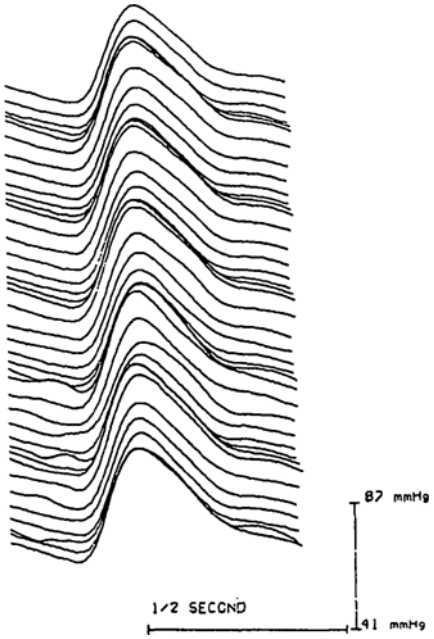


Fig.3 Blood Pressure Contourogram. Note the "bunching up" of the waveforms in phase with positive pressure ventilation.

Discussion There are several potential uses for these methods. Our interest is in their application to the investigation of cardio-respiratory interactions. The system enables clinicians to produce a hard-copy printout of a patient's blood pressure and airway pressure tracings in novel formats. It allows particularly quick and easy trend analysis of the BP wave and variations in the relationship between airway pressure and BP. In the future, the computer program can be modified to work in real-time so that there is no delay between obtaining the data from the patient and the plotting. Another possibility would be an additional plot of the incoming data on the video display at all times, allowing the user to screen the data before plotting it out on paper. The ultimate goal of this work is to develop a system to detect, record and interpret changes in a patient's cardiovascular state more rapidlyly.

References

[1] Journal of Clinical Investigation 1965; 44:1882.
[2] Anesthesia and Analgesia 1988; 67:170.
[3] Computer Methods and Programs in Biomedicine 1986; 23: 319.

Endotracheal Tube Cuff Pressures in Cardiac Surgical Patients

Richard M. Cooper and D. John Doyle
Department of Anaesthesia, Toronto General Hospital, Toronto

INTRODUCTION The importance of minimizing endotracheal tube (ETT) cuff pressures is well known [1,2]. High ETT cuff pressures may reduce mucosal blood flow in the trachea [3-5] leading to such complications as denuding of the tracheal mucosa, erosion of tracheal rings, tracheal stenosis, tracheo-esophageal and tracheo-innominate fistulae [6,7]. Although systems exist to prevent excessive cuff pressures [8-11] they are not widely used, so that in the usual clinical setting, detection of excessive cuff pressures (> 20 cm H_2O) requires periodic use of a cuff pressure manometer. In particular, in patients receiving nitrous oxide, diffusion of this gas into the cuff may result in a steady increase in cuff pressure over time [12-15]. Despite wide-spread recognition of the importance of keeping ETT cuff pressures at a minimum, we were concerned that excessive pressures may still be commonplace. To study this hypothesis, we conducted the following study.

METHODS 101 consecutive cardiac surgery patients entering the cardiovascular intensive care unit (CVICU) at Toronto General Hospital were studied. None had received nitrous oxide. All cuffs were inflated with air at the time of intubation according to the usual practices of the individual anaesthetists, who were unaware that that these patients were being so studied. Portex (Blue Line Soft Seal) and Mallinckrodt (Intermediate Hi-Lo) ETTs were used, generally 8.0 mm in females and 9.0 mm in males. On admission to the CVICU, the cuff pressure was recorded by the Respiratory Therapist, using a Portex cuff pressure manometer. As this manometer has a maximum scale reading of 60 cm H_2O, all pressures in excess of this amount were recorded as 60 cm H_2O. Following the initial cuff pressure measurement, the volume of gas in the cuff was determined by aspiration using a syringe. The cuff was then incrementally reinflated with air until no cuff leak was apparent while listening with a stethoscope over the trachea. The resulting new cuff pressure and volume of air were recorded.

RESULTS The mean cuff pressure on admission was 31.1 cm H_2O (SD = 15.1) and a mean volume of 7.9 ml (SD = 2.7) gas was aspirated. Following reinflation of the cuff with the minimum air needed to avoid a cuff leak, the mean cuff pressure was 15.2 cm H_2O (SD = 4.3) corresponding to a mean volume of 5.4 ml (SD = 1.8). The mean pressure differences were statistically significant (Wilcoxon ranked sign test, $P<0.001$). Figure 1 shows the pressure data in graphical form. A total of 67.3 percent of the patients had a cuff pressure in excess of 20 cm H_2O on admission to the CVICU, while 40.6 percent had pressures in excess of 30 cm H_2O.

DISCUSSION All patients in this study remained intubated until at least the following morning. In addition, some of these patients had periods of low perfusion pressure and systemic hypothermia, both of which might further compromise tracheal blood flow. Accordingly, the concerns about possible overinflation of the endotracheal cuff and consequent injury to the trachea are compelling. Nordan et al [16], based a study of blood flow in the mucosa of rabbit tracheal using radio-labelled microspheres, suggest that cuff pressures should not exceed 30 cm H_2O. In a study by Seegobin and van Hasselt [17], an endoscopic photographic technique was used to assess tracheal mucosal blood flow during intubation. At cuff pressures of 30 cm H_2O impairment of mucosal blood flow was observed, while blood flow was totally obstructed posteriorly at a cuff pressure of 50 cm H_2O. Excessive cuff pressures (reinflation pressure less than initial cuff pressure) were noted in 81 of our patients (80.2%), while cuff pressures greater than 30 cm H_2O occurred in 41 patients (40.6%). The selection of a patient population unexposed to nitrous oxide, likely underestimates the extent of this problem [12-15]. As well, in the vast majority of these patients presented for elective surgery, their cuffs could be inflated in a more controlled fashion than patients requiring a rapid sequence induction. Further studies are currently underway to determine the magitude of this problem in the aforementioned patient groups. The findings of this study serve to reemphasize the importance of monitoring cuff pressures during all surgical procedures, not just those in which nitrous oxide is used.

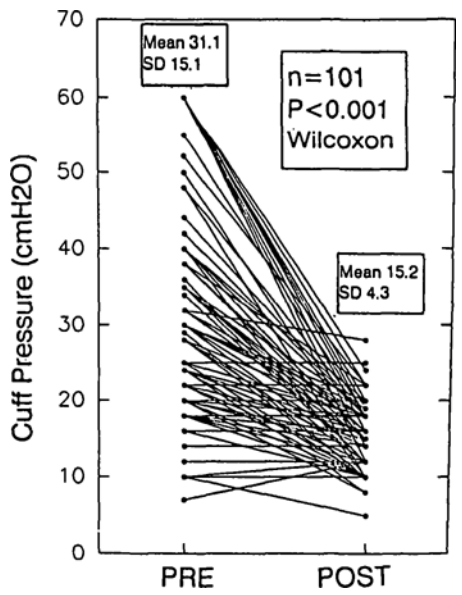


Figure: Endotracheal tube cuff pressures for 101 consecutive patients at the time of admission to our cardiovascular intensive care unit (PRE) and following introduction of the minimum air needed to prevent a cuff leak (POST).

REFERENCES

[1] Br J Anaesth 1981; 53:97. [2] Br Med J, 1984; 288:1763. [3] Am J Surg 1977; 133:562. [4] Br Med J 1979; 1:1173 [5] Br Med J 1979 1:1425. [6] Surg Gynecol Obstet 1969; 129:1235. [7] Thorax 1967; 22:1. [8] Anesth Analg 1980; 59:291. [9] Anesthesiology 1975; 43:478. [10] Lancet 1964; ii:509. [11] Ann Thorac Surg, 1970; 9:384. [12] Anesth Analg 1974; 53:480. [13] Br J Anaesth 1982; 54:1238. [14] Br J Anaesth 1981; 53:1227. [15] Anesthesiology 1975; 42:637. [16] Acta Anaesthesiol Scand 1977; 21:81. [17] Br Med J 1984; 288:965.

Simple Method for Estimating P_{50}

D. John Doyle
Department of Anaesthesia, Toronto General Hospital, Toronto

INTRODUCTION Estimation of P_{50}, the oxygen tension at which hemoglobin is 50% saturated, is often of clinical interest, especially in critically ill patients. Methods to estimate P_{50} have been reported [1-3], but none is simple enough for speedy calculation using a pocket calculator. Here we report on a very simple method for estimating P_{50} from a single arbitrary point on the oxyhemoglobin dissociation curve. The method, based on the Hill equation [4] for the oxyhemoglobin dissociation curve, needs only a single pair of oxygen tension/saturation measurements and a pocket calculator capable of performing power calculations.

DISSOCIATION CURVE DESCRIPTION Hill [4] has described an equation for the oxyhemoglobin dissociation curve which is appealingly simple: $SO_2 = PO_2^n/[PO_2^n+P_{50}^n]$ where SO_2 is the fractional oxygen saturation at an oxygen tension PO_2 and n is an empirical constant. Using Severinghaus' data [5] over the range of 15 to 100 mmHg, and choosing P_{50} = 26.6 mmHg from this data, the value of n which minimized the mean square error between the Hill curve and the Severinghaus data was determined (Figure 1). The best fit was obtained using n = 2.711. The quality of the fit is readily apparent by fitting the Hill equation for P_{50} = 26.6 and n = 2.711 through the Severinghaus data (Figure 2).

ESTIMATION OF P50 By algebraic manipulation of the Hill equation one can solve for P_{50}: $P_{50} = PO_2((1-SO_2)/(SO_2))^{1/n}$ As an example, suppose we obtain PO_2 = 80 mmHg from a blood gas machine and SO_2 = 0.95 from a co-oximeter. Using n = 2.711 we obtain P_{50} = 27 mmHg.

EVALUATION The Severinghaus data [5] in the clinical range of 15 to 100 mmHg may be used to evaluate the method. This curve is known to have a P_{50} of 26.6 mmHg. Each point on the curve allows us to obtain an estimate of P_{50} by the method described. The error in this estimate as a function of PO_2 for this data is shown in Figure 3. The square root of the average square error (root-mean-square error) is 1.27 mmHg. The method was also evaluated using sample data from Mountcastle [6] (Table 1), where the results of our method are compared with the nomogram developed by Canizaro et al [3]. As can be seen, our method is comparable in accuracy.

		P_{50} = 21		
SO_2	PO_2	True P_{50}	Doyle P_{50}	Canizaro P_{50}
0.9	50	21	21.8	24
0.8	37	21	21.9	22
0.7	30	21	21.8	22
0.6	24	21	20.6	21
		P_{50} = 27		
SO_2	PO_2	True P_{50}	Doyle P_{50}	Canizaro P_{50}
0.9	65	27	28.4	30
0.8	46	27	27.3	28
0.7	37	27	26.9	26
0.6	32	27	27.5	28
		P_{50} = 32		
SO_2	PO_2	True P_{50}	Doyle P_{50}	Canizaro P_{50}
0.9	75	32	32.7	36
0.8	56	32	33.2	34
0.7	45	32	32.7	33
0.6	38	32	32.6	33

TABLE Comparison of this method (Doyle P_{50}) with the method of Canizaro et al [3] (Canizaro P_{50}) for data obtained from Mountcastle [6]. (The Canizaro data is presented with less precision because it was obtained from a nomogram).

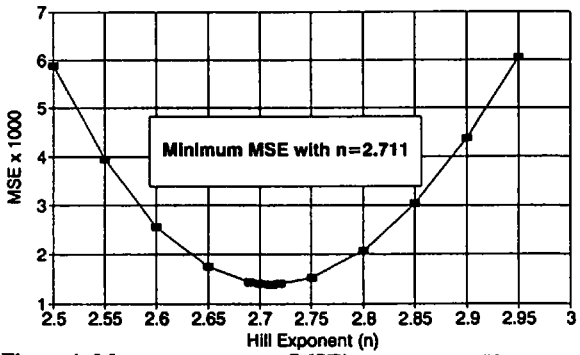


Figure 1. Mean-square error (MSE) between the Hill model and the Severinghaus data in the clinical range of PO2 of 15 to 100 mmHg for various values of the Hill exponent. A best fit is obtained for n=2.711.

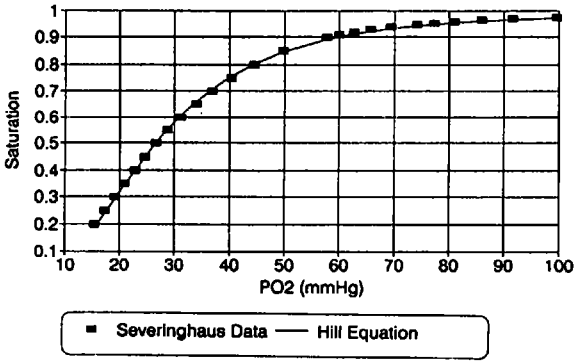


Figure 2. Hill equation with n=2.711 plotted against the Severinghaus data over the PO2 range of 15 to 100 mmHg.

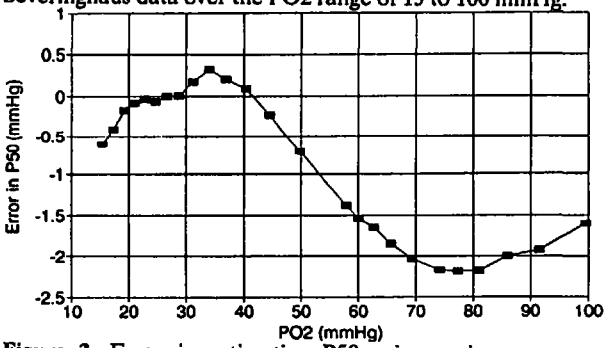


Figure 3. Error in estimating P50 using various oxygen tension values for the Severinghaus data over the range of 15 to 100 mmHg.

REFERENCES

[1] IEEE Trans Biomed Eng 1983; 30:250-254.
[2] J Appl Physiol 1975; 38:171-176.
[3] Ann Surg 1974; 180:364-367.
[4] J Physiol London 1910; 40:iv.
[5] J Appl Physiol 1966; 21:1108-1116.
[6] Mountcastle VB. Medical Physiology. St. Louis:Mosby, 1968 (p. 663).

Alveolar-Arterial Oxygen Tension Difference at Low Barometric Pressure

D. John Doyle
Department of Anaesthesia, Toronto General Hospital, Toronto

INTRODUCTION

The alveolar-arterial oxygen tension difference ($P_{A-a}O_2$) is commonly used in the assessment of pulmonary oxygen exchange. While the physiological shunt fraction (Qs/Qt) may represent the "gold standard", it is not always employed clinically both because the calculations involved are not always straightforward and because invasive access (eg. pulmonary artery catheterization) is needed to obtain the necessary mixed venous blood sample. By contrast, the alveolar-arterial oxygen tension difference ($P_{A-a}O_2$) is easy to calculate and is well-known to clinicians.

Because of the large extent to which $P_{A-a}O_2$ is used clinically, it has been the subject of much study. However, little knowledge exists about $P_{A-a}O_2$ changes under hypobaric conditions. For example, while unpublished theoretical studies performed by the author indicate that a reduction in $P_{A-a}O_2$ would be expected to occur under hypobaric conditions *(vide infra)*, direct experimental support for such a prediction is lacking in the literature.

In this report, we provide evidence to support the theoretical prediction that $P_{A-a}O_2$ is reduced under hypobaric conditions through the analysis of arterial blood gas data published by Dillard et al [1]. Dillard's team studied eighteen ambulatory retired servicemen with severe chronic obstructive lung disease. Arterial blood gas data was obtained while subjects were breathing room air at sea level and after 45 minutes of steady-state exposure to a simulated altitude of 8000 feet (2438 meters; P_B = 565 mmHg) using a hypobaric chamber [1]. The data provided (their Table I) allows the determination of $P_{A-a}O_2$ under these conditions.

METHODS

Using the data published by Dillard et al, P_AO_2 and $P_{A-a}O_2$ was calculated using standard equations. The respiratory quotient was assumed to be 0.8. The results are given in Table 1 below.

Table 1: Gas exchange data for 18 subjects at sea level and at 8000 ft altitude. Note the decrease in $P_{A-a}O_2$ under hypobaric conditions.

	Sea Level	Altitude
P_AO_2	102	61
P_aO_2(mean+/-SD)	72.4(9.0)	47.4(6.3)
$P_{A-a}O_2$(mean+/-SD)	29.6(9.9)	18.3(5.5)

COMPUTER MODEL

Insight into the expected magnitude and direction of changes in $P_{A-a}O_2$ under hypobaric conditions can be obtained using computer modelling methods. For example, Doyle has developed a computer model for gas exchange in the lung which is based on the shunt equation and which has been used to study the arterial/alveolar oxygen tension ratio [2]. A similar model has been developed by Vaile et al [3]. Using these techniques, a computer model for pulmonary oxygen exchange was developed. The table below indicates typical model parameters used and the obtained results.

Table 2: Model parameters and gas exchange indices determined from computer model. Note that the model predicts a reduction in $P_{A-a}O_2$ with decreasing barometric pressure. *(Parameters: Hb = 12 g/dL, Ca-vO_2 = 5 vol%, Qs/Qt = 0.15, PCO_2 = 40 mmHg, respiratory quotient = 0.8, VO_2 = 250 ml/min; CO = 5 l/m).*

	Sea Level	Altitude
PAO_2(1)	102	61
PaO_2(2)	89	51
$P_{A-a}O_2$	33	10

(1)From alveolar gas equation (F_IO_2 = .21; P_{CO2} = 40 mmHg; R = 0.8)
(2)From computer model

DISCUSSION

Hypobaric atmospheric conditions are commonly encountered in commercial and military air travel as well as in many cities at high altitude. For instance, commercial air travellers may be exposed to hypobaric conditions equivalent to altitudes as high as 8000 feet (2438 meters). Military personnel may be subject to even lower pressures during air travel [4]. Obviously, if pulmonary gas exchange is to be studied at altitude, the effect of hypobaricity on $P_{A-a}O_2$ is of interest.

Hoffstein et al [5] studied $P_{A-a}O_2$ in 23 healthy volunteers during a hypoxic challenge test based on rebreathing room air. Arterial PO2 was estimated indirectly by converting the arterial oxyhemoglobin saturation (measured using an ear oximeter) to oxygen tension using Kellman's equation with assumed pH values corresponding to an assumed bicarbonate value of 27 mmol/L. They also found that $P_{A-a}O_2$ narrowed with hypoxemia, although their hypoxemia was due to a reduction in oxygen concentration rather than a reduction in barometric pressuire. While their methods were indirect, they noted a more rigorous study "would require an indwelling arterial line for measurement of blood gases, which is an invasive procedure difficult to justify in normal humans." The data provided by Dillard et al thus present a remarkable opportunity to study $P_{A-a}O_2$ at altitude that would otherwise be difficult to achieve. The results agree with theoretical predictions made using a computer model of pulmonary oxygen exchange.

REFERENCES

[1]. Dillard TA, Berg BW, Rajagapal KR, Dooley JW, Mehm WJ. Hypoxemia during air travel in patients with chronic obstructive pulmonary disease. **Annals of Internal Medicine** 1989; 111:362-367.
[2]. Doyle DJ: Arterial/alveolar oxygen tension ratio: a critical appraisal, **Can Anaesth Soc J**, 1986; 33:471-4.
[3]. Vaile JP, Carlisle CJ, Annat G, Rousselet B, Motin J: Arterial-alveolar oxygen partial pressure ratios: a theoretical reappraisal, **Crit Care Med**, 1986; 14:153-4.
[4]. Gong H. Advising patients with pulmonary disease on air travel. **Annals of Internal Medicine** 1989; 111:349-351.
[5]. Hoffstein V, Duguid N, Zamel N, Rebuck AS: Estimation of changes in alveolar-arterial oxygen gradient induced by hypoxemia, **J Lab Clin Med**, 1984; 104:685-692.

ACUPUNCTURE DOES NOT PREVENT VOMITING FOLLOWING TONSILLECTOMY IN CHILDREN

S. M. Yentis FCAnaes, B. Bissonnette FRCPC.

Department of Anaesthesia, Hospital for Sick Children, 555 University Avenue, Toronto, Ontario M5G 1X8.

Introduction: Acupuncture at the wrist (P6 or "Neiguan" point) reduces nausea and vomiting following surgery and chemotherapy in adults,[1] but has not been studied in children. Vomiting is common after tonsillectomy, with reported incidence of up to 81% if opioid premedication is used.[2] The aim of this study was to examine the effect of acupuncture on postoperative vomiting in children undergoing tonsillectomy.

Methods: After Human Review Committee approval, informed written consent was obtained from the parents of 38 children of ASA physical status I or II presenting for elective tonsillectomy. The children were randomized into two groups and unpremedicated. Anaesthesia was induced with intravenous thiopentone 5.0 mg•kg^{-1}, atropine 0.02 mg•kg^{-1}, and succinylcholine 1.5 mg•kg^{-1}. Manual inflation of the lungs, taking care to avoid gastric inflation, was followed by tracheal intubation and spontaneous ventilation with isoflurane 1.5-2.0% and N_2O 66% in O_2. After induction of anaesthesia, patients in one group received acupuncture at the P6 point on the left side with 5 minutes' manual stimulation, using 0.2 mm diameter acupuncture needles, whilst the control group did not receive acupuncture. Estimated fluid deficit and maintenance requirements were replaced with intravenous Ringer's lactate solution. Intramuscular codeine phosphate 1.5 mg•kg^{-1} was administered just before extubation. The incidence of vomiting and/or retching was recorded in the recovery room and ward. The nursing staff, patients and parents were unaware of the group allocation. Intramuscular dimenhydrinate 1.0 mg•kg^{-1} was given if vomiting exceeded 3 episodes during any one hour period. Oral acetaminophen 10 mg•kg^{-1} or intramuscular codeine 1.0 mg•kg^{-1} was available postoperatively as required for pain. Other data collected included age, sex, duration of anaesthesia, duration of stay in the recovery room, recovery scores at 0,15 and 30 minutes,[3] time to drinking fluids and time to discharge from hospital. Statistical significance ($p<0.05$) was determined using the unpaired t-test and Chi-squared analysis.

Results: Age, sex, weight, duration of anaesthesia, recovery scores, length of stay in the recovery room, times to drinking and discharge, and analgesic requirements did not differ significantly between the groups. The incidence of vomiting was 39% in the acupuncture group, and 40% in the control group (see table).

Discussion

Antiemetic drugs such as droperidol may be associated with increased postoperative sleepiness and extrapyramidal symptoms,[4] and are therefore usually not given during paediatric tonsillectomy. If effective, acupuncture would be an attractive alternative as it is free of side effects.[1] This study demonstrates that acupuncture is not a useful antiemetic when administered after induction of anaesthesia for tonsillectomy. This might be because any antiemetic effect is reduced by general anaesthesia. The influence of general anaesthesia on the antiemetic effects of acupuncture is unclear, although it is thought that the timing of the acupuncture with respect to the emetic stimulus is more important.[5] Alternatively, the P6 point may have been incorrectly or inadequately needled, since the patients were anaesthetized and thus unable to describe the sensation of heaviness or dullness ("chi") that often accompanies correct placement.[1] Finally, P6 acupuncture may be an ineffective antiemetic in children undergoing tonsillectomy, even if administered to awake patients. This could be tested in older children, since acupuncture is painless, although younger children might be too scared.

References:

1. Br J Anaesth 1989; 63: 612.
2. Anaesth Int Care 1990; 18: 5.
3. Can Anaesth Soc J 1975; 22: 111.
4. Br J Anaesth 1980; 52: 831.
5. Br Med J 1988; 296: 135.

Table

	Groups	
	Control	Acupuncture
Number of patients	20	18
Age (yrs)*	6.5± 3.5	5.5 ± 2.9
Duration of anaesthesia (min)*	24 ± 7	25 ± 6
Incidence of vomiting†	8 (40)	7 (39)

*mean ± SD
†Number (percentage)

ANAESTHETIC MORBIDITY ASSOCIATED WITH SURGICAL CORRECTION OF VELOPHARYNGEAL INSUFFICIENCY IN CHILDREN

L. Halpern MD, L. Roy MD FRCPC
Department of Anaesthesia, Hospital for Sick Children, Toronto, Ontario

Introduction: The superiorly based pharyngeal flap is a surgical procedure designed to correct hypernasal speech. This involves construction of a flap of pharyngeal tissue to obstruct air flow through the nose during phonation.[1] This operation may present difficulties perioperatively for both patient and anaesthetist because of extensive manipulation of the airway. Further, many of these patients have associated medical problems. Following a death of a 6 year old child in our recovery room 16 hours after a pharyngeal flap for velopharyngeal insufficiency (VPI), we conducted a five year retrospective review of our experience with surgical correction of VPI.

Methods: The medical records of all children who underwent a pharyngeal flap for VPI from March, 1985 to March, 1990 were reviewed retrospectively. Those children who had another procedure along with the pharyngeal flap were included in the study. All follow-up information was obtained from clinic visit dictations and subsequent admissions which appeared in the patient record. Items which were specifically evaluated were the type of surgical repair, the incidence and severity of perioperative complications, the anaesthetist's evaluation of the difficulty of intubation and any associated medical problems found in these children.

Results: The medical records of 102 children were reviewed. There were 45 boys and 57 girls with a mean age of 7.4 years. All children had a superiorly based pharyngeal flap performed by one of four faculty plastic surgeons. There were 15 complications (14.7% incidence) noted (Table 1). Complications were grouped into two categories: 1) postoperative bleeding and related problems 2) postoperative airway obstruction without bleeding. Seven complications (46.7%) were in the postoperative bleeding group, 6 occurring within 36 hours after surgery. Four of these children had resultant pulmonary aspiration requiring intubation and admission to the intensive care unit for 2 to 5 days. All eventually recovered. Two other children in this group had extensive bleeding on emergence while still intubated. They were reanaesthetized, explored and the bleeding controlled. The remaining child was readmitted to hospital 10 days postoperatively for oropharyngeal bleeding which resolved spontaneously. Seven children encountered airway obstruction postoperatively. Five of these episodes occurred in the first 24 hours postoperatively and were associated with falling oxygen saturations (< 90%). These patients were managed with assisted ventilation until the airway obstruction subsided. One of these children required reintubation. All five of these children improved as they awoke in the recovery room. Two children developed sleep apnea following discharge from the hospital and eventually required takedown of the pharyngoplasty. Finally, one child developed hematochezia 7 days after discharge. This resolved spontaneously. Thirty-one children (30.4%) had significant associated medical problems accompanying their VPI. Most prominent were the velo-cardio-facial syndrome in 7 children, neuromuscular disease in 4 children and congenital heart disease in 3 children. Of note, 9 children (8.8%) were described in the anaesthetic record as having been a difficult intubation. Three of these patients required fiberoptic intubation. The other 6 were intubated with direct laryngoscopy following more than one attempt. There were no deaths in the 102 patients. The death noted in the introduction did not occur during the 5 years which were reviewed.

DISCUSSION: The results of this study demonstrate that in our institution the incidence of complications from surgical correction of VPI with a superiorly based pharyngeal flap in the 5 year period from March, 1985 to March,1990 is 15%. Most of the complications occurred in the early postoperative period and were the result of postoperative bleeding and/or airway obstruction. Similiar to our experience with the development of sleep apnea are 2 case reports describing the onset of sleep apnea following surgical correction of VPI, one child dying 2 weeks postoperatively at home.[2,3] Further, nearly one third of the cases reviewed had significant associated disorders and nearly 10% had complex airway anatomy. Information derived from this review and alarm arising from our recent recovery room death have compelled us to intensify our perioperative management. The physicians providing care for these children are obligated to be aware of the perioperative risks of this procedure, and to arrange overnight admission to a unit capable of close surveillance and monitoring.

References.

1. Cleft Palate Journal, 16;46,1979.
2. Journal of Pediatrics, 96;645,1980.
3. Arch Otolaryngol, 110;611,1984.

Table 1. Distribution of 15 complications following surgical correction of VPI in 102 children.

	POSTOPERATIVE COMPLICATIONS	
TIME OCCURRENCE	BLEEDING	AIRWAY OBSTRUCTION
First 24 hours	6/102(5.8%)*	5/102(4.9%)
After 24 hours	2/102(1.9%)	2/102(1.9%)

*Four children with aspiration leading to ICU admission.

CONTINUING MEDICAL EDUCATION IN ANAESTHESIA: IS THERE A PLACE FOR "NEEDS ASSESSMENT"?

FA Burrows MD FRCPC, DW Fear MD FRCPC
Department of Anaesthesia, The Hospital for Sick Children and the University of Toronto, Toronto, Ontario

INTRODUCTION: Needs assessment in continuing medical education (CME) constitutes the assessment of the extent and nature of deficiencies in the competence and performance of physicians. The determination of priorities is an integral part of needs assessment. The Department of Anaesthesia at the University of Toronto (U of T) has no needs assessment program. The purpose of this study was to examine CME activity of university affiliated anaesthetists, assess the presence of personal learning needs programs and determine the necessity for a "Needs Assessment" program.

METHODS: A blinded questionnaire was distributed to 200 members of the Department of Anaesthesia at the U of T to gather information on demographics, current CME activity, use of a learning needs assessment program or desire for such a program.

RESULTS: There were 132 respondents (66%); 55% had ≥10 years and 45% <10 years anaesthetic experience. Journals, lectures and seminars were considered the most efficient while telemedicine and videotapes were considered the least efficient CME activities. The Canadian Anaesthetist Society and the American Society of Anesthesiologists annual meetings were considered to provide the most satisfactory CME experience; the International Anesthesia Research Society and the Provincial Ontario Medical Association/CAS meetings were the least satisfactory. Of respondents, 67% denied having any organized personal CME program to keep their knowledge and skills up to date and those who did (33%), relied primarily on journals and conferences to guide their CME activity. Seventy-eight percent of respondents denied having any mechanism to identify their CME needs and 88% felt such a mechanism would be useful.

DISCUSSION: The most successful and effective CME programs are those which address the most important learning needs of the participants. Needs Assessment is one of the most difficult and least understood aspects of CME planning, it is one of the most important components but currently is inadequately practiced. There are two types of learning needs: Perceived needs represent the perspective of the learners, while True needs are more objectively determined by independent assessments using factually recorded data. The majority of university affiliated anaesthetists rely on topics in journals and at meetings for their CME. Such meetings rarely base their topics on a Needs Assessment or if they do it usually reflects a survey of previous attendees' opinions which are "perceived" rather than "true" needs. A very high percentage of respondents have no organized CME activity or method to identify their CME needs and would consider a Needs Assessment program.

This survey suffers several weaknesses. Response to a survey is rarely 100% and as such respondents frequently represent a biased audience to whom the survey is particularly relevant. Data obtained by this means, however, does contribute to the opinion of the population. This survey reflects only university affiliated anaesthetists and the results may differ in the peripheral non university settings where it is known from coincidental studies that telemedicine is extremely popular.The results therefore cannot be extended to all anaesthetists.

CONCLUSION: CME in Anaesthesia at the U of T is provided by methods that have not assessed the true needs of the Anaesthesia community. The majority of individual anaesthetists recognize the necessity of Needs Assessment programs.

REFERENCES:

1. Laxdal OE. Needs assessment in continuing medical education: A practical guide. J Higher Educ 1982; 57:827-34.
2. Grosswald SJ, Bennof MJ. Assessing educational needs in a medical specialty society. Möbius 1987; 7:4-10.

DIAZEPAM PREMEDICATION IN ADOLESCENTS: A DOSE RESPONSE STUDY

S.M. Kemp BSc MD FRCPC, S. Hillier MB FFARCS, J. Lerman MD FRCPC.
Department of Anaesthesia and the Research Institute, The Hospital for Sick Children, University of Toronto, Toronto, Ontario, Canada. M5G 1X8

Introduction:

Preoperative anxiety may adversely affect the induction of anesthesia.[1] Although diazepam is used as an anxiolytic agent in adolescents, we have questioned its effectiveness. Therefore, we sought to determine the effectiveness of oral diazepam as a preoperative anxiolytic agent and the dose-response relationship for anxiety in adolescents.

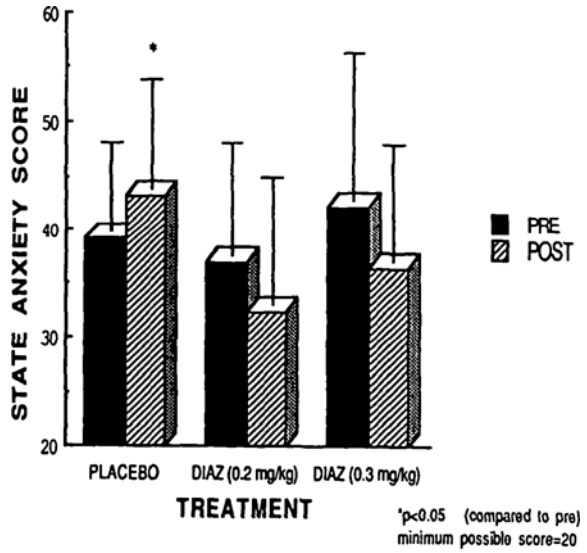
Methods:

With approval from the hospital ethics committee, informed written consent was obtained from both the patient and parent. All patients were twelve to nineteen years of age, ASA physical status 1 or 2, fasting and admitted as in-patients. The study design was a randomized, double-blinded, placebo trial. Forty-five adolescents were assigned to one of three treatment groups: placebo, diazepam 0.2mg/kg and diazepam 0.3mg/kg (to a maximum of 21 mg). All medication was administered orally in capsule form, 90 minutes before surgery. Each patient completed the Spielberger[2] self-evaluation questionnaire for anxiety on two occasions. The first response was obtained before premedication and the second, after premedication and immediately before arrival in the operating room.

After intravenous access was established with local anesthesia and graded for ease of insertion, thiopental and succinylcholine were administered for induction of anesthesia. On the day after surgery, each patient was interviewed for their impressions of the preoperative medication and the anesthetic induction experience. Statistical significance ($p<0.05$) was accepted. Data are presented as means ± SD. Data were analyzed using one-way ANOVA and the Newman-Keuls test, paired t test, and Fisher's exact test.

Results:

The mean age and weight, and the sex distribution of patients did not differ significantly among the three treatment groups.The anxiety state and trait scores before premedication, did not differ significantly among the three groups. In the group that received placebo, the anxiety state scores after premedicaton, increased significantly compared to before premedication scores (figure). In contrast, the anxiety state scores did not increase significantly from before to after premedication in either the 0.2mg/kg or 0.3mg/kg diazepam groups. Infact, not only did the anxiety scores not increase, they showed a trend downward. Pre- and postoperative interviews revealed that the patients were able to correctly identify their preoperative medication ≥87% of the time ($p<0.03$).



Discussion:

We found that either 0.2mg/kg or 0.3mg/kg oral diazepam given 90 minutes before surgery attenuates preoperative anxiety in the adolescent. The group that received 0.3mg/kg however, had greater ease of insertion of the intravenous catheter and patient satisfaction was greater. All patients that received diazepam pre-operatively, stated that they would recommend oral diazepam to other adolescents prior to a surgical procedure.

References:

1. Johnson M, Anxiety in surgical patients. Psychol Med 1980; 10:145-152

2. Spielberger CD, Manual for the State-Trait Anxiety Inventory. Consulting Psychologists Press, Palo Alto, 1983.

THE EFFECT OF N_2O ON PROPOFOL REQUIREMENTS AND RECOVERY IN CHILDREN

M. Sloan, M.D., M. Crawford, M.D., J. Lerman, M.D., B. Bissonnette, M.D., N. Sikich, R.N.
Department of Anaesthesia and the Research Institute
The Hospital for Sick Children, University of Toronto, Toronto, Ontario, Canada M5G 1X8

Introduction: Propofol is a new sedative-hypnotic intravenous agent designed for induction and maintenance of general anaesthesia. Among its advantages, propofol has pharmacokinetic properties that provide rapid induction and recovery from anaesthesia.[1] Currently, the experience with propofol in the paediatric population is limited. Therefore, we undertook this study to evaluate the effect of N_2O on propofol requirements in children undergoing minor surgery.

Methods: After obtaining ethical committee approval and informed consent, 10 fasting and unpremedicated children, 3-12 years of age, were studied. All children were ASA I or II and were scheduled for general, orthopaedic, plastic, or urologic surgery with an expected duration of anaesthesia of greater than one hour and an expected blood loss of less than 10%. Patients with a history of allergy to the anaesthetic drugs or their constituents, a history of previous adverse experience with general anaesthesia, or major systemic disease were excluded from the study. Patients were randomized to receive propofol and one of two supplemental treatments, air in O_2 or N_2O in O_2, for maintenance of anaesthesia.

Intravenous access was secured, and lidocaine 0.2 mg/kg was injected with the tourniquet inflated. After 20-30 sec the tourniquet was deflated, and anaesthesia was induced with intravenous propofol 3.0 mg/kg and immediately followed by a continuous infusion of propofol 0.2 mg/kg/min using a syringe pump. Tracheal intubation was facilitated with vecuronium 0.15 mg/kg, and the patients were mechanically ventilated after intubation. Anaesthesia was maintained with a propofol infusion supplemented by either a mixture of air in O_2 or N_2O in O_2 for an FiO_2 of 0.30 and vecuronium 0.05 mg/kg when needed. The rate of the infusion was adjusted according to hemodynamic responses. Fentanyl (2.0 µg/kg bolus) was administered if signs of light anaesthesia persisted after adjusting the propofol infusion. Oxygen saturation was maintained greater than 95%, and the end-tidal CO_2 tension was maintained between 30 and 40 mmHg. At the end of surgery, residual neuromuscular blockade was reversed with neostigmine 0.05 mg/kg and atropine 0.02 mg/kg. Propofol and N_2O were discontinued as soon as the surgeon completed the operation. Recovery was assessed by recording the time when the patient opened his/her eyes, responded to simple verbal commands, and was oriented to name, age, and location. Statistical analysis ($p<0.05$) was performed using the unpaired t-test.

Results: There were no significant differences in the ages and weights of the two groups of patients. There were no significant differences in the duration of anaesthesia and the total dose of propofol between the two groups (table). In terms of recovery from anaesthesia, there were no significant differences in the times to opening of eyes, response to verbal commands, or orientation between the two groups.

When considering the ten patients as a single group, none of the children exhibited an allergic response to propofol or had any other adverse outcome. One child (10%) complained of pain at the site of propofol administration while seven (70%) experienced involuntary movements during induction of anaesthesia. Two children (20%) developed hemodynamically insignificant sinus arrhythmia during anaesthesia. One child (10%) teared throughout the entire surgery and, despite repeated boluses of propofol and increasing the infusion rate to 0.3 mg/kg/min, required fentanyl (2.0 µg/kg) supplementation. None of the children had intraoperative recall and one child (10%) vomited postoperatively. Five children (50%) developed pruritus during the immediate postoperative period. The pruritus resolved spontaneously and did not require therapy.

Discussion: Both induction of and recovery from anaesthesia are rapid with propofol. The dosage requirements of propofol and the speed of recovery are unaffected when N_2O is used to supplement propofol in children. Propofol is an effective anaesthetic agent for children undergoing minor surgical procedures. However, the exact place of this new agent in the armamentarium of the paediatric anaesthetist remains to be defined.

Supported with a grant from ICI Pharma, Canada.

Reference:

1. Anesthesiology 71:260, 1989

Table: Propofol Requirements and Recovery Characteristics

	Propofol	Propofol/N_2O
Age (years)	8.4 ± 3.5	7.6 ± 2.4
Weight (kg)	31.0 ± 13.6	28.6 ± 8.6
Sex (M/F)	4/1	3/2
Duration of anaesthesia (min)	90.2 ± 57.6	95.4 ± 46.1
Propofol dose* (mg/kg)	21.8 ± 10.9	17.0 ± 5.5
Recovery Events**		
Eye opening (min)	11.2 ± 6.1	12.6 ± 8.0
Response to commands (min)	14.6 ± 8.9	13.2 ± 8.2
Orientation (min)	21.8 ± 13.6	20.8 ± 13.6

data are mean ± SD
* including induction dose (3.0 mg/kg)
** interval between end of drug administration and event

HYPOXIC PULMONARY VASOCONSTRICTION IN SINGLE LUNG ANAESTHESIA IN HUMAN SUBJECTS.

M Friedlander FRCPC, AN Sandler FRCPC, B Kavanagh MRCPI, S Lawson RN, L Panos FRCPC, T Winton FRCPC, J Benumof MD

Departments of Anaesthesia and Thoracic Surgery, Toronto General Hospital, University of Toronto, Toronto, Ontario and the Department of Anesthesiology, University of California, San Diego, California, USA.

Introduction:
Hypoxic Pulmonary Vasoconstriction (HPV) has been demonstrated in a variety of animal and human studies in clinical and laboratory conditions[1]. One Lung Anaesthesia in the lateral position for thoracic surgery is a situation in which HPV is considered to play a critical role in attenuating Qs/Qt and maintaining arterial oxygenation[2]. However HPV has never been clearly demonstrated in this situation. The purpose of this ongoing study is to investigate the role of HPV in single lung adult anaesthesia.

Method:
Following institutional ethics committee approval and informed patient consent, 4 patients (ASA I or II) scheduled for thoracotomy, were anaesthetised with thiopentone, midazolam, fentanyl and pancuronium. A double lumen endotracheal tube (ETT) was inserted. Radial and pulmonary artery catheters (PAC) were placed and the patient turned to the lateral position. Chest radiography confirmed PAC position. ETT position was confirmed with fibreoptic bronchoscopy. The study was divided into four consecutive stages - BASE: 2 lung ventilation, PRE: 1 lung ventilation (1LV), SNP: 1LV with sodium nitroprusside (SNP) infusion to decrease mean arterial pressure by 20%, and POST: 1LV with SNP discontinued. SNP was used to induce vasodilation and thereby ablation of HPV. Haemodynamic and gas exchange data were recorded during each stage after stable conditions were achieved. All data was recorded and the study completed before surgical incision. Results were expressed as means ± SEM. Analysis included ANOVA and paired t-tests, with $p<0.05$ considered significant.

Results:
Institution of 1LV was associated with a decrease in PaO_2 ($p<0.02$), but mean Qs/Qt was unchanged (Fig. 1, Table 1). Infusion of SNP was not associated with significant changes in PaO_2 or Qs/Qt. Discontinuation of SNP resulted in no further changes.

Discussion:
During one lung anaesthesia in the lateral position, HPV may not be a clinically important influence in maintaining arterial oxygenation. SNP may not exacerbate arterial deoxygenation by ablating HPV. If these conclusions are supported by further cases in this study, this may have an important impact on research and clinical practice in this area.

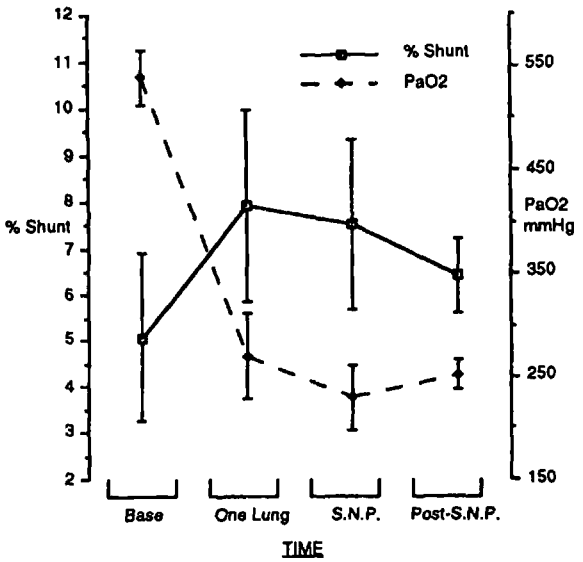
References:
1. J Appl Physiol 59:189-196
2. Anesth Analg 64:821-33

TABLE 1

	I Base. 2 LV	II Pre. 1 LV	III SNP 1 LV	IV Post 1 LV
MAP	81 ± 3	84 ± 4	61 ± 1 *	95 ± 7
MPAP	22 ± 2	22 ± 3	17 ± 2	20 ± 2
PAOP	15 ± 2	13 ± 1	10 ± 1	16 ± 1
Q	4.0 ± 1	4.7 ± 1.2	5.1 ± 1.4	4.2 ± 1.1
PaO_2	539 ± 25	270 ± 42 *	229 ± 32	251 ± 15
SaO_2	99 ± 0	99 ± 0	99 ± 0	99 ± 0
PvO_2	53 ± 4	49 ± 3	47 ± 1	44 ± 2
SvO_2	86 ± 2	82 ± 2	83 ± 0	79 ± 1
SVR	1626 ± 398	1490 ± 313	981 ± 236*	1890 ± 391*
PVR	162 ± 44	163 ± 18	141 ± 30	81 ± 19
Q_S/Q_T	5 ± 2	8 ± 2 *	8 ± 2	6 ± 1

* $p<0.05$

Fig. 1 Qs/Qt and PaO2 ChangesOne Lung Ventilation and S.N.P. Infusion.



A NOVEL METHOD OF ADMINISTERING SUFENTANIL-O2 ANAESTHESIA FOR CORONARY ARTERY BYPASS SURGERY

Karski J, MD., Teasdale S, MD., Chung F, MD., Cruise C, MD., Skala R, MD.,Zulys V, MD
Toronto General Hospital, University of Toronto, Toronto, Ontario.

Introduction: Induction of anaesthesia for cardiac surgery by rapid intravenous bolus injection of sufentanil has been associated with a significant decrease in blood pressure and heart rate[1]. The possibility of these haemodynamic effects has limited the use of sufentanil for cardiac anaesthesia in our centre in spite of reports of superior intraoperative haemodynamic stability and earlier postoperative awakening obtained with sufentanil[2].
We studied the haemodynamic effects of sufentanil administered by a different technique, namely intravenous infusion over a predetermined time period. With institutional ethics committee approval, 27 consecutive patients (24 males, 3 females) aged 50 to 70 years (59± 7.7) with good left ventricular function (LVEF>40%) who were booked for elective coronary artery bypass surgery were studied.

Methods: Premedication with sublingual lorazepam (0.04-0.06 mg/kg) and intra-muscular morphine (0.1-0.15 mg/kg) was given 90 minutes before induction. Anti-anginal medications were continued up to the time of surgery. Metoprolol (50 mg) was administered per os with the premedication if the patient was not already receiving a beta blocker in an effort to standardize pre-operative conditions.
Invasive monitoring was instituted before anaesthesia and baseline haemodynamics determined. Patients were induced with an infusion of sufentanil (8ug/kg) over 4 minutes. Two subsequent doses of sufentanil (6ug/kg each) were given over 2 minutes one prior to skin incision and one prior to sternotomy. Pancuronium (2 mg) was administered immediately before induction and the remaining pancuronium (total=0.1 mg/kg) was given during the first dose of sufentanil. Three additional intravenous boluses of sufentanil (50 ug each) were permitted for control of hypertension or tachycardia to maintain values within 20% of preoperative baseline before resorting to a vasodilator {nitroglycerin (NTG)} or propranolol.
The following data were collected: adequacy of preoperative sedation, haemo-dynamic parameters before and after intubation, skin incision, sternotomy and aortic root dissection, and perioperative awareness. Use of vasodilators and extra doses of sufentanil were recorded.
Statistics: The Statistical Analysis System programs (VMS version 6.06) was employed to examine discrete data using Chi-square and continuous data using analysis of variance.
All comparisons were Bonferroni adjusted.

Results: All but three patients were judged to be adequately sedated preoperatively. None had recall of intraoperative events. Patients were awake 5.0± 2.8 hours after the end of surgery.
No vasopressors were required during induction or during the pre-bypass period. Although specific post-induction haemodynamic values were significantly different from preoperative baseline (table 1), the variations were small and did not exceed 20% of the control value except in 2 patients (7%) who received NTG to treat hypertension and 1 patient who received atropine for bradycardia (45 beats /min).
Additional 50 ug doses of sufentanil successfully lowered blood pressure to desired levels in 3 patients but was generally ineffective in lowering blood pressures to the low levels required for aortic cannulation, and 8 patients required NTG infusion transiently.
The most troublesome side-effect was chest wall rigidity seen in 33% of the study patients not prevented by the 2 mg pancuronium priming dose. Earlier administration of pancuronium during the induction dose of sufentanil controlled this disturbing event in subsequent patients. One patient required propanolol for atrial fibrillation.

TABLE 1

	PRE-ANES	1' PRE	1'POST SUFENTA	1' POST SUFENTA	1' POST SKIN	1' POST STERNOTOMY	1' POST DISSECT.
HR	59± 1.9		64± 2.0*	67± 2.2*	61± 2	61± 1.8	62± 1.9
SAP	131± 3		121± 2.7*	130± 4	123± 3.2*	128± 3	113± 3*
DAP	64± 1.6		60± 1.7	64± 2.2	63± 1.9	66± 1.9	59± 1.8*
MAP	88± 1.9		82± 2.0*	86± 2.7	84± 2.3	88± 2.3	77± 2.1*
CO	5.0± 0.2	5.	4± 0.2	5.6± 0.2*	4.9± 0.2	4.7± 0.1	4.7 0.2

* statistically significant difference from control values but not exceeding 20 % of baseline.

Conclusion: Sufentanil administered by intravenous infusion provided stable haemodynamics for anaesthetic induction of patients with good ventricular function before elective CABG surgery. Infusion of sufentanil prior to skin incision and prior to sternotomy was associated with normotension (within ±20% of baseline) in 25 (93%) patients. No patient had recall of intraoperative events and 75% awoke within 5.0 hours postoperatively.

References:

1. Spiess BD, Sathoff RH,et al High-dose sufentanil: four cases of sudden hypotension on induction. Anesth Analg 65:(6)703-5, 1986.

2. Ikeda R, et al. A comparison of hemodynamic changes with sufentanil-O_2 and fentanyl-O_2anesthesia for coronary bypass grafting. Japanese J Anesth 38:(11)1469-75, 1989.

ANTIFIBRINOLYSIN THERAPY FOR THE PREVENTION OF POST-CPB BLEEDING.

Karski J, MD., Teasdale S, MD., Young P,RN., Carroll J, RN.,Ivanov J, RN., Glynn M, MD..

Toronto General Hospital, University of Toronto, Toronto, Ontario.

INTRODUCTION: Patients undergoing cardiac surgery with cardiopulmonary bypass (CPB) are at risk of significant postoperative bleeding. Excessive bleeding contributes to postoperative morbidity and mortality and exposes the patient to reoperations as well as to the risk of blood transfusions. Apart from possible surgical causes of bleeding, multiple complex changes in the hemostatic mechanisms have been described after CPB. The most important changes are transient platelet dysfunction and activation of the fibrinolytic system. Release of plasminogen activator associated with manipulation of the heart and activation of factors XII (Hageman) and B (Bb) of the complement system may be responsible. Fibrinolytic hemorrhage has been estimated to cause at least 12 to 25% of bleeding episodes[1]. Antifibrinolytic agents have been employed to prevent or treat fibrinolytic hemorrhage[2].

In our institution two antifibrin-olytic agents have been used in the pre-bypass period to prevent induction of fibrinolysis. Epsilon-amino-caproic acid (EACA or AMICAR) in doses of 10-15 gm or tranexamic acid (Cyklokapron) in doses of 6-12 gm were administered as intravenous infusions over 2 hours prior to CPB. Cyklokapron is ten times more potent than EACA , binds more strongly to plasminogen, has a longer half-life and is less expensive. Experience with Cyklokapron after CPB is limited.

METHOD: We collected data retrospectively on 206 consecutive patients undergoing first time coronary artery bypass surgery (CABG) with CPB. EACA was given to 66 patients, 80 received Cyklokapron and 60 received no antifibrinolysin. Availability of the drug in the hospital pharmacy determined the choice of agent.
Patients were anesthetized with high dose Fentanyl/Pavulon technique with routine invasive monitoring. Heparin was given (initial dose 300 ug/kg) to maintain the ACT above 400 sec. Cardiopulmonary bypass utilized non-pulsatile flows of between 2.0-2.4 L/min and the pump circuit was primed with 2.5 liters of Ringer's lactate solution, 5000 units of heparin and 100 ml 25% albumin. A semi-porous membrane oxygenator was employed. Systemic hypothermia (25-28^{0}C) was maintained during the cross clamp period. Following discontinuation of CPB, heparin was reversed with protamine sulphate (1 mg per 100 units of heparin) to approximate the control ACT. Mediastinal and pleural drains were employed to collect the blood which was autotransfused for up to 6 hrs post operatively.

MEASUREMENTS: As estimates of intra-operative blood loss are grossly inaccurate we collected and analyzed post-operative chest tube drainage after 6 and 24 hours in ICU, total amount of blood and blood products transfused, haemostatic parameters (PT,PTT and platelets), as well as daily haematocrits.
STATISTICS: Results were analyzed using the SAS statistical programs to compare clinical variables by analysis of variance (ANOVA) or Chi-squares, serial measurements with 2-way ANOVA using the general linear models procedure. Duncan's multiple range test was used to specify differences when the F ratio of the ANOVA was significant ($p<0.05$).

RESULTS: Patients receiving prophylactic antifibrinolysins EACA and Cyklokapron, bled significantly less than the control group (Fig. 1). With the numbers of patients analyzed to date there was no significant difference between blood loss with EACA as compared to Cyklokapron although a trend favouring Cyklokapron is suggested. Pretreatment with Cyklokapron significantly reduced blood requirements in the postoperative period (Table I).

Our preliminary results indicate that antifibrinolytic agents significantly reduce postoperative blood loss in patients undergoing CPB for first time coronary artery surgery.

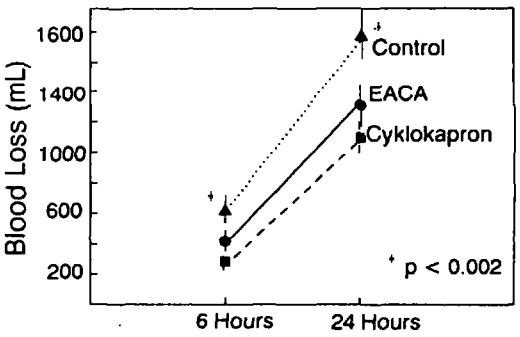


Figure I: Post operative chest drainage with prophylactic antifibrinolysins compared to controls.

Table I

Volume of Packed Cells Transfused Perioperatively (ml).

GROUP	CYKLOKAPRON	AMICAR	CONTROL
OR Packed Cells	108±259	176±336	214±320
Total Packed Cells	264±438*	340±420	550±613

*p>0.005 when compared to control group

1. Ann NY Acad Sci 1964;115:302-4.

2. J Thorac Cardiovasc Surg 1963;46:673-9.

THE OUTCOME OF PATIENTS WITH TRANSPLANTED HEART UNDERGOING SUBSEQUENT OPERATIONS

D.C.H. Cheng, FRCPC; D. Ong, MD
Department of Anaesthesia, University of Toronto, The Toronto Hospital, Toronto Western Division, Toronto, Ontario, M5T 2S8

Introduction: As world-wide experience increases, together with the advancement in immunosuppression therapy, approximately 85% of heart transplanted patients may now be expected to survive at least 1 yr, and most are alive 5 yrs after transplantation (1). For subsequent surgery, this group of patients will present to anaesthetists with an unusual combination of problems, principally related to complex medication therapy and alterations in hemodynamics resulting from cardiac denervation. This retrospective study reports the anaesthetic management and surgery on outcome of heart transplanted patients following subsequent operations during 1985-1990.

Methods: From March 1985 to May 1990, 86 patients underwent heart transplantation at our institution. Twenty-eight patients (32.6%) returned for a total of 51 surgical procedures. For the purpose of analysis as independent variable, only the first repeated surgery in cath patients was included. The data was grouped into type of surgery, preoperative demographic and associated diseases, duration of transplanted heart, perioperative hemodynamics, postoperative complications (hypotension, right heart failure, arrhythmia, infection, renal failure, hepatic dysfunction and bleeding), and was analyzed in relation to type of anaesthesia and postoperative total outcome by Chi square, Fisher Exact and t-tests where appropriate.

Results: In 28 heart transplanted patients (M:F, 24:4) who returned for additional surgical procedures, 12 (42.9%) were elective and 16 (57.1%) were emergency surgery. The incidence of mortality was 1/12 (8.3%) and 5/16 (31.3%) in elective and emergency surgery respectively. The type of anaesthesia and surgical procedures were tabulated in table 1. When return surgery was divided into less than 3 days post-transplantation (group A), all 12 surgeries were emergency, while surgery more than 3 days post-transplantation (group B), 12 (75%) were done as elective cases and 4 (25%) were done as emergency cases. Group A patients were likely to be monitored by an arterial line (10 vs 4) or pulmonary artery catheter (7 vs 1) ($p<0.05$), and required significantly more cardiac medications intraoperatively when compared to group B.

Table 1:

Surgical procedure	Anaesthesia Type (no. of patients)
Reopening of mediastinum	GA (13)
Ophthalmology	Neuroleptic (4)
G.I.	GA (3), Spinal (1)
Pacemaker	Neuroleptic (2)
Dental	GA (2)
Thrombectomy	GA (1)
Brain tumor Biopsy	Neuroleptic (1)
Vocal Cord Augmentation	Neuroleptic (1)

The anaesthetic given was 19 (67.9%) general anaesthesia (GA), 1 (3.6%) spinal and 8 (28.6%) neuroleptic. Although all 5 deaths occurred in GA group and one in neuroleptic group, no significant difference was found between type of anaesthesia and mortality or postoperative complications. Sex and ASA classification were not significant in determining the type of anaesthesia, but the time to surgery following heart transplantation was significantly less in GA (153.8 $\pm$ 56.5 days, x $\pm$ SEM) than neuroleptic group (638.9 $\pm$ 199.2 days). The duration of surgery was significantly longer in GA (104.4 $\pm$ 24.5 min) than neuroleptic group (42.5 $\pm$ 3.5 min). For cardiovascular response, significantly lower SBP was found during pre- and post-induction in GA when compared to neuroleptic group. Whereas, no significant difference was found in HR between the two groups (table 2).

Table 2:

Hemodynamic	Anaesthesia	Pre-induction	Post-induction
SBP (mmHg)	GA	99.5 $\pm$ 6.2*	103.3 $\pm$ 5.1*
	Neuroleptic	149.3 $\pm$ 11.2	146.8 $\pm$ 11.9
HR (bpm)	GA	95.3 $\pm$ 2.8	95.2 $\pm$ 3.3
	Neuroleptic	86.9 $\pm$ 5.2	86.3 $\pm$ 4.9

Mean $\pm$ SEM
* $p<0.05$ (GA vs Neuroleptic)

Discussion: In our heart-transplanted population, 32.6% were subjected to at least one additional operation. General, spinal and neuroleptic anaesthesia appeared not to significantly affect the induction hemodynamics and postoperative outcome in these patients. This study suggests that the cardiac-transplanted patient presents an acceptable anaesthetic risk for surgery.

References:

1. Transplant Proc 17:199-203, 1985.

BEDSIDE ASSESSMENT OF NECK MOBILITY IS CLINICALLY RELEVANT.

F. Chow, MD; G. Packota, DMD, DipOR, MS; R. Yip, MD, FRCPC, W.E. Code, MD, FRCPC
University of Saskatchewan, Departments of Anaesthesia and Dentistry, Saskatoon, Saskatchewan

INTRODUCTION: Currently, pre-op clinical examination considers freatures that are believed to indicate difficulty of intubation. However, a simple quantitative rule that is useful for clinical assessment of neck extension has not been described.

Atlanto-occipital mobility is the most important cervical joint in determining neck extension for the "sniffing position."[1] Thirty-five degrees of extension is possible at the normal atlanto-occipital joint.[1] Good extension of the atlanto-occipital joint approximates the axes of the mouth and trachea, thus facilitating intubation by direct laryngoscopy.

Difficult airways secondary to reduced atlanto-occipital extension can be diagnosed by C-spine radiographs. The single best discriminatory variable to distinguish between straight forward airways and difficult airways, is degree of neck extension ($p < 0.001$).[2]

The relatively low incidence of difficult intubations do not warrant neck radiographs of every patient from a risk-benefit perspective. This study tested the hypothesis: There is a relationship between topographic bedside clinical measurements with degree of radiograph neck extension.

METHOD: Forty volunteers, 22 men and 18 women participated. The distances between the mandibular tip and sternal notch were measured by tape measure, with the neck in neutral, flexion and extension positions. Teeth were kept clenched.

Differences of sternal and mandibular tip distances between the neutral and extension position were calculated. The same was done with flexion position and distances.

Neck radiographs of the volunteers were taken in the identical respective positions using a standardized protocol.

Superimposition of the flexion or extension radiographs on the neutral radiograph using C_5 alignment as the reference point was done. The angle of flexion and extension was measured with a protractor.

The difference between tape-measured distances of extension with neutral were correlated with radiographic neck extension angles, using Pearson's coefficient of correlation. This was done separately for the men and women. Similarly this was done for neck flexion. A t test was used to assess the significance of these correlations in both groups.

RESULTS: A correlation coefficient was derived for topographic extension minus neutral distance and the radiographic extension angle.

See Table 1: Measurements

M = $r = 0.66$ $t = 3.99$ (0.0005 level)

F = $r = 0.56$ $t = 2.7$ (0.01-0.005 level)

t values showed r was statistically significant at the 0.01 to 0.0005 level (the probability that the coefficient of correlation r was due to chance is 1/100 to 1/2000).

There was no correlation shown between the following:

(1) Radiographic neck extension with neck length, a reflection of patient height.

(2) Radiographic flexion angles and the topographic flexion, neutral distance difference.

(3) Range of flexion to extension distance and the sum of the radiographic flexion and extension angles.

DISCUSSION: Prevalence of difficult intubation ranges from 0.5% to 13% in a series of studies.[2] The estimates for failed intubation are 0.05 - 0.3%.[3] Undiagnosed difficult airways are a major source of morbidity and mortality secondary to hypoxia and gastric aspiration.

There are obvious common causes of difficult direct laryngoscopy that are easily diagnosed. More subtle anatomic variations which contribute to difficulty such as reduced atlanto-occipital extension and reduced atlanto-occipital gap still require quantitative clinical values.[2] Difficult intubation causes can be multifactorial, however, limited neck extension may be the single most important undiagnosed factor.

The calculated coefficient of correlation "r" showed moderate to good correlation between topographic extension minus neutral distance and radiographic extension angle, (intuitively, a large extension minus neutral distance should correlate with a large extension angle). In contrast there was no correlation between radiographic flexion angles with any measurements involving flexion. Neck length was shown not to be a determinant of neck extension measured radiographically.

CONCLUSION: A reduced neck extension distance measured from the mandible tip to sternal notch from the neutral position predicted a reduced degree of radiographic neck extension. We therefore accept the hypothesis that bedside measurements can be used clinically to assess neck extension of which the atlanto-occipital joint is a major component. A reduced topographic extension distance from the neutral may suggest an intubation difficulty.

REFERENCES:

1. Brechler, VL. Anes & Anal, 1968; 47 362-73.
2. Bellhouse, CP and Dore, C. Anasth Intens Care, 1988; 16:329-37.
3. Wilson, ME et al. Br J Anaesth (1988), 61, 211-16.

TABLE 1: Measurements

Mandibular Tip to Sternal Notch Distance (cm)

	n	Age Range	Neutral Range	Neutral Average	Extension Range	Extension Average
M	22	24-36	10-16cm	13.0cm	16.5-24.7cm	21.0cm
F	18	26-36	10-15cm	11.9cm	18.0-23.0cm	19.9cm

	Topographic Measurements		Radiographic Measurements	
	Ext-Neutral Range	Ext-Neutral Average	Ext-Angle Range	Ext-Angle Average
M	5.2-11.2cm	8.0	14^{o}-24.5^{o}	17.8^{o}
F	5.5-10.0cm	7.9	14^{o}-23.0^{o}	21.3^{o}

PREVALENCE OF LATEX SENSITIZATION IN 100 HOSPITAL PHYSICIANS AT THE UNIVERSITY OF TORONTO

J. Bradley, M.D., R. Arellano, M.D., G. Sussman, M.D.
Department of Anaesthesia, The Toronto Hospital, Toronto General Division, 200 Elizabeth Street, Toronto, Ontario. M5G 2C4.

INTRODUCTION

Mounting evidence has shown that anaphylaxis can occur in a hospital setting following transmembranous or transperitoneal absorption of latex (1-4). Latex is a natural sap obtained from the tree, Havea brasiliensis. It is commonly found in "rubber" containing materials such as surgeons gloves and catheters equipped with inflatable rubber balloons.

Sensitization to latex commonly occurs via the transcutaneous route. Turjanmaa et al.(5) have suggested that the prevalence of latex sensitization is higher among hospital employed primary care givers than in a control population. This suggests that physicians who have an occupational exposure to latex may represent a population at risk for anaphylaxis should they undergo medical procedures in which transmucosal or transperitoneal absorption of latex is possible.

Our study was designed to determine the prevalence of sensitization to latex in doctors with an occupational exposure to latex gloves.

METHOD

With institutional approval, 100 physicians from three teaching hospitals employed in the departments of Anaesthesia, Surgery and Radiology who had a history of occupational exposure to latex gloves were studied. Occupational history and allergic history were recorded. The method of skin testing has been described by Sussman et al.(1). Skin prick tests were performed on the forearm with latex (Bencard, Mississauga, Ontario). Positive histamine (Bencard, Mississauga, Ontario) and negative sterile saline controls were included. The results were read after 10 minutes. Wheal and flare reactions which were at least half the size of the histamine controls were regarded as positive.

RESULTS

No undue systemic reactions resulted from the skin testing procedure. Out of 100 doctors that were studied,the prevalence of latex sensitization was 9%. One of the subjects who tested latex positive had a history of anaphylaxis when a latex balloon was inflated during a barium enema.

DISCUSSION

There have been several reports of intra-operative anaphylactic reactions in patients who have had their peritoneal cavity exposed to surgical latex gloves (2-4). The Hospital for Sick Children in Toronto has reported twenty cases of anaphylactic reactions in spina bifida patients who were having laparotomies (2). These patients had all been exposed to years of latex through indwelling type urological catheters. Our study showed a 9% prevalence of positive skin testing to natural latex. This is probably due to the chronic exposure these physicians have had from wearing latex gloves either in the hospitals or offices. One of the nine latex sensitized physicians had a previous history of anaphylaxis to latex. The differential of an anaphylactic reaction to latex should be considered whenever severe hypotension or bronchospasm occurs intropera tively in physicians exposed previously to natural latex.

REFERENCES

1. Sussman G., Bradley J., Tarlo S., Dolovitch J.: Natural Latex Hypersensitivity Reactions. Clinical and Investigative Medicine. 1990;13

2. Swartz J.S., Gold M., Braude B.M., Dolovich J., Gilmour R.F., Shandling B.: Intraoperative Anaphylaxis to Latex: An Identifiable Population at Risk. Canadian Journal of Anaesthesia 1990; 37:5131

3. Leynadier F., Pecquet C., Dry J.: Anaphylaxis to Latex During Surgery. Anaesthesia 1989; 44:547-50.

4. Gerber A.C., Jörg W., Zbinden S., Seger R.A., Dangel P.H.: Severe Intraoperative Anaphylaxis to Surgical Gloves: Latex Allergy, an Unfamiliar Condition. Anesthesiology 1989; 71:800-2.

5. Turjanmaa K.: Incidence of Immediate Allergy to Latex Gloves in Hospital Personnel. Contact Dermatitis 1987; 17:270-75.

EVALUATION OF A NEW CERAMIC ENDOTRACHEAL TUBE FOR LASER AIRWAY SURGERY

M. Sosis, M.D., Ph.D., B. Braverman, Ph.D., A Ivankovich, M.D.
Rush-Presbyterian-St. Luke's Medical Center, Chicago, Illinois

Laser-induced endotracheal tube combusion poses a serious patient hazard during airway surgery. A survey of otolaryngologists involved in these cases noted that endotracheal tube fires and explosions were the most frequent serious complication of laser airway surgery.[1] Fuji systems has recently introduced a new silicone endotracheal tube containing ceramic particles for laser use. We compared it to conventional polyvinylchloride endotracheal tubes and foil wrapped endotracheal tubes in this investigation.

Methods: Size 8.0 mm internal diameter Phycon endotracheal tubes (Fuji Systems, Tokyo, Japan) were compared to 8.0 mm internal diameter polyvinylchloride endotracheal tubes (Mallinckrodt, Hi-Lo, Argyle, NY, USA). The polyvinylchloride endotracheal tubes were studied as received from the manufacturer or after wrapping them with 0.25 inch wide 1 mil copper foil tape (Venture Tape Corp., Rockland, Massachusetts, USA). This tape was applied in a continuous overlapping spiral manner starting at the cuffed end of the endotracheal tube. The endotracheal tube under study was placed on a wet towel in air and had 5 liters/min of oxygen flowing through it. The endotracheal tubes were subjected to either continuous laser radiation at 30 watts from a Sharplan (Tel-Aviv, Israel) 733 carbon dioxide laser positioned perpendicularly 17.5 cm above the endotracheal tube or 34 watts of continuous output from a LaserSonics (Santa Clara, California, USA) model 8000 Nd-YAG laser. The Nd-YAG laser was propagated via a 600 micron fiber bundle and was directed perpendicularly at the endotracheal tube to be studied. The laser's output was continued until a blow-torch fire occurred or 60 or 95 seconds had elapsed for the carbon dioxide and Nd-YAG studies respectively.

Results: All five trials with the carbon dioxide laser directed onto the Phycon endotracheal tubes resulted in blowtorch ignition of the endotracheal tubes after 35.98 $\pm$ 5.93 seconds (mean $\pm$ S.D.). The range was 25.9 to 44.1 seconds. None of the copper foil wrapped polyvinylchloride endotracheal tubes was affected by 60 seconds of continuous carbon dioxide laser radiation. All of the five plain polyvinylchloride endotracheal tubes subjected to carbon dioxide laser radiation were ignited and blow-torch fires occurred after 1.24 $\pm$ 0.40 seconds (mean $\pm$ S.D.). The range was 0.93 to 2.0 seconds. The times to ignition of the Phycon endotracheal tubes by the carbon dioxide laser were significantly greater than that for the plain polyvinylchloride endotracheal tubes (P less than 0.001) as determined by the Student's t-test.

Nd-YAG laser radiation initiated blowtorch combustion of the five Phycon endotracheal tubes studied after 46.67 $\pm$ 26.16 seconds (mean $\pm$ S.D.). The range was 17.9 to 91.0 seconds. As was the case with the carbon dioxide laser, none of the copper foil-wrapped endotracheal tubes was affected by 95 seconds of continuous Nd-YAG laser fire. The application of Nd-YAG laser radiation onto the shafts of the bare polyvinylchloride endotracheal tubes resulted in blowtorch ignition after 1.70 $\pm$ 0.55 seconds (mean $\pm$ S.D.).The range was 0.9 to 2.6 seconds. The times to Nd-YAG laser ignition of the Phycon endotracheal tubes were significantly (P less than 0.01) greater than that for the plain polyvinylchloride endotracheal tubes as determined by the Student's t-test.

Discussion: The high energy density of the surgical laser, combined with its proximity to combustible endotracheal tubes during laser airway surgery, has resulted in catastrophic airway fires that have seriously burned patients. In a survey of otolaryngologists active in laser airway surgery, Fried determined that such endotracheal tube fires and explosions are the most common serious complications occurring during these cases.[1] The incidence of such laser-induced endotracheal fires has been estimated to be 0.57%, making them one of the most frequent serious mishaps in clinical anaesthesia.[2]

A variety of techniques have been developed to protect endotracheal tubes from the laser. The use of metallic foil wrapping to protect endotracheal tube shafts from the carbon dioxide has been shown to be highly effective when the correct foil wrap is carefully applied.[3] However, none of the foil tapes has been approved for this application by government regulatory bodies. Also, specially manufactured endotracheal tubes have been developed for these applications. Comparative evaluations by our group have shown only one such endotracheal tube to be unaffected by the carbon dioxide laser operating at high power.[4] None of the specially manufactured endotracheal tubes tested provided satisfactory protection from the Nd-YAG laser set to high power.[5]

The Fuji Phycon endotracheal tube is fabricated from ceramic particles that are extruded into a silicone matrix. Unlike foil wrapped endotracheal tubes, the Phycon endotracheal tube has a smooth, nontraumatic exterior and a thinner wall thickness. It has been approved for laser use and comes in a prepackaged, ready to use, sterile form. Our study shows that the Phycon endotracheal tube, although combustible, is much less susceptible to the effects of the carbon dioxide and Nd-YAG lasers than were the plain polyvinylchloride endotracheal tubes.

References

1. Fried MP: Laryngoscope 93:275-278, 1983.
2. Snow JC, Norton ML, Saluja TS, Estanislao AF: Anesth Analg 55:146-147, 1976.
3. Sosis MB: Anesth Analg 68:392-393, 1989.
4. Sosis M, Heller S: Anesthesiology 69:A251, 1988.
5. Sosis MB: Anesth Analg 69:802-804, 1989.

EVALUATION OF FOIL COVERINGS FOR PROTECTING ENDOTRACHEAL TUBES FROM THE KTP LASER

M. Sosis, M.D., Ph.D., B. Braverman, Ph.D., A.D. Ivankovich, M.D.
Department of Anesthesiology, Rush-Presbyterian St. Luke's Medical Center, Chicago, Illinois

The proximity of the surgical laser to combustible endotracheal tubes during airway surgery has converted them into veritable "blow-torches" which have caused serious patient injuries.[1] The metallic foil wrapping of combustible endotracheal tubes has been shown to protect them from the carbon dioxide[2] and Nd-YAG lasers.[3] This study was undertaken to determine whether self-adhesive metallic foil tapes or the Laser-Guard protective coating could adequately protect polyvinylchloride endotracheal tubes from the potassium-titanyl-phosphate (KTP) laser. This laser is being used increasingly in otolaryngologic surgery of the upper airway and, consequently, in common with the carbon dioxide and Nd-YAG lasers, it might ignite an endotracheal tube and cause serious burns to the patient.

Methods: A Laserscope (San Jose, California, USA) model CE 3924 KTP laser was set to its maximum output of 18 watts in the continuous mode of operation. The laser's output was propagated via a fiberoptic bundle and directed perpendicularly at Mallinckrodt (Glens Falls, New York, USA) size 8 mm internal diameter "Hi-Lo" polyvinylchloride endotracheal tubes which had 5 liters/minute of oxygen flowing through them. The laser was actuated until combustion occurred or 1 minute had elapsed. The endotracheal tube to be tested was surrounded by air and rested on wet towels during the experiment. Seven endotracheal tubes were studied. Five were wrapped with 0.25 inch self-adhesive metallic foil tapes in a continuous overlapping spiral manner with a single piece of foil starting just above the endotracheal tube's cuff. The tapes used were: 1) Radio Shack (Tandy Corp., Fort Worth, Texas, USA) No. 44-1155; 2) Venture (Rockland, Massachusetts, USA) 1 mil thick copper foil tape; 3) 3M (St. Paul, Minnesota, USA) No. 433; 4) 3M No. 1430; and 5) 3M No. 425. The Laser-Guard (Merocel Corp., Mystic, Connecticut, USA) protective coating was also applied to a polyvinylchloride endotracheal tube and was moistened with water according to the manufacturer's instructions before it was tested with the laser. Finally, a plain, unprotected polyvinylchloride endotracheal tube was studied as a control. The adhesive side of the foil tapes was also tested by wrapping an endotracheal tube with the foil tape with the adhesive side facing outward.

Results: The plain unprotected polyvinylchloride endotracheal tube started burning after 14 seconds of laser contact. Laser application to the non-adhesive side of the five tapes studied had no affect after 1 minute. However, when the laser was fired at the adhesive side of the Radio Shack No. 44-1155 tape, flames were seen after 7 seconds of laser acutation and the tape broke apart. Laser impact onto the adhesive side of the 3M No. 1430 tape caused the endotracheal tube to melt under the tape in 6 seconds. For the other tapes, the endotracheal tubes melted in 60 seconds. The Laser-Guard protected endotracheal tube was unaffected by 1 minute of continuous laser contact, but its foam coating was noted to be missing at the site of laser contact. However, the underlying embossed silver foil layer was unaffected.

Discussion: Three factors play a role in the occurrence of catastrophic fires during laser airway surgery.[1] The surgical laser presents a high powered source of radiation in a very small area. Combustible endotracheal tubes such as those fabricated from polyvinylchloride or rubber have been used and may be in very close proximity to the site of surgery especially during otolaryngologic surgery of the upper airway. Finally, the anaesthetic gases used may support and enhance combustion. Inadvertant laser contact with a combustible endotracheal tube has been documented to cause severe airway fires which have seriously injured patients.[1] In an attempt to prevent such endotracheal tube fires, metallic foil taping, with the appropriate tape has been advocated when the carbon dioxide[2] or Nd-YAG[3] laser is used. This study represents the first investigation of the protection afforded by metallic foil tapes when used with the KTP laser.

The KTP laser produces radiation with a wavelength of 532 nanometers which has a green colour. It is readily absorbed by hemoglobin and consequently has an intrinsic hemostatic effect. Its degree of tissue penetration and scattering is intermediate between that of the carbon dioxide and Nd-YAG lasers. Unlike the carbon dioxide laser, it can be propagated via a fiberoptic bundle.

This study demonstrates that KTP laser contact with a plain polyvinylchloride endotracheal tube or with the adhesive backing of the Radio Shack No. 44-1155, Venture copper foil or 3M. Nos. 433, 1430, and 425 tapes, when applied to a polyvinylchloride endotracheal tube led to blow torch ignition or the melting of the endotracheal tube. The Laser-Guard protective coating consists of a rectangular sheet of silver foil which has been coated with adhesive on one side and a foam coating on the other side. Silver was chosen because this metal has a high thermal conductivity. When the foam layer is moistened, it acts as a heat sink and affords a smooth, nontraumatic exterior to the wrapped endotracheal tube. Under the conditions of this experiment, only the Laser-Guard protective coating adequately protected the shaft of the endotracheal tubes tested. Its use is therefore recommended.

References:

1. Cozine K, Rosenbaum LM, Ashkanazi J, Rosenbaum SH: Laser-induced endotracheal fire. Anesthesiology 55:583-585, 1981.
2. Sosis MB: Evaluation of five metallic tapes for protection of endotracheal tubes during CO_2 laser surgery. Anesth Analg 68:392-393, 1989.
3. Sosis MB, Dillon F: What is the safest foil tape for endotracheal tube protection during Nd-YAG laser surgery? A comparative study. Anesthesiology 72:553-555, 1990.

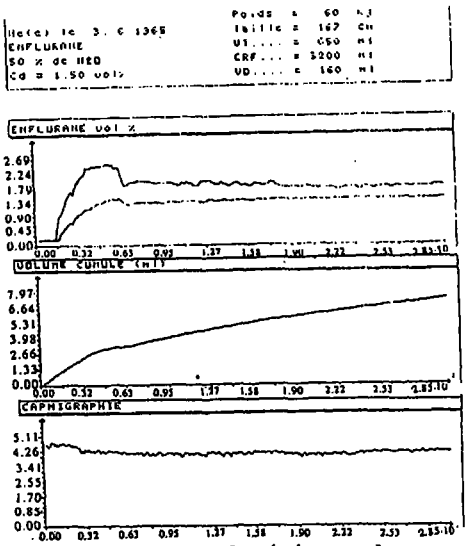
Gestion informatique de la concentration alvéolaire d'halogéné en circuit fermé ou semi-fermé.

M. Manganas, M.D., A. Lephay, M.D., Th. Fournier, M.D., N. Kadri, M.D., M. Ossart, M.D.,
Département d'Anesthésie-Réanimation B - CHRU NORD - F - 80054 AMIENS

INTRODUCTION : L'anesthésie en circuit fermé ou semi-fermé grâce en partie au progrès des appareils de monitorage permet une anesthésie sans danger. Le problème qui persiste reste la grande variabilité de la concentration alvéolaire en halogénés qui oblige à adapter en permanence le pourcentage d'anesthésique volatil délivré. L'objectif de notre travail est l'utilisation d'un système d'informatique couplé au circuit fermé ou semi-fermé et à un analyseur de vapeurs halogénées pour maintenir stable par rétrocontrôle la concentration alvéolaire.

MOYENS ET METHODES : Le système a d'abord été testé en atelier. Il comprend un respirateur (Siemens 710) muni d'un canister, un analyseur de vapeurs halogénées (Siemens 120) et un capnographe branché sur l'"Y" du circuit patient. L'anesthésique volatil halogéné (Enflurane dans notre étude) est injecté sous forme liquide par une seringue autopulsée dans le segment expiratoire du circuit (la vaporisation des halogénés étant quasi instantanée). Celle-ci est commandée par un ordinateur et asservie aux données fournies par l analyseur de vapeurs halogénés. Les données concernant le patient (poids, taille, âge, sexe), pourcentage O_2/N_2O, type d'halogéné choisi sont entrés dans l'ordinateur. Elles permettent le calcul par le micro-processeur du volume courant (Vt), de la capacité résiduelle fonctionnelle (CRF), de l'espace mort (VD) et de la concentration alvéolaire "idéale" à atteindre et à maintenir stable (appelée concentration désirée ou Cd définie à partir de la MAC 95). Le patient est prémédiqué en intra-musculaire par une benzodiazépine et un vagolytique. L'induction anesthésique est faite par voie intra-veineuse : Propofol, Fentanyl et Vécuronium. Dés l'intubation endotrachéale réalisée, le patient est relié au système. Le relais de la narcose est alors pris par l'Enflurane. Grâce à l'analyseur d'halogéné, on obtient la concentration maximale ou inspirée et minimale ou de fin d'expiration qui sert de base à la régulation. L'ordinateur est interrogé environ 60 fois par cycle de ventilation. Les courbes de concentration en halogénés et de capnographie sont affichées en permanence à l'écran. Des alarmes sonores et visuelles peuvent se déclencher lorsque les valeurs sont en dehors des normes fixées. Les courbes et la liste des alarmes sont éditées en fin d'intervention par l'imprimante.

RESULTATS : L'étude porte sur 20 patients de chirurgie orthopédique. La durée des interventions est d'environ 2 heures. Les données concernant le patient apparaissent à l'écran. La concentration désirée est atteinte très rapidement (2 à 3 minutes) et sans oscillation. Elle est maintenue stable grâce au système de rétrocontrôle informatique (les écarts étant inférieurs à 5 p.cent). En fin d'intervention, les courbes de concentrations en halogénés, les valeurs cumulées et la capnographie sont visualisées en permanence sur l'écran et peuvent être éditées en fin d'intervention.



Concentrations en halogénés, volumes cumulés, capnigraphie, en fonction du temps.

DISCUSSION : Pour la phase d'augmentation de concentration alvéolaire, on utilisait jusqu'alors le modèle de LOWE (1), mais celui-ci est trop éloigné de la réalité (grande variabilité d'un patient à l'autre, surestimation de la dose à administrer). Une nouvelle équation a été établie pour obtenir de façon rapide et reproductible la Cd (à 5 p.cent près). Le système d'injection des halogénés en seringue auto-pulsée permet de fonctionner d'emblée en circuit fermé strict sans passer par une phase de circuit ouvert pour saturer la CRF du patient et le circuit. Le débit de la seringue est asservie aux données de l'analyseur de vapeurs halogénées et la concentration alvéolaire reste stable. A tout moment, l'utilisateur peut intervenir et modifier un des paramètres. La sécurité est assurée par l'ensemble des alarmes sonores visuelles et l'affichage permanent des courbes de concentration à l'écran.

CONCLUSION : La gestion informatique de la concentration alvéolaire d'halogéné en circuit fermé ou semi-fermé donne en plus des avantages déjà connus du circuit fermé, une anesthésie mieux adaptée au patient, à sa physiologie. L'administration des anesthésiques halogénés est plus régulière.

BIBLIOGRAPHIE :
1 - LOWE HJ. The anesthetic continuum. (pp 11-37) in : Low flow and closed system anesthesia : Aldrete JA, Lowe JH, Virtue RW. Ed. Grune and Stratton, New York, 1979.

USE OF ENDTIDAL pCO2 AND TRANSCUTANEOUS pCO2 AS NONINVASIVE MEASURES OF ARTERIAL pCO2 IN EXTUBATED PATIENTS FOLLOWING GENERAL ANAESTHESIA.

BP Kavanagh MB, AN Sandler FRCPC, KE Turner FRCPC, V Wick BScN, S Lawson RN.
Dept. of Anaesthesia, Toronto General Hospital, Toronto, Ontario, Canada.

INTRODUCTION: Detection of respiratory depression in postoperative patients is a difficult problem, and definitive testing may necessitate analysis of arterial PCO_2. Noninvasive assessment of $PaCO_2$ in intubated patients is achieved by measurement of end-tidal (ET) or transcutaneous (TC) PCO_2[1]. However, accurate noninvasive measures of $PaCO_2$ in extubated postoperative patients are lacking. This study was designed to assess the accuracy of ET-CO_2 and TC-CO_2 in such patients.

METHODOLOGY: Following institutional ethics committee approval and completion of written informed consent, 30 patients who were scheduled for elective surgery requiring insertion of an indwelling arterial catheter and who were extubated postoperatively, were included. Expired gas was sampled using soft nasal cannulea linked to the sampling port of an 'Ohmeda 5200 CO_2 Monitor'. ET-CO_2 values were recorded as those displayed digitally corresponding to a flat plateau. All $ETCO_2$ values were termed $ETCO_2$(All). Data from which imperfect capnograph traces were excluded, were termed $ETCO_2$(Select). A transcutaneous PCO_2 sensor attached to a 'CRITIKON-FasTrac'(Johnson and Johnson) CO_2 monitor was placed on prepared skin below the clavicle. This sampled transcutaneous PCO_2 at 41°C, and reported results which were automatically corrected for patient temperature. Both monitors were calibrated each time before use, and were maintained in accordance with the manufacturer's guidelines. Patients received supplemental oxygen by face mask. Measurements of ET-CO_2, TC-CO_2, arterial blood gasses and were made every 15 min for 2 hours. Statistical analysis included calculation of linear regression coefficient, R^2, and standard error of the estimate(SEE). $P<.05$ was considered significant. Agreement is reported as bias (mean of differences)$\pm$standard deviation[2].

RESULTS: Demographic characteristics (mean$\pm$SEM) included Age 55$\pm$2.5 yrs, Weight 77.0$\pm$2.4 kg, Height 168.0$\pm$2.5 cm. 232 data collections were made from 30 patients (Table 1). Regression coefficients derived from $ETCO_2$ compared with $PaCO_2$ improved when $ETCO_2$ data with imperfect plateaus were deleted (Table 1). Correlation worsened when $PaCO_2$ was corrected for body temperature. The bias values for $ETCO_2$ and $TCCO_2$ with temperature corrected $PaCO_2$ were as follows (bias$\pm$SD): [$ETCO_2$(all)-$PaCO_2$] = 1.3+6.7 mmHg; [$ETCO_2$(select)-$PaCO_2$] = 0.4+5.3 mmHg; [$TCCO_2$-$PaCO_2$] = 4.15+8.1 mmHg. Several patients demonstrated $ETCO_2$ values greater than the corresponding $PaCO_2$ values, even with selected $ETCO_2$ values (Fig 1). Comparison of the temperature corrected and non-temperature corrected $PaCO_2$ yielded: R=0.5, R^2=0.25, SEE=5.1 (p=0.00), Bias [corrected-uncorrected $PaCO_2$] = -1.9$\pm$5.7.

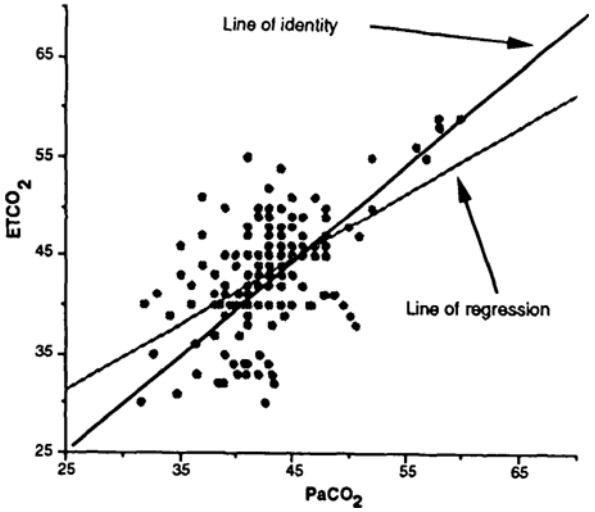
DISCUSSION: $ETCO_2$ and $TCCO_2$ monitors are non-invasive and may provide useful data regarding trends in $PaCO_2$. However, our data suggests that these monitors are not sufficiently accurate to replace direct measurement of $PaCO_2$ in extubated patients following general anaesthesia. Agreement between temperature corrected and uncorrected $PaCO_2$ values is poor in this population.

REFERENCES: (1) J Clin Monit 3:149-154, 1987.
(2) Lancet 2: 307-310, 1986.

Table 1.(Correlation with corrected p_aCO_2)

Variable	R	R^2	SEE	p	n
ETCO2 (All)	0.3	0.1	5.7	0.0	232
ETCO2 (Select)	0.7	0 3	5.1	0.0	149
TCCO2	0.4	0.1	7.5	0.0	232

End-Tidal CO_2 vs Temperature Corrected $PaCO_2$



A COMPARISON OF THE CARDIOVASCULAR EFFECTS OF ATRACURIUM, VECURONIUM AND SUCCINYLCHOLINE IN THE SETTING OF ACUTE β_1 ADRENERGIC BLOCKADE DURING INDUCTION OF ANAESTHESIA

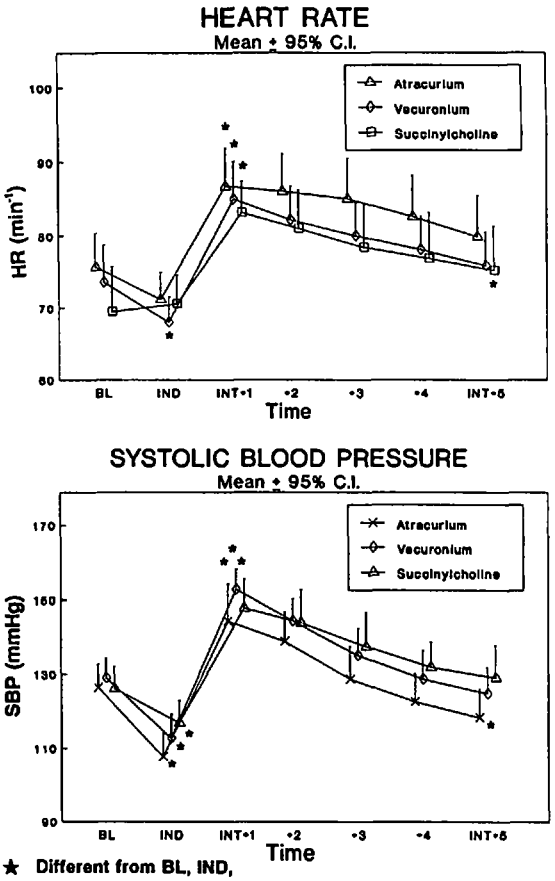
C. Wherrett M.D., R.J. Martineau M.D., D.R. Miller M.D., P.J Sullivan, M.D., K.A. Hull R.N.
Ottawa General Hospital and The University of Ottawa, Ottawa, Ontario

INTRODUCTION: Esmolol is a short-acting β_1-adrenergic blocking drug which is effective when administered as an intravenous bolus to control hypertension and tachycardia in response to tracheal intubation.[1,2] However, esmolol doses greater than 1.5 mg.kg^{-1} may cause hypotension when anaesthesia is induced with thiopentone and succinylcholine (SDC).[3] In place of succinylcholine, neuromuscular blockade for tracheal intubation is becoming more frequently established using either atracurium (ATR) or vecuronium (VEC). Although these drugs have relatively few cardiovascular effects, atracurium may occasionally induce hypotension when administered in full paralysing doses. It was hypothesized that esmolol, when given as a bolus, might exaggerate a hypotensive response during anaesthetic induction. A randomized, double-blind study was therefore conducted to compare the cardiovascular effects of ATR, VEC and SDC in the setting of acute β_1 adrenergic blockade during induction of anaesthesia.

METHODS: Seventy-five unpremedicated Day Surgery patients entered this double-blind study after giving written informed consent to the protocol approved by the hospital Human Experimental Procedures Committee. Excluded were patients greater than 70 years of age, those with a history of hypertension (blood pressure > 150/90) or major systemic disease, and any with contraindications to the use of β-adrenergic blocking drugs. Patients were randomly allocated to one of three groups to receive either ATR (0.5 mg.kg^{-1}), VEC (0.1 mg.kg^{-1}) or SDC (2.0 mg.kg^{-1}). Following application of the monitors, each patient received fentanyl 1.0 μg.kg^{-1}, curare .04 mg.kg^{-1} IV and droperidol 0.5 mg. Anaesthesia was then induced with thiopentone 5.0 mg.kg^{-1} IV following which the study drug (ATR, VEC or SDC) was given intravenously over 30 sec from a coded syringe, immediately followed by esmolol 1.5 mg.kg^{-1} IV over 30 sec. Tracheal intubation was performed 90 sec later, after which the lungs were ventilated with 66% N_2O in oxygen. Heart rate (HR) and systolic blood pressure (SBP) were measured non-invasively before and after induction (BL and IND respectively), and for the first 5 minutes after intubation (INT+1...INT+5). Cardiac Index (CI) was determined using bioimpedance cardiography, with systemic vascular resistance index (SVRI) being calculated assuming CVP = 0. Data were analyzed using a general linear models procedure, with statistical significance assumed when $P<0.05$.

RESULTS: The groups were similar with respect to mean age, height, weight and sex distribution. There was little change in HR following IND, but mean HR values increased transiently ($P<0.05$) in all three groups in response to INT, with maximum values of 87±4, 85±5 and 83±5 bpm for ATR, VEC and SDC respectively. Induction caused a decrease in SBP which was similar for all 3 groups ($P<0.05$). The maximum blood pressure response to airway instrumentation occurred at INT+1, but mean values were not different when comparing each of the 3 groups at corresponding times post-intubation. Cardiac index and SVRI also decreased after induction ($(P<0.05)$, but again there were no differences between groups (P=NS) at corresponding times with respect to each of these parameters.

DISCUSSION: Transient variations in HR, SBP, CI and SVRI were observed during this induction-intubation sequence. However, the magnitude of these changes was clinically acceptable, especially in view of a study population consisting of unpremedicated day surgery patients. More importantly, the changes in HR and SBP were not different whether ATR, VEC or SDC was used to achieve neuromuscular blockade when esmolol was administered to attenuate the cardiovascular response to intubation.



★ Different from BL, IND, INT+1 and INT+5 ($P < 0.05$)

REFERENCES:
1. Can J Anaesth 1990; 37:202-5
2. Can J Anaesth 1990; 37:206-9
3. J Cardiothorac Anesth; 1990; 4:31-6

The Pharmacodynamics of Propofol vs Age

JB Dyck MD, J Varvel MD, O Hung MD, SL Shafer MD

Stanford University, Palo Alto, CA 94305

Introduction: It has been shown that the dose of thiopental required for induction of anesthesia is inversely related to age.[1,2] The induction dose of propofol has also been shown to diminish with age.[3] We examined the changes in the pharmacodynamics of propofol that occur with age.

Methods: Informed consent was obtained from 60 healthy male patients between 23-82 years of age. EEG electrodes were placed in the standard 10/20 configuration to record leads FP3 FP4 CZ3 and CZ4. An arterial line was placed in the left radial artery and an intravenous was inserted with normal saline running at 2 ml/kg/hr. The arterial pressure waveform, ECG and 4 channels of EEG were recorded on FM cassette tape for later offline analysis. Propofol 0.5 mg/kg/min IV was administered as a zero order infusion until 3 seconds of burst suppression was present on the EEG. Blood was sampled at 1, 1.5, 2, 2.5, 3, 4, 5, 6, 8, 10, 12, 15, 20, 30, 45, 60, 90, 120, 180, 240, 360, 480, 600, 900, 1440 min. EEG data was collected for 5 minutes before the infusion was started until the patient was again responding to verbal command. The tapes were digitized at 128 hz with 12 bit resolution onto a desktop computer. Aperiodic analysis of the EEG signal using a PC based version of the Lifescan algorithm, produced the univariate EEG parameter, microvolts/second. The number of microvolts/second was collapsed semiparametrically with the plasma propofol concentrations to produce the concentration effect relationship. The concentration of propofol in the effect site at peak activation (Cepeak) of the EEG and at half of peak activation (Ce1/2peak) and the t1/2 Ke0 were regressed against age. Significant correlation was determined to be present if the slope of the regression differed from 0 by greater then twice the standard error.

Fig. 1

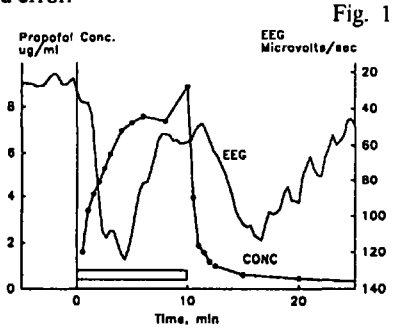
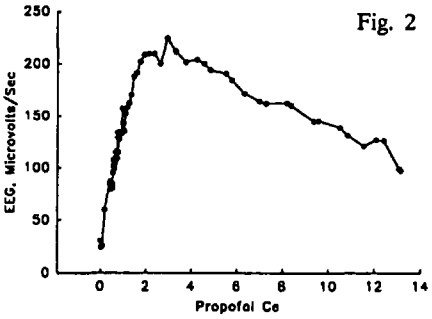


Fig. 2



Results: Fig. 1 is an example of the propofol EEG microvolts/second tracking the plasma concentrations. Fig. 2 is an example of the concentration effect profile after semiparametrically collapsing the concentration effect loop. The semiparametric approach assumes only a monoexponential decline of drug concentration from the effect compartment with an exit rate constant of Ke0. It does not require a specific dynamic model. It can be seen that the dynamic model for propofol is biphasic with initial EEG activation followed by depression. It would be a gross model misspecification to use the standard sigmoidal EMax model for this concentration effect data. When 3 seconds of burst suppression has been attained, there are still large bursts of high voltage activity between the periods of isoelectricity, therefore, in most cases the number of microvolts/second did not depress below baseline values. Fig. 3, 4, and 5 show the regression of age vs Cepeak, Ce1/2peak, and t1/2 Ke0 respectively. Age was not significantly correlated with any of these pharmacodynamic measurements.

Fig. 3

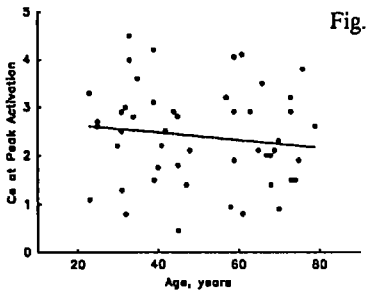


Fig. 4

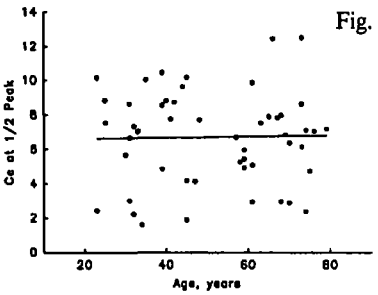
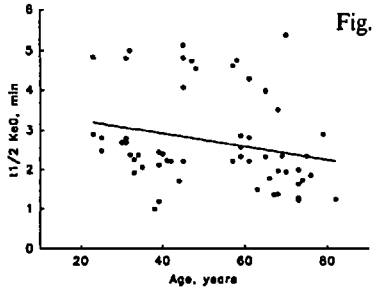


Fig. 5



Discussion: When total number of microvolts/second is used as the measure of drug effect, elderly patients do not show an increased sensitivity to propofol. This finding is similar to previous work with thiopental which shows that the decrease in dose requirement in the elderly is a result of kinetic rather then dynamic differences.[1,2]

References:

1. Homer TD, Stanski DR: The effect of increasing age on thiopental anesthetic requirement and disposition. Anesthesiology 62: 714-724, 1985.

2. Stanski DR, Maitre PO: Population pharmacokinetics and pharmacodynamics of thiopental: the effect of age revisited. Anesthesiology 72:412-422, 1990.

3. Dundee JW, Robinson FP, McCollum JSC, Patterson CC: Sensitivity to propofol in the elderly. Anaesthesia 41:482-485, 1986.

VECURONIUM IS MORE POTENT IN MONTREAL THAN IN PARIS

P Fiset MD FRCPC, F Donati PhD MD FRCPC, P Balendran MB FFARCS, C Meistelman MD, E Lira MD, DR Bevan MB MRCP FFARCS.
Departments of Anaesthesia, Royal Victoria Hospital & McGill University, Montreal, H3A 1A1.

INTRODUCTION

In 1969, Katz et al. reported that both d-tubocurarine and succinylcholine produced a more intense block and had a longer duration of action in New York than in London [1]. This intriguing transatlantic difference never has been confirmed, and never tested for the newer muscle relaxants. The purpose of this study was to compare dose-response relationships obtained in Montreal and Paris.

METHODS

After approval of the respective Hospitals' Ethics Committees, 39 patients, ASA physical status I or II, aged 18-75 years, were studied simultaneously in Montreal and Villejuif, a suburb of Paris. Anaesthesia was induced with thiopentone, 5-10 $\mu g.kg^{-1}$, and fentanyl, 1-3 $\mu g.kg^{-1}$, and the lungs were ventilated manually via a mask with nitrous oxide, 70%, in oxygen. The ulnar nerve was stimulated supramaximally, via surface electrodes at the wrist at a frequency of 2 Hz for 25, every 20 s. The force of contraction of the adductor pollicis muscle was measured with a force-displacement transducer. Stimulation commenced four minutes after induction of anaesthesia. Vecuronium, 20, 30 or 40 $\mu g.kg^{-1}$, was given by random allocation 5 minutes after induction. Maximal first twitch (T1) depression and time to reach minimum T1 were recorded. Dose-response curves were constructed from the logit transformation of T1 depression versus logarithm of dose at each location. The curves were compared by analysis of covariance. A P value of < 0.05 was considered to indicate statistically significant differences.

RESULTS

The patients in both locations were comparable with respect to sex, height and weight. The patients in Paris were 51 $\pm$ (SEM) 3 years of age, slightly older than the Montreal patients (44 $\pm$ 3 years). The slopes of the dose-response curves did not differ significantly, but the curve obtained in Paris was shifted significantly to the right by 27%, compared with the Montreal curve ($P = 0.01$) (Figure 1). The ED_{50} and ED_{95} were 26 and 44 $\mu g.kg^{-1}$ respectively in Montreal, compared with 33 and 72 $\mu g.kg^{-1}$ in Paris. Onset time was independent of dose and location.

DISCUSSION

This study demonstrated that the potency of vecuronium was greater in Montreal than in Paris, and confirmed the earlier observations made by Katz et al. [1]. The methodology used in both centres was rigorously identical. The patients also received the same anaesthetic. The similarity between sex, height and weight between both centres suggests that differences in body habitus cannot account for the different responses to vecuronium. Based on the dose-response curves, dosage recommendations for vecuronium might differ according to geographical area.

REFERENCE

1. Br J Anaesth 1969; 41: 1041-7.

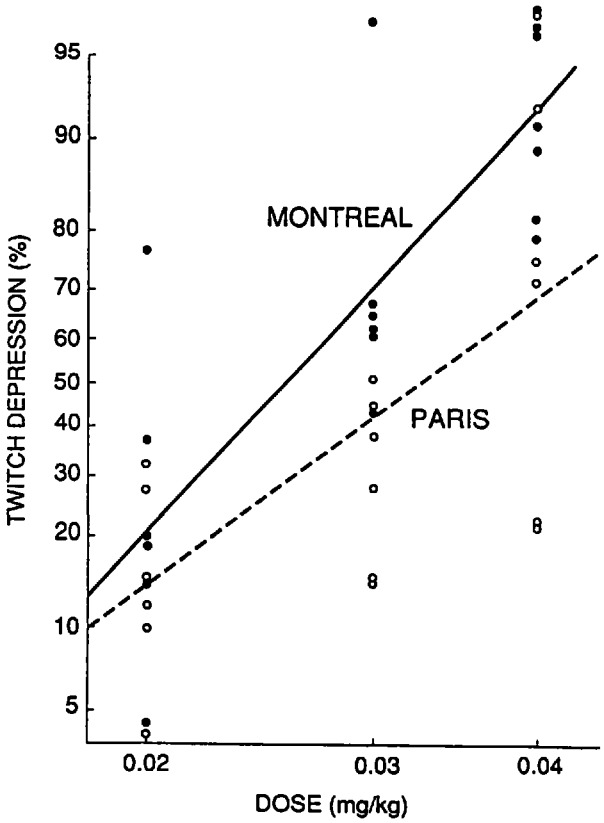


Figure 1: First twitch depression (T1) versus log dose of vecuronium.

ONSET OF NEUROMUSCULAR BLOCKADE: THE EFFECT OF HEART RATE

M. Sloan, M.D., B. Bissonnette, M.D., J. Lerman, M.D.
Department of Anaesthesia and the Research Institute
The Hospital for Sick Children, University of Toronto, Toronto, Ontario, Canada M5G 1X8

Introduction: The speed of onset of neuromuscular blockade with vecuronium is faster in children than it is in adults.[1,2] The reason why children should have a faster onset of paralysis is unclear. One explanation is that more rapid delivery of non-depolarizing drugs to the neuromuscular junction in children results in a more rapid onset of action.[3] In order to test this hypothesis we studied the effect of heart rate on the speed of onset of neuromuscular blockade with vecuronium during N_2O-O_2-narcotic anaesthesia in children.

Methods: After obtaining ethical committee approval and informed consent, 20 fasting and unpremedicated children, 2-8 years of age were studied. All children were ASA I or II and scheduled for minor elective surgery. Children with a history of renal, hepatic or neuromuscular disease, or in whom a difficult intubation was anticipated were excluded from the study.
Anaesthesia was induced with intravenous thiopentone 5.0 mg/kg, fentanyl 2.0 μg/kg, and diazepam 0.15 mg/kg. Patients were randomly assigned to one of two treatment groups to receive either 0.02 mg/kg of atropine or no atropine during induction. After induction, ventilation was assisted with 70% N_2O and 30% O_2 via mask.
After the loss of consciousness, the ulnar nerve in the forearm was stimulated via surface electrodes using a Datex Relaxograph EMG monitor, which delivered a supramaximal train-of-four (2 Hz for 2 sec) stimulus every 10 sec. The degree of neuromuscular blockade was determined by the height of the first twitch (T1) of the train-of-four as compared to the control twitch, and the response of the abductor digiti minimi muscle was recorded with a PSION LZ64 computer.[4] After a control twitch was obtained, vecuronium 0.2 mg/kg was administered and the time until the height of the first twitch reached 5% of control (onset) was recorded. Heart rate was continuously monitored and recorded at 30 sec intervals during the study period. Statistical analysis ($p<0.05$) was performed using the unpaired t-test. Linear regression was used to extrapolate the straight line portion of the recorded twitch response to a T1 of 5% of the control twitch height.

Results: There were no significant differences in the ages and weights of the two groups of patients. At all time intervals, heart rates in the atropine group were significantly greater than those in the non-atropine group ($p<0.001$). There was no significant difference between the onset times of the two groups of patients (table).

Discussion: It is generally assumed that the onset of paralysis with non-depolarizing muscle relaxants in children is faster than that in adults because the relaxants are delivered to the neuromuscular junction more rapidly.[3] Since heart rate is a major determinant of cardiac output in children, an increase in heart rate would be expected to increase the rate of delivery of drugs to their target organs. However, we have shown that heart rate does not affect the speed of onset of neuromuscular blockade with vecuronium in children during N_2O-O_2-narcotic anaesthesia. Therefore, further work is necessary to determine why children have a more rapid onset of neuromuscular blockade than adults.

Supported with a grant from Organon, Canada.

References:
1. Anesth Analg 70:86, 1990
2. Anesthesiology 73:A1103,1990
3. Br J Anaesth 57:1204, 1985
4. Can J Anaesth 37:386, 1990

Table: Heart Rate and Onset of Neuromuscular Blockade

Group	Heart Rate (beats per min)					Onset (sec)
	Pre vec	30 sec after vec	1.0 min after vec	1.5 min after vec	2.0 min after vec	
Atropine	138 ± 12*	135 ± 15*	137 ± 12*	138 ± 16*	143 ± 13*	56 ± 21
No atropine	90 ± 11	92 ± 11	90 ± 10	89 ± 11	95 ± 14	62 ± 18

data are mean ± SD
vec = vecuronium
* $p<0.001$ compared to non-atropine group

QUANTITATIVE ASPECTS OF ATRACURIUM'S DEGRADATION TO LAUDANOSINE IN HUMANS

V. Nigrovic, M.D. and M. Banoub, M.D.

Departments of Anesthesiology and Pharmacology, Medical College of Ohio, Toledo, OH, USA

Quantitative and temporal aspects of atracurium (Atr) degradation in vivo are not yet resolved. The compound undergoes spontaneous degradation (via Hofmann elimination). Only one of the postulated degradation products has been detected in plasma of patients treated with Atr. That metabolite -- laudanosine (Ldn) -- displays a rather unique time course in plasma: its concentration is initially high and decreases during the first 10 min. A steady decline ensues only after an extended period of sustained plasma concentrations. The goal of the present study was to answer the questions concerning the in vivo degradation of Atr to Ldn: (1) Is a single degradation pathway to Ldn suited to provide Ldn in quantity and at the rate required by the observed plasma concentrations? (2) How fast does Atr decay to Ldn? (3) What fraction of the Atr dose degrades to Ldn? and (4) How many Ldn molecules are formed from one molecule of Atr (in theory, up to 2 molecules may be formed)?

MATERIAL AND METHODS. We based our calculations on the plasma concentrations of Atr or Ldn reported by Parker and Hunter (1). Thirteen observations for the plasma concentrations of Atr and 20 for Ldn were available. Data from two groups of patients were analyzed: a control group consisting of 7 normal and a second one consisting of 8 cirrhotic patients. Each model of Atr degradation to Ldn and of Ldn disposition was formulated in terms of the Laplace transforms for the input and distribution functions for either Atr or Ldn. Estimates of the parameters required by each model were adjusted to minimize the sum of squared deviations between the observed data and the curves derived from each model.

RATIONALE. Assuming that the disappearance of Atr from plasma is solely due to its conversion to Ldn, then -- in theory -- the biexponential decay of Atr in plasma may be ascribed either to the degradation of Atr in the central or in both the central and the peripheral compartments. Each of the two resulting models of Atr disposition contains only one elimination rate constant; this constant represents at the same time an estimate of the formation rate constant for Ldn. Since two Ldn molecules may be formed from one of Atr, we further considered that each estimated rate constant may be used to define either the simultaneous or sequential formation of 2 molecules of Ldn. Thus, four variants of the input function of Ldn were formulated. The estimates of the disposition parameters of Ldn were adjusted to optimize the simulation of the plasma concentrations of Ldn. In addition to these four models based on a single rate constant for the decay of Atr and the formation of Ldn, we have formulated a model based on two rate constants for the formation of Ldn from Atr. The essential characteristics of the model were: (i) A fraction of the Atr dose decays very rapidly and the residual portion of the dose with the rate observed for the in vitro decay of Atr at pH 7.4 and 37 °C; (ii) The slow decay of Atr occurs in both the central and the peripheral compartments of Atr; (iii) Two molecules of Ldn are formed from one of Atr; (iv) The disposition of Ldn proceeds according to a two compartment model with the input into, and the elimination out of, the central compartment.

RESULTS. Plasma concentrations of Atr in control patients were well fitted by the assumption of a single elimination rate constant independent of whether the constant had been assumed to act only on the central compartment ($t_{\frac{1}{2}}$ 7.4 min) or on both the central and the peripheral compartments ($t_{\frac{1}{2}}$ 19.9 min). When the formation rate constant of Ldn was assigned either of these values, none of the four variants of the model characterized by a single rate constant for the degradation of Atr even approached the time course of Ldn in plasma of control patients. On the other hand, an excellent fit of the plasma concentrations of Ldn was obtained by postulating that Atr decays to two Ldn molecules along two pathways. Optimal simulation was obtained by postulating that about 30% of the Atr dose decays rapidly ($t_{\frac{1}{2}}$ ca 0.25 min) and the rest slowly ($t_{\frac{1}{2}}$ ca 50 min). Ldn formed from Atr displayed a biexponential decay pattern in plasma: Approximately one half of the amount formed disappeared rapidly and the other half more slowly ($t_{\frac{1}{2}}$ 85 min). In cirrhotic patients, the amount of rapidly decaying Atr was approx. one half of that in the control patients and the distribution and elimination ($t_{\frac{1}{2}}$ 114 min) of Ldn were slower. The central volume of distribution of Ldn was similar in the control and cirrhotic patients (490 and 605 $ml \cdot kg^{-1}$, resp).

DISCUSSION. The analysis demonstrates that a single rate constant for the decay of Atr to Ldn can not be defined such that it at the same time satisfies the disappearance of Atr from plasma and the formation of Ldn. However, the plasma concentrations of both Atr and Ldn can be very satisfactorily simulated by the assumption of a dual degradation pathway of Atr to Ldn. The very rapid degradation of Atr involves only a fraction of the Atr dose and, due to its rapidity, is likely to be confined to blood. The chemical nature of this degradation pathway remains unknown. The slower degradation pathway proceeds at the rate compatible with that observed in vitro for the spontaneous decomposition of Atr and, most likely, corresponds to Hofmann elimination. Several questions and implications are raised by the postulate of the very rapid degradation of Atr: (i) If confirmed, the degradation would represent a heretofore unsuspected degradation pathway for Atr. (ii) That fraction of the dose of Atr that disappears rapidly can not participate in the production of muscle paralysis. (iii) All pharmacokinetic parameters that were previously calculated using the nominal dose of Atr need to be re-evaluated.

ACKNOWLEDGEMENT

The authors express their deep appreciation to Dr. JM Hunter for the permission to use the data in Ref (1). The support of VN by the B.B. Sankey Anesthesia Advancement Award from the International Anesthesia Research Society is gratefully acknowledged.

REFERENCES.

(1) Parker CJR, Hunter JM: Br J Anaesth 62:177-183, 1989.

ANTIEMETIC PROPHYLAXIS WITH MIDAZOLAM FOR STRABISMUS SURGERY

WM Splinter, MD, FRCP, DW Roberts, MD, FRCP, EJ Rhine, MD, FRCP, HB MacNeill, MD, FRCP, GE Bonn, MD, FRCS, WM Clarke, MD, FRCS, LP Noel, MD, FRCS.
Departments of Anaesthesia and Ophthalmology, Children's Hospital of Eastern Ontario, and The University of Ottawa, Ottawa, Ontario, Canada.

Introduction: Vomiting is common after strabismus surgery.[1,2] Droperidol, the current antiemetic of choice, has side effects, such as excess sedation, dysphoria and oculogyric crisis. Recently, it has been suggested that midazolam, a sedative with few side effects, may be an effective antiemetic. We compared the efficacy and side effects of droperidol and midazolam among children undergoing strabismus repair.

Methods: We studied 142 healthy (ASA physical status I-II) children of ages 18 months to 14 years undergoing elective strabismus surgery with parental consent and Hospital Ethics Committee approval. Patients were randomly assigned to one of two groups. A blocked and stratified design was used to control for differences in number of muscles adjusted and induction technique. Induction was by inhalation with nitrous oxide/oxygen/halothane or intravenously with sodium thiopentone. Before tracheal intubation, the patients were administered 20 mcg/kg atropine, 100 mcg/kg vecuronium, and 50 mcg/kg STUDY DRUG (droperidol or midazolam). Anaesthesia was maintained with 70%N_2O/0.5-1.5% halothane/29%O_2. At the end of the operation the muscle relaxant was reversed with atropine, 20 mcg/kg, and neostigmine, 60 mcg/kg, and the tracheal tube was removed before the return of airway reflexes.
Postoperative orders included the following: 1. Oral fluids if requested by the patient, 2. IV maintained until discharge from Day Care Surgery, and 3. Excessive emesis, i.e. 3x or greater, to be treated with 50 mcg/kg of droperidol IV. The patient and parents were seen by the surgeon 24 hours after surgery. The incidence of vomiting at home and any unusual events were recorded. Data were compared with ANOVA, Mann-Whitney-U test, Chi-square analysis, and Fisher Exact Test. Accepted alpha error was 0.05.

Results: The groups were similar with respect to age, weight, ASA class, length of surgery, operative procedure. Midazolam and droperidol had similar effects on vomiting after surgery (TABLE I). One patient in each group was admitted to hospital because of vomiting. There were no other observed unusual events. A highly significant predictor of post-operative vomiting was the number of muscles repaired, P<0.001 (TABLE II). The incidence of vomiting after similar operative procedures was not effected by the duration of anaesthesia.

Discussion: Midazolam or droperidol at 50 mcg/kg reduces the incidence of post-strabismus-repair vomiting. The incidence of vomiting after multiple muscle repair remains high at the dosage of antiemetic utilized in this study. The mechanism of action of midazolam needs to identified.

References: 1. Can Anaesthe Soc J 1986; 33: 57-62.
2. Anesthesiology 1986; 65: 322-5.

TABLE 1

DRUG	INCIDENCE OF VOMITING
Midazolam	33/71 (46%)
Droperidol	29/71 (41%)

TABLE II

No. of Muscles	Incidence of Vomiting
1	5/39 (13%)
2	45/88 (51%)*
3&4	12/15 (80%)

(*P<0.001 1vs2, P<0.02 2vs3&4)

THE EFFECT OF EPIDURAL LOCAL ANAESTHETIC INFUSION ON RESPIRATORY FUNCTION FOLLOWING ELECTIVE AORTIC ANEURYSM RESECTION

RYAN T, FFARCSI, MORIARTY J, FFARCSI, BOUCHIER-HAYES D, FRCSI, CUNNINGHAM AJ, FRCPC

DEPARTMENT OF ANAESTHESIA, BEAUMONT HOSPITAL, DUBLIN, IRELAND.

Introduction:
Epidural administration of local anaesthetic agents may decrease morbidity and mortality following abdominal surgery in high risk patients.[1] The objective of this study was to assess the effects of epidural local anaesthetic infusion on postoperative respiratory dysfunction.

Methods:
Following Ethics Committee approval and informed consent 20 patients scheduled for elective abdominal aortic aneurysm resection were randomly allocated to receive either bupivacaine 0.1% (n=10) or saline (n=10) via an epidural catheter following aortic clamp release. The retroperitoneal approach was utilised in all but one patient studied. Preoperative cardiac status was assessed by physicial examination, electrocardiogram and resting left ventricular ejection fraction with radionuclide ventriculography. Preoperative respiratory function was assessed by physical examination, chest roentgenogram, FEV1, FVC, FRC, A-aDO_2, gradient and intrapulmonary shunt with F_IO_2 0.40.

Radial and pulmonary artery catheters were inserted under local anaesthesa. A standardised anaesthetic technique was used for all patients and consisted of premedication with oral diazepam, induction with fentanyl 3-6$\mu g.kg^{-1}$, thiopentone 1-3$mg.kg^{-1}$, vecuronium 0.1 mg.kg-1. Controlled normocapnic ventilation was commenced with N2O/O2 and isfolurane 0.25-1.0%. The following peroperative data were recorded - duration of surgery, duration of aortic clamping, blood loss, transfusion requirements and fluids administered. An 8ml bolus of the allocated solution was administered via a lumbar epidural catheter after clamp release. An infusion of the same solution at 8 ml per hour was initiated on arrival in ICU.

The intensive care staff, unaware of the patients random study allocation, administered morphine 2.5-5mg iv for pain and determined fitness for weaning and extubation according to defined criteria. A-aDO_2 gradient and intrapulmonary shunt measurements were repeated 1, 4 and 24 hours following surgery. FEV1 and FVC measurements were repeated on days 1, 3 and 5 and FRC on day 5. Data was analysed by Students t test. $P<0.05$ was considered significant.

Results:
The two groups were comparable with regards to age and preoperative cardiorespiratory status. The intraoperative course, as determined by duration of aortic cross clamp, intravenous fluid and blood requirements were similar in the two gropus. Epidural bupivacaine infusion was associated with shorter duration of ventilation (6.39±2.75 hrs vs. 16.8±3.14 hrs, $P<0.05$) shorter ICU stay (48.67±8.17 hrs vs. 81.6±12.2 hrs, $P<0.05$) reduced morphine requirement (19.6±4.65 mg vs. 25.7±3.77 mg ns) and reduced midazolam requirements (2.44±1.29 mg vs. 6.95±3.09 mg ns). Postoperative reductions in A-aDO_2 gradient, spirometry and FRC was similar in the two groups.

Figure I

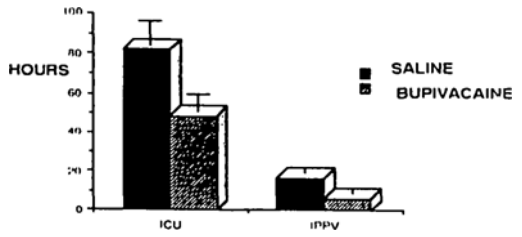
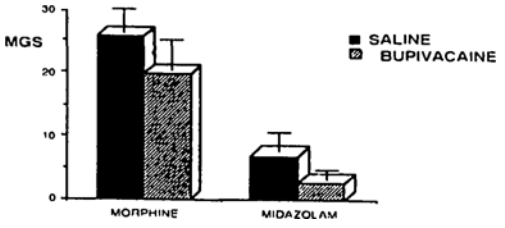


Figure II



Discussion:
In this study epidural bupivacaine infusion lead to a shorter duration of ventilation and ICU stay. Narcotic requirements in each group were modest and not significantly different. Pulmonary dysfunction was comparable in the two groups. As the retroperitoneal surgical approach is associated with less pulmonary dysfunction [2,3] compared with the conventional transabdominal approach the benefit from epidural analgesia in this patient population may be limited.

References:
1. ANESAV: 1987; 66: 729-36
2. J Cardiovasc Surg: 1987; 28: 270-4
3. Can Anaesth J: 1989; 36: S71

A DOUBLE BLIND, PLACEBO-CONTROLLED TRIAL OF TRANSDERMAL FENTANYL FOR POST-HYSTERECTOMY PAIN RELIEF. II: RESPIRATORY EFFECTS

AN Sandler MB, AD Baxter MB, P Norman MD, B Samson MD, M Friedlander MB, S Lawson RN, K Hull RN.
Departments of Anaesthesia, Toronto General Division, University of Toronto and Ottawa General Hospital, University of Ottawa, Ontario, Canada.

Incorporation of fentanyl into a Transdermal Therapeutic System (TTS) has provided continuous postoperative analgesia after several surgical procedures. This study evaluated the long term respiratory effects when TTS-fentanyl was used for post-hysterectomy analgesia.

Methods: With institutional approval and informed consent, 20 patients (ASA 1-2) undergoing abdominal hysterectomy were entered into a randomized, double-blind, placebo controlled trial comparing two dosage levels of TTS-fentanyl. Gp I (placebo, N=8), were treated with non-opioid TTS patches. Gp II (N=6) were treated with a TTS-fentanyl 50 patch (releases 50 ug/hr fentanyl) and Gp III (N=6) with a TTS-fentanyl 75 patch (releases 75 ug/hr fentanyl). Blinding was achieved by applying the two different sized patches (active or placebo) to all patients, producing the required fentanyl/placebo combinations. TTS patches were applied 2 hr preop after diazepam premedication. Patients were given a standard general anaesthetic including sufentanil 0.5 ug/kg, thiopentone 3-5 mg/kg, pancuronium 0.1 mg/kg, N_2O and isoflurane. Postoperatively all patients used a morphine-loaded PCA device as required for supplementary analgesia. Patients were monitored continuously by trained nursing personnel for 72 hr after patch application, and for 12 hr after patch removal. Analgesia was assessed by visual analogue score (VAS 0=no pain, 10=maximum pain) and morphine requirement. Respiratory effects were monitored continuously with Respiratory Inductive Plethysmography and pulse oximetry for 8 hr preoperatively and 84 hr postoperatively. Slow Respiratory Rate (SRR) was defined as <10 breaths/min for 5 min and Apnea (AP) as Vt<100 ml for 15 sec or longer. Arterial blood gases were drawn if repeated episodes of Hb saturation <90% or respiratory rate <8/min occurred. Results were analysed using the Kruskaul-Wallis test and ANOVA.

Results: There were no significant differences between groups for age, weight, height or duration of surgery. All 3 groups achieved excellent analgesia. Although not significant, supplementary morphine requirements were less for the TTS-fentanyl groups. Eight patients, all in the TTS groups required ABG determination (TTS-50=3, TTS-75=5). There were significantly more episodes of SRR in the first 24 hr postoperatively in the TTS groups and a tendency to more episodes of AP (not significant) as well (Figs 1,2). There were no significant differences in mean Hb saturation between the groups (Fig 3). In this pilot study, TTS-fentanyl was associated with increased respiratory effects of minimal clinical significance in most patients. However, further large scale studies are currently underway.

Fig 1: Mean SRR Episodes per Hour (±SD)

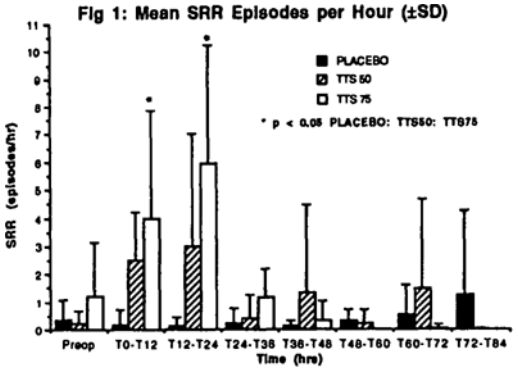


Fig 2: Mean Apneic Episodes per Hour (±SD)

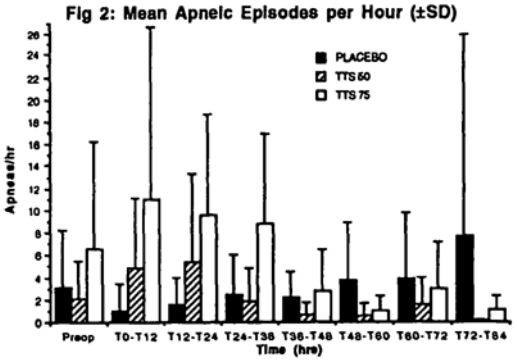
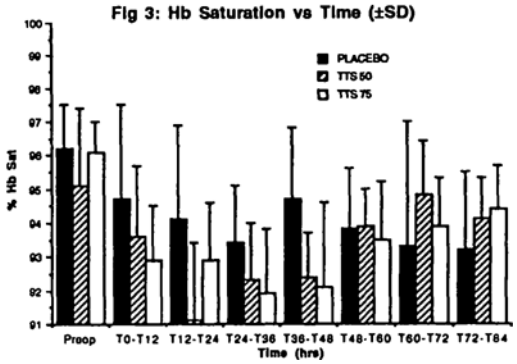


Fig 3: Hb Saturation vs Time (±SD)



PATIENT-CONTROLLED ANALGESIA (PCA): USE PATTERNS IN ABDOMINAL AND THORACIC SURGERY

V.W.S. Chan FRCPC, F. Chung FRCPC, N. Mati MD, D. Evans FRCPC, C. Cruise FRCPC, D. Shumka FRCPC, C. Seyone MD
Department of Anaesthesia, Toronto Western Division, The Toronto Hospital, University of Toronto, Toronto, Ontario

Introduction: PCA infusers are commonly set to deliver analgesics in two modes: (a) on demand only (PCA) and (b) on demand + continuous baseline infusion (P + C). This study determined the overall use pattern and cost of therapy in patients following major abdominal and thoracic surgery while using PCA or PCA + continuous infusion.

Method: Following institutional approval, preoperative informed consent and PCA use instruction, PCA devices (Abbott Lifecare 4100™) were applied to 161 postsurgical patients (84 male,77 female; 20-83 yo; 38-157 kg) in 3 groups: cholecystectomy (53), bowel resection (67) and thoracotomy (41). Use of parenteral narcotics prior to PCA initiation was not limited. All patients received morphine in one of the two mode settings:(a) PCA only (unit dose 1-2 mg) in 64 patients and (b) PCA (unit dose 1-2 mg) + Continuous infusion (0.5-1 mg/h) in 97 patients. Lockout intervals were standardized at 10 min and 4 hour limit did not exceed 30 mg.
On the day of surgery (POD 0), PCA therapy was initiated as soon as patient's arrival to the ward or to the intensive care unit. Morphine administration was continued until patients tolerated oral feeding and analgesics or when analgesic requirement was deemed minimal. Pain relief assessment was done twice daily by an anesthetist. PCA dosage adjustment was made, if necessary, to guarantee satisfactory analgesia in all patients. Nursing assessment done every 2 h monitored levels of somnolence (score 0-3, 0 = alert, 3 = somnolent; difficult to arouse) and respiratory depression (respiratory rate < 10). In each patient, cumulative morphine dose every 2 h, days of PCA use and postoperative hospital stay were recorded. As well, the cost of PCA therapy per patient was calculated (based on pre-filled morphine 30 ml vial at 1 mg/ml @ $7.95, PCA tubing set @ $4.95, and infuser use @ no charge). Statistical analyses were performed using Chi-square, Pearson correlation and Bonferroni t-tests. $P < 0.05$ was considered significant.

Results: Patients on P + C delivery mode consumed significantly higher morphine dosage following cholecystectomy and bowel surgery when compared to PCA mode alone (Table 1). The use pattern was distinctly different among the three surgical types. While the hourly morphine consumption was highest in thoracotomy patients (Table 1), use duration was longest in bowel surgery patients (Table 2). Due to prolonged use (5-6 days), PCA therapy was most costly in the bowel surgery group (PCA: $39, P + C: $71).
Irrespective of delivery mode, morphine utilization was effective and was highest in the early post-anesthetic period, i.e. first four hours (Figure 1). Diurnal variation in PCA use was not observed. Age, height and weight showed no correlation with morphine consumption. Duration of hospital stay was not different regardless of PCA mode setting. No complication of somnolence or respiratory depression was noted.

Discussion: Cost of PCA therapy is determined by its use pattern. Our results indicate a higher morphine consumption pattern during the use of P + C mode. For bowel surgery, the cost of therapy was nearly doubled when compared to PCA mode alone. As previous study has failed to reveal improved analgesic efficacy with P + C mode (1), it is essential to determine the cost effectiveness of P + C mode in the future.

References:

1. Vinik HR, et al: Anesth Analg 70:S418, 1990

TABLE 1: PCA morphine consumption (mg/h)

	POD 0		POD 1		POD 2		POD 3	
Mode	*PCA*	*P+C*	*PCA*	*P+C*	*PCA*	*P+C*	*PCA*	*P+C*
Cholecystectomy	1.8 ± 0.3	2.8 * ± 0.2	1.4 ± 0.2	1.9 ± 0.2	1.0 ± 0.2	1.5 * ± 0.2	1.3 ± 0.2	1.2 ± 0.2
Bowel surgery	2.0 ± 0.2	3.7 * ± 0.4	1.5 ± 0.2	2.6 * ± 0.3	1.3 ± 0.2	1.9 ± 0.3	1.1 ± 0.2	1.7 ± 0.2
Thoracotomy	2.8 ± 0.4	4.1 ± 0.6	2.4 ± 0.3	2.5 ± 0.3	2.2 ± 0.3	2.1 ± 0.3	1.6 ± 0.3	2.1 ± 0.4

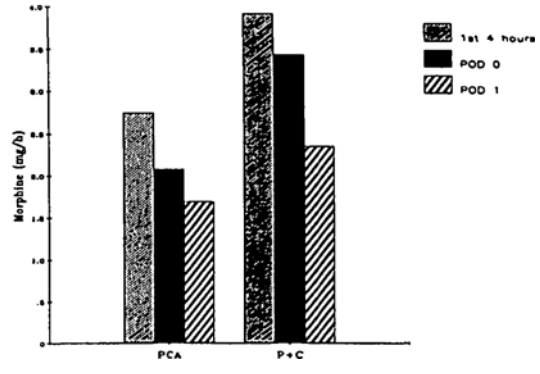
Values are mean + SEM
Mode: PCA = PCA alone, *P + C* = PCA + continuous
*P < 0.05; (PCA vs P + C)

TABLE 2

	PCA use (days)		Total morphine consumption (mg)		**total cost ($)	
	PCA	*P+C*	*PCA*	*P+C*	*PCA*	*P+C*
Cholecystectomy	3.2 ± 0.1	3.3 ± 0.2	72.3 ± 10.9	100.8 ± 13.2	31.3	39.2
Bowel surgery	4.9 ± 0.4	5.6 ± 0.4	116.6 ± 15.5	228.8* ± 35.8	39.2	71.0
Thoracotomy	3.3 ± 0.2	3.5 ± 0.3	118.1 ± 16.2	144.7 ± 32.3	39.2	47.2

Values are mean ± SEM
*P < 0.05; (PCA vs P + C)
**Total cost = cost of morphine + tubing set (assumed 1.5 set/patient)

Figure 1



CONTINUOUS BRACHIAL PLEXUS BLOCKADE VIA AN AXILLARY CATHETER FOR POSTOPERATIVE ANALGESIA

Peter T. Leung, MD, FRCPC
Dept. of Anaesthesia, Pain Management Service,
St. Michael's Hospital, University of Toronto, Ontario

INTRODUCTION

Postoperative pain following major elbow reconstruction is a significant impediment to the early initiation of full range of motion. Conventional methods of pain control are not adequate to allow for optimal use of a continuous passive motion (CPM) device. We describe a technique of continuous brachial plexus blockade using an infusion of local anaesthetic (LA) via an axillary catheter to provide effective postoperative analgesia and allow full use of CPM.

METHOD

Informed consent was obtained from 8 patients with severe elbow ankylosis scheduled for major reconstructive procedures. Surgery was performed under general anaesthesia as chosen by the attending anaesthetist. Postoperatively, neurovascular function of the arm was assessed and documented to be intact by the surgical staff. Under aseptic conditions, the brachial plexus was located with the aid of a nerve stimulator (Neuro Technology DigiStim III) set at 2 milliamperes. The axillary sheath was punctured using an IV cannula placement set with a blunt tipped needle (Arrow Int. Inc. BP-01200). The blunt tipped metal needle allowed for better feel on entering the sheath and reduced the possibility of inadvertent vascular puncture. Following advancement of the teflon cannula into the brachial plexus sheath, a modified epidural catheter (Portex 4912-18) was introduced 5-10 cm through the cannula. Modification of the epidural catheter included shortening proximally and cutting off the tip and side holes to produce a single distal port. This avoided solution leakage and allowed for reconfirmation of catheter placement using a thin metal wire (stylet of Deseret Intracath 38-3382-1) through the catheter and the nerve stimulator. The catheter was sutured in place and a clean occlusive dressing applied. The catheter was tested with up to 20 ml of carbonated xylocaine 2% or bupivacaine 0.5%. When signs of sensory blockade were obtained, an infusion of bupivacaine 0.15% at a rate of 10 ml per hour was initiated using an infusion pump (Abbott Life Care 5000). Adequacy of pain relief was assessed by judging the patient's tolerance of the CPM device at the extremes of flexion or extension and the need for extra local anaesthetic top-up boluses or supplemental parenteral narcotics. Presence of sympathetic, sensory and motor blockade was documented daily. Patients were interviewed retrospectively for satisfaction of the technique and their level of overall pain throughout the postoperative period.

RESULTS

The axillary catheters were left in place for 6 to 10 days with an average of 8.4±1.6 days. One catheter was judged to be ineffective after the first test dose and was replaced. No catheter needed to be replaced after satisfactory neural blockade was established after the first test dose.

All patients were able to tolerate CPM satisfactorily with occasional top up doses of LA bolus and supplemental parenteral narcotics. One patient required no intervention. In seven patients, supplemental analgesia was administered. The average number of interventions was less than one per day although no patient required supplementation after day 5. The LA infusion dose was adjusted in 2 of 8 patients: increased concentration in one and decreased concentration in the other due to excessive numbness. All patients were satisfied with this technique for postoperative pain relief while CPM was in use. One reported no pain and all others experienced only mild overall pain. Seven patients were found to have increased postoperative range of motion and return of useful function of the elbow; the other patient was lost to follow up. There were no complications from the use of the catheter and daily examinations revealed no evidence of infection.

DISCUSSION

Continuous local anaesthetic infusion via a catheter within the brachial plexus sheath was a successful way of providing postoperative pain relief for major elbow surgery requiring CPM in our 8 patients. Movement from the CPM device increases pain level above that usually encountered in the postoperative period with immobilization. This catheter technique is effective and could be extended to other anatomic sites such as the interscalene approach and to other type of surgery, e.g. those requiring prolonged sympathetic blockade. Although bupivacaine blood levels were not measured, other investigators have reported non-toxic bupivacaine levels at the dosages used. This technique of continuous brachial plexus blockade for postoperative analgesia was found to be easily mastered, effective and well accepted by post-surgical patients using CPM.

REFERENCES

1. Hall JA, Lennon RL, Wedel DJ. Reg Anesth 15:1S:58, 1990
2. Kirkpatrick AF, Bernarczyk LR, Hime GW, Szeinfeld M, Pallares VS. Anesthesiology 62:63-67, 1985

0.1% BUPIVACAINE DOES NOT IMPROVE POSTOPERATIVE EPIDURAL FENTANYL ANALGESIA FOLLOWING ABDOMINAL OR THORACIC SURGERY

NH Badner MD, WE Komar RN, M Rajasingham MD, B Farren MD
Department of Anesthesia, University of Western Ontario, London, Ontario, Canada

Introduction:

Epidural infusions of fentanyl combined with 0.1% bupivacaine are claimed to be superior to fentanyl alone for postoperative analgesia.[1] Our recently completed, randomized, double-blind study however found this not to be true following total knee joint replacement.[2] This may not apply for general surgical patients as visceral pain is mediated by sympathetic fibres, which are more readily blocked by local anesthetics. This study was therefore repeated in postoperative abdominal and thoracic surgical patients.

Methods:

Following institutional approval and written informed consent, 30 patients scheduled for abdominal or thoracic surgery received in random, double-blind fashion, continuous epidural infusions of fentanyl or a mixture of fentanyl and bupivacaine postoperatively. Patients with contraindications to epidural catheter insertion, age greater than 75, neurological, psychiatric, or significant cardiovascular disease were excluded. The epidural catheter was inserted prior to surgery and its position verified with 2% CO_2 lidocaine or 0.5% bupivacaine. Patients received general anaesthesia for the operative procedure. At wound closure patients received an epidural bolus of 0.1 ml/kg of the study solution and on arrival in the recovery room an infusion was started at 6 ml/hr. Solution concentrations were fentanyl 10 ug/ml with or without 0.1% bupivacaine (1.0 mg/ml). Patients were assessed for analgesia using a visual analogue scale (VAS, 0 = no pain, 100 = worst pain ever), side effects, sensory loss to pinprick or ice, motor blockade using the Bromage scale, and postural hypotension at the times shown. Patients were continuously monitored for oxygen saturation and respiratory rate using a cardiorespiratory oximeter (Nonin Medical Inc., Associated Respiratory Services, Mississauga, Ont.). Inadequate analgesia was treated with a 3 ml bolus and an increase in the infusion rate of 2 ml/hr. Parametric data was analyzed using unpaired t-tests and two factor ANOVA for repeated measures, and nonparametric data with chi-square and Mann Whitney U analyses.

Results:

There were no significant differences in demographic data or type of surgical procedure between the two groups. The infusion rates and pain scores at the measurement times are shown in figures 1 & 2. The incidence of desaturation and slow respiratory rates are shown in table 1. There were no significant differences in these variables or in the incidence of side effects between the two groups. One patient in the mixture group had bilateral leg weakness.

Figure 1 Analgesia - Pain Scores

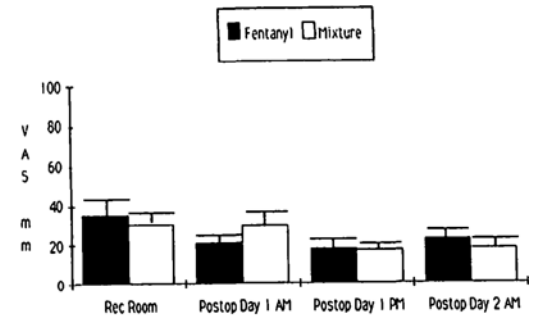
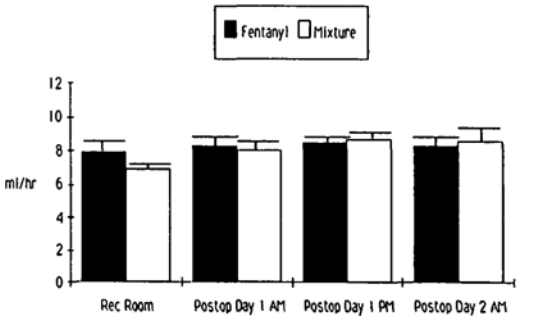


Figure 2 Infusion Rates



	$SaO_2 < 90$		RR < 10	
Time Period	Fentanyl	Mixture	Fentanyl	Mixture
RRD-POD1AM	5.6 ± 2.8	10.1 ± 5.2	14.8± 4.3	6.8 ± 3.2
POD1AM-PM	17.9 ± 7.1	13.3 ± 6.3	14.6± 3.7	7.2 ± 2.6
POD1PM-2AM	14.2 ± 6.1	8.2 ± 4.1	12.4± 3.2	13.6 ± 5.3

Table 1. Respiratory changes as % of time monitored. Values are means ± SEM; ns differences

Discussion:

As there were no significant differences in VAS scores, infusion rates, incidence of desaturation, slow respiratory rates or the incidence of side effects, we conclude that 0.1% bupivacaine does not improve postoperative epidural fentanyl infusion analgesia.

References:

1. Reg Anesth 14:2S:32, 1989
2. Can J Anaesth 37:S54, 1990

CONTINUOUS LUMBAR PLEXUS BLOCK FOR PAIN RELIEF FOLLOWING HIP SURGERY

G. Vaillancourt, MD, G. Blaise, MD, S. Cournoyer, RN, C. Hollmann, RN
Depts. of Anesthesiology and Nursing, Notre-Dame Hospital, Montreal, Quebec H2L 4M1

INTRODUCTION

Up to 70% of patients having hip surgery present moderate to severe pain postoperatively (1). Epidural analgesia has been used in these patients with success. However it has been suggested that epidural analgesia require close monitoring and care which may not always be available on a regular ward. A continuous lumbar plexus block (CLPB) is not likely to produce an important sympathetic block or a respiratory depression. Therefore it could be safer and more easily managed by the nursing staff when compare to epidural analgesia. To our knowledge, a study on the use of CLPB for pain relief after hip surgery has not been done. We report here the results of a double-blind placebo-controlled randomized study on the use of CLPB for postoperative pain relief following hip surgery.

METHODS

The study was approved by the ethics comitee. 19 elderly ASA I-III patients signed an informed consent and received general anesthesia with a thiopental, fentanyl and succinylcholine induction for hip surgery. Once asleep, all patients were positionned in lateral decubitus and had a CLPB performed on the operative side with the use of a neurostimulator and a 22 gauge needle. A 24g catheter was inserted through the needle. Patients then randomly received either a bolus of 20ml of bupivacaine 0.25% with epinephrine 1:200,000 followed by a perfusion of 3ml/h of the same mixture for 48 hours (group B) OR 20ml of saline 0.9% followed by a perfusion of 3ml/h of saline 0.9% for 48h (group P). Maintenance of anesthesia was accomplished with isoflurane, fentanyl and vecuronium. The hemodynamic stability on surgical incision (% change in blood pressure and heart rate from pre-incision values) and the amount of fentanyl and isoflurane needed for maintenance were noted. At the end of surgery, all patients were taken to recovery room and allowed to awake. They were then given IV/IM meperidine as needed for 48 hours. Pain in recovery room and on the ward was evaluated with a visual analog scale.

RESULTS

Age, sex and weight were similar in both groups. Patients treated with bupivacaine had a trend toward receiving less fentanyl and isoflurane intraoperatively although not statistically significant. More B patients were judged hemodynamically stable than P patients intraoperatively. VAS score in recovery room and on the ward in both groups were not different. The mean amount of IM meperidine given, the incidence of post-operative nausea and vomiting and the hospital stay were similar in both groups. Technical problems with the 24g catheters occured in 5 patients, 3 in group P and 2 in group B; catheter disconnexion occured in 3 and catheter biocage in 2. No other complication associated with the technique was noted.

DISCUSSION

CLPB for postoperative pain relief following knee surgery has been shown both to be effective (2) and ineffective (3). In our study, the improved intraoperative hemodynamic stability would seems to confirm that our LPB technique was adequate. The absence of postoperative pain relief may be due to the low dose of bupivacaine perfusion we used to avoid any risk of toxicity. Alternatively, it could be due to postoperative catheter migration or pain pathway after hip surgery bypassing the lumbar plexus.

REFERENCES

1. Bonica J. The management of pain. 1990
2. Dahl JB. Anesthesia 1988: 43: 1015-1018
3. Tuominen MJ. Acta Anaesthsiol Scand 1989: 33: 84-88

Table 1

	Group B n=10	Group P n=9	Significance
Mean dose of intraoperative fentanyl (μg)	147	200	NS *
Isoflurane, MAC/h	0.70	0.97	NS
Intraoperative hemodynamic stability **	9/10	4/9	$p<0.05$
VAS score (recov room)	4.7	4.3	NS
VAS score (ward)	4.5	4.6	NS

* NS = not significant
** less than 10% change in blood pressure and heart rate (incision vs pre-incision level)

FENTANYL SUPPLEMENTATION OF EPIDURAL ANAESTHESIA FOR CAESAREAN SECTION: COMPARISON OF TWO METHODS

T W Breen MD, J A Janzen MD FRCPC

Department of Anaesthesia, Foothills Hospital, University of Calgary, Calgary, Alberta

INTRODUCTION

Fentanyl has been added to local anaesthetics to improve the quality of epidural anaesthesia for Caesarean section. Epidural fentanyl may be administered as the epidural block is being estabilished (prior to delivery),[1,2] or following delivery of the infant.[3] Both methods demonstrate the benefit of fentanyl in improving the quality of the block obtained. Fentanyl used before delivery appears to be safe for the infant as evidenced by APGAR scores, neurobehavioural scoring systems, and low neonatal plasma fentanyl levels. However, the concern for neonatal respiratory depression is always present. We undertook a study to compare anaesthesia obtained when the epidural fentanyl was given either with the initiation of epidural anaesthesia, or after delivery of the infant.

METHODS

Following hospital ethics committee approval and informed patient consent, 38 ASA I-II patients for elective Caesarean section with epidural anaesthesia were enrolled in this randomized double-blind study. All patients had an epidural catheter placed at the L2,3 or L3,4 interspace. Following volume loading and a test dose of 3 ml lidocaine 2% with 1:200,000 epinephrine, patients were randomized to receive either fentanyl 75 g (Group I, n=16), or preservative free saline 1.5 ml (Group II, n=22). Surgical anaesthesia was then obtained with incremental epidural injections of lidocaine 2% with 1:200,000 epinephrine every 3 minutes until a T4 block was obtained. Following delivery, Group I patients received 1.5 ml epidural saline and Group II patients received epidural fentanyl 75 g, both diluted to 10 ml with saline. Patients rated their pain at skin incision, bladder retraction, uterine incision, peritoneal closure, and skin closure on a 4 category rank scale. Analgesia was supplemented with nitrous oxide, ketamine or fentanyl (post delivery) as needed. Shivering, abdominal pain, nausea, vomiting, sedation, pruritus and chest pain were noted. APGAR scores and umbilical arterial blood gas tensions were measured. Data were analyzed using Student's t-test and Fischer's exact test where appropriate. Statistical significance was inferred by a $p < 0.05$.

RESULTS

The patient groups were similar with respect to age, height, weight, and gestational age. The incidence and severity of pain, shivering, nausea and vomiting, sedation, and pruritus were similar. Use of vasopressors and supplemental analgesics were not different. APGAR scores and umbilical cord pH values were similar. No patients in Group I complained of chest discomfort, whereas 8 of 22 patients in Group II did complain ($p = 0.01$).

DISCUSSION

The addition of fentanyl to local anaesthetics for epidural anaesthesia is becoming routine in many institutions. Our data suggest that the timing of administration of fentanyl is not important with respect to intraoperative analgesia, shivering, nausea, or sedation. However, early administration of fentanyl seems to dramatically decrease the incidence of intraoperative chest pain. The etiology of intraoperative chest pain remains unknown. Single dose epidural fentanyl is thought to exert primarily a local, rather than systemic analgesic effect.[4] Absence of chest pain in the group receiving fentanyl prior to delivery suggests that the chest pain may be mediated at the spinal cord level, and may be susceptible to blockade by intraspinal narcotics.

TABLE

	Group I (fentanyl) (Mean SD)	Group II (saline) (Mean SD)
Age (yr)	30.7 ± 3.1	32.2 ± 4.2
Weight (kg)	77.5 ± 9.1	76.0 ± 13.3
Height (cm)	163.5 ± 4.9	162.6 ± 6.3
Gestational Age (wk)	38.8 ± 1.2	38.9 ± 1.3
Time to T4 block (min)	15.6 ± 3.6	14.6 ± 2.9
Time to S2 block (min)	12.2 ± 2.7	13.9 ± 3.7
Lidocaine dose (mg/kg)	4.24 ± 0.96	4.09 ± 1.06
Cord pH	7.33 ± 0.02	7.32 ± 0.03

REFERENCES

1 Anesthesiology 1988; 68: 938-43
2 Anaesth Intens Care 1990; 18: 22-30
3 Anesthesiology 1985; 63: 694-8
4 Anesthesiology 1984; 61: 276-310

THE EFFECT OF TEMPERATURE ON LIDOCAINE HCl and CO_2 DURING EPIDURAL ANAESTHESIA FOR CAESAREAN SECTION

CT Crochetière FRCP(c), GH McMorland FRCP(c) , MJ Douglas FRCP(c), AA Kamani FRCP(c).
Department of Anaesthesia, University of British Columbia and Grace Hospital, Vancouver , B.C. and Hôpital Ste-Justine, Montréal, QC.

Introduction:

The advantage of carbonated lidocaine is controversial.[1-3] However, it is regarded by many anaesthesiologists as the agent of choice for Caesarean section. It has become the practice in some hospitals to keep the lidocaine-CO_2 vials in the refrigerator, in an attempt to increase the speed of onset , in spite of the lack of any evidence to support this belief. The efficacy of lidocaine-CO_2 is possibly related to the quantity of gas in solution and we know that the solubility of a gas is greater in cold solution. This study compares the effect of carbonation and temperature on lidocaine using 4 solutions: lidocaine-HCl or lidocaine-CO_2 , (with 1:200,000 epinephrine) either at room temperature (23°C) or cold (~5°C).

Methods:

Institutional ethical approval and written consent from each patient were obtained. 80 ASA I or II patients scheduled for elective Caesarean section were randomly assigned to one of the 4 groups and studied in a double-blind manner. After insertion of the epidural catheter at L_{2-3} or L_{3-4} level, a test dose of 3ml of the chosen solution was injected, followed by standardized incremental doses until a sensory block to T_4 was obtained. The onset time (thermosensitivity loss at L_1), time to S_1 block and T_4 segment, intensity (Dutton scale)[4] and duration of block, complications and side-effects, were recorded. The temperature and pH of the local anaesthetic were recorded and maternal oral temperature was measured before epidural blockade and after surgery. Data were analyzed for statistical significance using Chi square test of independance and 2 factors Anova with interaction. Significance was considered if $p < 0.05$.

Results:

Total dose required and duration of surgery were similar. Onset time and T_4 block were more rapid in lidocaine-CO_2 groups (Table below), temperature had no effect. The incidence of nausea was higher in lidocaine-CO_2 groups ($p < 0.003$). Carbonation and temperature did not have any effect on quality of anaesthesia, intensity of motor block, incidence of hypotension and shivering, duration of block and maternal temperature. The pH of the solutions was not significantly changed by lowering the temperature.

Conclusion:

Our results indicate that lowering the temperature of lidocaine CO_2 or HCl does not have any significant effect. In pregnant patients the epidural space is highly vascularized and probably warms up the cold solutions rapidly. Techniques involving a more direct approach of nerves may possibly be affected. Carbonation produced a more rapid block with respect to L_1 and T_4 segments without increasing hypotension. Those results are statistically significant but the clinical relevance is not obvious, the differences being small (~2minutes) and incidence of side effects being the same except for nausea. In conclusion, carbonation and/or lowering temperature are not the solution to achieve a faster block.

Reference:

1. Acta Anaesth Scand 1965; 16:55
2. Reg Anesth 1986; 11:62
3. Anesthesiology 1985; 21:348
4. Br J Anaesth 1984; 56:1361

	Groups				
Time(mins)	HCl	Cold HCl	CO_2	Cold CO_2	p
Onset*	5.0 (1.3)	5.2 (1.0)	4.0 (1.1)	4.7 (1.5)	$p < 0.006$
S_1 Block*	12.9 (3.3)	11.6 (3.8)	10.2 (3.0)	12.5 (4.2)	NS
T_4 Block*	19.0 (4.3)	20.1(5.8)	16.9 (4.1)	17.3 (3.5)	$p < 0.02$

* mean (sd)

SELF ADMINISTERED MIXTURE OF ENTONOX AND ISOFLURANE IN LABOUR

Sunil K. Arora F.F.A.R.C.S., M. Tunstall F.F.A.R.C.S., J. Ross F.F.A.R.C.S.
Department of Anaesthesia, Aberdeen Royal Infirmary, Foresterhill,
Aberdeen AB9 2ZB Scotland

INTRODUCTION: There is a need to improve the effectiveness of self-administered inhalation analgesia in childbirth. The quality of analgesia provided by premixed 50:50 nitrous-oxide in oxygen (Entonox), the only agent in general use, has been classified as satisfactory for only about 50% of mothers[1]. Alternative to entonox are the volatile agents. Isoflurane 0.75% and enflurane 1% have both been shown to produce better anagesia in the first stage of labour but are associated with increased drowsiness[2,3]. The present study was designed to test the effectiveness of adding 0.25% isoflurane to entonox in a double blind crossover trial.

METHOD: After ethical committe approval and informed patient consent 41 mothers in normal labour participated in the study. An Oxford miniature vaporiser (OMV 50) was calibrated to provide an inspried concentration of approximately 0.25% isoflurane. The OMV was interposed in the breathing tube between the entonox demand valve and the patient expiratory valve-facemask assembly. To make it double blind the OMV was concealed in a box from the investigator's and mother's view. It was switched in or out by another midwife according to a random number sequence. Mothers received either entonox or entonox-isoflurane for five consecutive contractions. At the sixth contraction mothers breathed room air. For the next five contractions mothers breathed the other agent. The pain relief score was entered by the mother on a 10cm linear scale. Results were compared using Wilcoxin rank signed score test. The degree of sedation, reaction to odour, patients co-operation and any adverse effects were recorded by the investigator.

RESULTS: the entonox-isoflurane mixture provided significantly more pain relief that entonox alone ($p < 0.001$)(Fig 1). Patient related data and sedation scores are shown in table 1 and 2 respectively. The number of mothers affected by dizziness by both agents, by entonox-isoflurane alone and by entonox alone were 5, 4 and 1 respectively. The odour of entonox-isoflurane was classified as pleasant, acceptable, unpleasant and nauseous by 22, 11, 4, and 2 mothers respectively.

DISCUSSION: Entonox is well established for pain relief of pain in childbirth. The simplicity, safety and acceptability of this analgesic method will ensure its continued use. Our results show that entonox-isoflurane mixture provides more pain relief than does entonox alone. There was slight increase in the sedation score but none of them lost verbal contact. Most patients tolerated the odour of isoflurane, and some said it was pleasant, very few were repelled by it. The OMV 50 has been assessed in detail in a field surgical environment[4]. Its performance may however be quite adequate when set to deliver low concentrations in the labour ward.

The study concludes that entonox isoflurane mixture is worthy of a larger trial to assess its safety for use by unsupervised midwives.

REFERENCES:
1. Br J Obstet Gynaecol 1974:81:603-607.
2. Anaesthesia 1985;40:424-426.
3. Anaesthesia 1984;39:24-26.
4. Anaesthesia 1984;39:183-185.

Fig. 1 GROUPED LINEAR ANALOGUE SCORES FOR PAIN RELIEF
0=worst 10=best

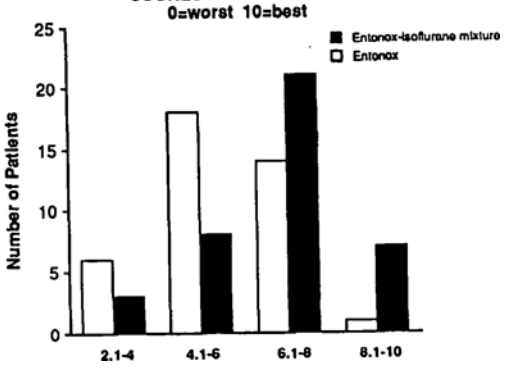


Table 1 PATIENT RELIEF DATA
(Mean ± Standard Deviation; or Actual Number)

	16 Multipara	23 Primipara
Age	29.3 (± 3.4)	28.3 (± 8.4)
Uterine contractions min^{-1}	3.3 (± 0.5)	3.4 (± 0.6)
Last cervical assessment	4.75 (± 0.8)	4.1 (± 1.6)
Receiving oxytocin infusion	7	6
Prior analgesia		
• None	5	6
• Diamorphine only	3	5
• Entonox only	7	4
• Entonox and diamorphine	1	8
Using mouthpiece instead of mask	4	10
Co-operation		
• Good	14	22
• Fair	1	1
• Poor	1	0

Table 2 SEDATION SCORES BEFORE AND AFTER
Tests Inhalations

	Multipara	Primipara
Score	0 1 2 3	0 1 2 3
No. of mothers		
• Before	11 4 1 -	15 8 - -
• After	10 4 2 -	15 7 2 -

0 = Fully alert
1 = Responds well to command - movements slow
2 = Moderate to slow response to command
3 = Unsatisfactory response to command

ANAESTHESIA FOR CAESAREAN SECTION: A COMPARISON OF TWO SPINAL NEEDLES

D.C. Mayer MD, S.K. Weeks MBBS FFARCS.

Departments of Anaesthesia, McGill University and Royal Victoria Hospital, Montreal, H3A 1A1

INTRODUCTION

Spinal anaesthesia is a safe, rapid and effective anaesthetic technique for Caesarean Section. Enthusiasm for this technique has been limited by the high incidence of post-dural puncture headaches (PDPH). Although many factors may influence the incidence of PDPH, needle characteristics other than size have not been fully evaluated. A pencil point needle (Whitacre) was developed to create less dural trauma than the standard cutting needle (Quincke) [1]. Recently, a 24G block needle (Sprotte) has been introduced which has a very low incidence (0.02%) of causing PDPH's, when used for diagnostic lumbar puncture and spinal anaesthesia [2]. The Sprotte is a modified pencil-point needle and has an ogival-shaped tip and is more rounded. We prospectively compared the 24G Sprotte needle to a 27G Quincke needle in patients undergoing Caesarean Section. This study is ongoing presently.

METHODS

After Ethics Committee approval, 45 patients consenting to spinal anaesthesia were randomly assigned to two groups. In Group 1, spinal anaesthesia was established with the 24G Sprotte needle (n=23), and in Group 2, the 27G Quincke needle (n=22) was used. All patients were prehydrated with 1 - 1.5l of normal saline prior to the block. Hyperbaric bupivacaine (0.75%) was the sole agent administered, and the dose given was at the discretion of the anaesthetist (range 12-15 mg). Blocks were performed in the right lateral decubitus or sitting positions at the L2-3 or L3-4 interspace. The Quincke needle was used with the bevel oriented parallel to the dural fibres. The number of attempts, presence/absence of paresthesias, level of anaesthesia achieved, intravenous fluid replacement (IVF's), estimated blood loss (EBL), and other medications given during the surgery (including ephedrine) were recorded. No restriction was placed on patient activity after discharge from the Recovery Room. Each post-operative day until discharge, all patients were seen by an anaesthetist, who was unaware of which needle was used. Patients were directly asked if they had a headache (HA). Patients who were noted to have HA's that were postural in nature were asked to classify the HA according to this scheme:

Class I = mild HA when sitting/ambulating
Class II = moderate to severe HA when sitting/ambulating
Class III = moderate to severe HA supine.

Also, patients were asked to rate PDPH's on an unmarked visual analogue scale (VAS) of 10 cm.

RESULTS

The demographic data of the two groups is shown in Table 1. The results are shown in Table 2. Twenty-eight cases were elective and seventeen were non-elective. One patient who was randomized to the Quincke group was considered a technical failure when apparent lumbar puncture did not result in satisfactory anaesthesia. No PDPH developed in this patient. All other patients (n=44) had successful and uneventful spinal anaesthetics. No patients in either group developed PDPH's.

DISCUSSION

The overall incidence of PDPH's in this study was 0%. A recent study comparing the 24G Sprotte needle to a 25G Quincke for Caesarean Section anaesthesia showed a marked difference in the incidence of PDPH's (5 of 55 needing epidural blood patch in the Quincke group, versus 0 in the Sprotte group) [3]. Another study using the Sprotte needle for 130 Caesarean sections resulted in no PDPH's [4]. Our study shows that the PDPH rate for the 27G Quincke is very low, and may be comparable to the 24G Sprotte. This cannot be confirmed based on the number of cases done in this study, and more data is being collected currently. Subjectively, the 24G Sprotte needle appears to be more rigid than the 27G Quincke. Additionally, a large lateral orifice (1.2 mm) allows for rapid confirmation of subarachnoid placement. Spinal anaesthesia for Caesarean Section was well accepted by patients, and continuing evaluation of these needles is warranted.

REFERENCES

1. JAMA 147: 657-658, 1951.
2. Regional-Anaesthesie 10: 104-108, 1987.
3. Anaesthesia 45: 656-658, 1990.
4. Anesthesiology 73: A1003, 1990.

TABLE 1
- Demographic Data -

	Sprotte (n=23)	Quincke (n=21)
Age (yrs)	29.9 (3.9)	30.3 (4.9)
Height (cm)	163.1 (7.4)	158.1 (5.4)
Weight (kg)	72.3 (10.3)	72.0 (6.9)
Gravidity	2.2 (1.1)	2.1 (0.9)
Parity	0.9 (0.8)	0.9 (0.7)

Values are presented as mean (SD).

TABLE 2
- Results -

	Sprotte (n=23)	Quincke (n=21)
Marcaine dose (mg)	13 (0.5)	12.7 (0.7)
Sensory level (median)	T_2	T_3
Follow-up (days)	4.9 (0.7)	4.8 (0.8)
Number of attempts	1.5 (0.7)	1.6 (0.9)
Ephedrine (mg)	16 (10)	11 (10)
IVF's (ml)	2973 (257)	3095 (203)
EBL (ml)	848 (191)	890 (106)
PDPH (#)	0	0

Except as noted, values are presented as mean (SD).

NITROUS OXIDE IN LABOUR: ANALGESIC EFFICACY AND OXYGEN DESATURATION.

B Kavanagh MB, P Norman FRCPC, D Daley FRCPC, A Sandler FRCPC, S Lawson RN.
Department of Anaesthesia, Toronto General Hospital, Toronto, Ontario.

INTRODUCTION: Nitrous oxide has been used for analgesia during labour for many years. Several groups have reported it to be beneficial (in as many as 90% of patients in one study[1]). However, none have used objective validated pain assessments. In addition, the safety of the technique has been assumed but not verified. In particular, diffusion hypoxaemia is a potential concern. Previous studies measuring oxygenation during N_2O analgesia in labour have recorded desaturation in 4/4 and 3/7 patients[2,3]. This prospective study was therefore designed to objectively evaluate the analgesic efficacy and effects on arterial oxyhaemoglobin saturation of 50% N_2O:O_2 administration during labour.

METHODS: Following institutional ethics committee approval and informed consent, 9 women (ASA I) in labour were studied. While the women were in early labour, explanations were given regarding the study protocol, visual analogue scale (VAS) pain score assessment and proper use of intermittent N_2O analgesia. The data collection commenced when the patients required analgesia in advanced labour. Patients were initially monitored for 5 contractions with no N_2O, and for 5 further contractions using 50% N_2O:O_2. A VAS pain score was recorded by the patient after each contraction. Digital pulse oximetry (Nellcor N-100) was used continuously throughout the study. An investigator was in constant attendance to eliminate artifacts and to record the minimum O_2 saturation (SaO_2) with each contraction. O_2 desaturation was defined as $S_aO_2 < 90$ for > 15 sec. Following the study, patients indicated if they found the N_2O beneficial or not.

Data was analyzed using paired Student's t-tests and presented as means$\pm$SEM. $P<0.05$ was considered statistically significant.

RESULTS: Demographic data were: Age 31.7$\pm$2.1 yrs(mean$\pm$SEM), time since onset of labour 6.2$\pm$1.5 hrs, Cervical dilatation 6.0$\pm$1.0 cm. Pooled pain score data revealed identical mean VAS scores before and during N_2O administration (8.3$\pm$0.3 for both)(Fig. 1). Analysis of individual patients' VAS scores revealed significant worsening in VAS score ($p<0.05$) in 2 patients, and a significant improvement in 2 patients ($p<0.05$), with no changes in the remaining 5 patients. 5 patients (56%) stated subjectively that they found N_2O beneficial, 4 (33%) found N_2O of no benefit, and 1 (11%) was undecided.

Comparison of pooled O_2 saturation data revealed mean values of 97.2$\pm$0.22% before N_2O, and 95.3$\pm$0.94% after N_2O ($p<0.03$) (Fig. 1). O_2 desaturation was noted in 2 patients following N_2O. One had 3 desaturations, with the lowest recorded SaO_2= 65%, and a mean duration of desaturation 60 sec. The second patient desaturated to SaO_2=89%, and the desaturation lasted 15sec.

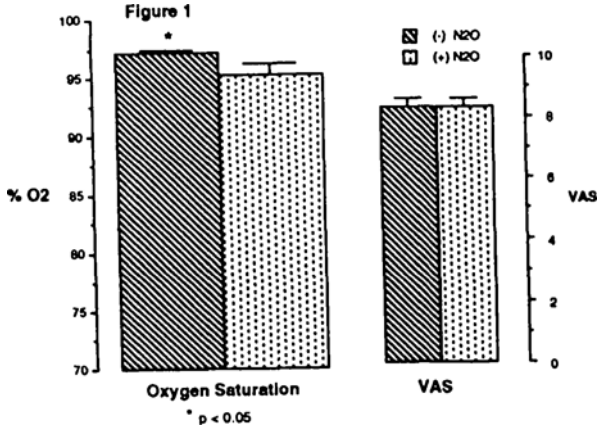
DISCUSSION: The initial analysis of this ongoing study suggests that although N_2O may be perceived as having beneficial analgesic effect by many patients, objective data do not support this. Furthermore, significant O_2 desaturation is a definite risk in some patients.

These preliminary data cast doubt on the efficacy/safety profile of N_2O as an analgesic agent for use during labour.

REFERENCES:

(1) Br Med J 1:709-713, 1970.
(2) Anesth Analg 68:S167, 1989.
(3) Br J Anaesth 62:316-318, 1989.

Figure 1



LIDOCAINE-HCL VS LIDOCAINE-CO_2 FOR EPIDURAL DURING CAESAREAN SECTION : WHAT DO NEONATES THINK ABOUT IT ?

J Guay F.R.C.P.(c), P Gaudreault F.R.C.P.(c), A Boulanger F.R.C.P.(c), A Tang F.R.C.P.(c), L Lortie, C Dupuis Ph D.
Departments of Anesthesia, Pediatrics and Biochemistry, Ste-Justine Hospital and University of Montreal, Montreal, Que.

INTRODUCTION:

The capacity of carbonated lidocaine to diffuse in body tissues is superior to that of lidocaine hydrochloride (L-HCL), which could account for its more rapid onset of action [1,2]. During the first 30 minutes following an epidural injection, the serum concentration of L-CO_2 is greater than that of L-HCL [2]. According to some authors, there is a greater transplacental transfer of L-CO_2 compared to L-HCl [3]. It has been clearly shown that lidocaine may cause changes in the neurobehavioural examination of the neonate, in particular the response to auditory stimuli [4]. This effect has been confirmed by the study of auditory evoked potentials [5]. To date, there has been no study which compares the effects of these two lidocaine solutions administered in the epidural space on the newborn. The aim of this study is to compare both L-CO_2 and L-HCL during caesarean section with respect their passage through the placenta, and their effects on the newborn.

METHODS:

Twenty-six patients ASA 1 physical status scheduled for elective caesarean section were divided at random into two groups. One group receiving, via an epidural catheter, 20 ml of L-HCL 2 % with epinephrine 5 ug.ml^{-1} freshly added (+E) (Group HCL = 13 patients); the other group receiving 20 ml of equivalent concentration of L-CO_2 + E (Group CO_2 = 13 patients). The patients were placed in decubitus dorsal position with left uterine displacement, and were given a bolus of 1 to 2 litres of Ringers lactate prior to epidural injection. Lidocaine was then injected into the epidural space via a catheter at the following rate: Time 0 (T_0) = 3 ml, T_3 = 5 ml, T_4 = 5 ml, T_5 = 5 ml, T_6 = 2 ml. In an effort to maintain an equal quantity of lidocaine in all patients, those in whom the T_4 level was not attained within 20 minutes were withdrawn from the study (HCL = 2 patients, CO_2 = 2 patients). At the moment of birth, serum concentrations of lidocaine were measured both in the mother and the umbilical vein. All newborns were examined by the same blinded pediatrician at 15 minutes, 2 hours and 24 hours of life using the technic described by Amiel-Tison (NACS) [6].

RESULTS:

The concentrations of lidocaine in the serum of the mother and newborn were comparable in both groups. Measured at birth, approximately 40 minutes after the injection, the ratio of serum concentrations in the newborn to those of the mother was 20 % higher in the HCL group than in the CO_2 group. Neverthless, this difference was not statistically significant. The mean scores of NACS were in the normal range (>36/40) at all times for both groups. The auditory response to stimuli at 15 minutes of life was slightly better in the CO_2 group where only 2 responses were abnormal compared to 4 in the HCL group. The difference was not statistically significant.

DISCUSSION:

The transplacental transfer of L-CO_2 was similar to that of L-HCL. The neonatal behavioural examination was normal in both groups and we conclude that both solutions are similiar with repect to their effects on the neonate.

REFERENCES:

1. Anesth Analg 1987;66:739-45
2. Reg Anesth 1986;62-7
3. Can J Anaesth 1981;28:217-23
4. Anesth Analg 1984;63:301-8
5. Arch dis Child 1989;64:934-8
6. Anesthesiology 1982;56:340-50

	Injection-delivery time (min)	Lidocaine Serum Concentrations (umol.L^{-1})			Venous cord pH	Neurobehavioral Adaptive Capacity Score Response to sounds (Total score)		
		Mother	Neonate	Ratio		15 min	2 hrs	24 hrs
HCL	41.0 ± 5.4	8.04 ± 2.36	3.92 ± 0.95	0.54 ± 0.24	.7.33 ± 0.07	1.6 ± 0.5 (37.3 ± 2.1)	1.8 ± 0.4 (37.5 ± 2.1)	1.9 ± 0.3 (38.9 ± 0.7)
CO2	40.1 ± 4.9	8.61 ± 1.48	3.86 ± 0.84	0.45 ± 0.07	7.35 ± 0.03	1.8 ± 0.4 (37.3 ± 1.6)	1.9 ± 0.3 (38.2± 1.8)	2.0 ± 0.0 (38.8 ± 1.1)

MECHANISMS INVOLVED IN THE BRADYCARDIA PRODUCED BY ANTICHOLINESTERASES

S.B. Backman MD PhD, M. Bachoo PhD, C. Polosa MD PhD.

Department of Anaesthesia, Royal Victoria Hospital, Department of Physiology, McGill University, Montreal, H3A 1A1

INTRODUCTION

Bradycardia produced by anticholinesterases is thought to occur because hydrolysis of acetylcholine (ACh) tonically released from parasympathetic postganglionic nerve terminals is blocked [1]. An alternate hypothesis is direct activation of peripheral cardiac inhibitory pathways: it has been shown that anticholinesterases behave as cholinergic agonists in the autonomic peripheral nervous system [2]. The aim of this investigation was to study the mechanisms of anticholinesterase-induced bradycardia.

METHODS

Cats were anaesthetized with sodium pentobarbitone and artificially ventilated. Parasympathetic traffic to the heart was interrupted by bilateral vagotomy. Sympathetic transmission to the heart was blocked with propranolol (3 mg/kg, i.v.). Arterial pressure, heart rate and EKG were continuously recorded. The distal end of the sectioned vagus nerve was electrically stimulated to activate parasympathetic preganglionic axons. The anticholinesterases studied were neostigmine and edrophonium. Other drugs used were the nicotinic antagonist hexamethonium bromide (C6), the muscarinic antagonists atropine and pancuronium, and the muscarinic agonist methacholine. Hemicholinium-3 (HC-3) was used to depress ACh release from parasympathetic nerve terminals.

RESULTS

The mean heart rate of vagotomized and propranolol-treated cats was 139 $\pm$ 23 beats/min (S.D., n=40). Neostigmine evoked a dose-dependent decrease in heart rate (10% reduction with 0.05 mg/kg i.v., max reduction 60% with 0.5 mg/kg, n=12, Figure 1). This effect did not appear to be due to blocking cholinesterase activity because equivalent cholinesterase inhibition by edrophonium produced a much smaller bradycardia (10% reduction with 1.5 mg/kg i.v., max 15% with 10.0 mg/kg, n=6, Fig 1). The neostigmine-induced bradycardia appeared to involve ACh release because it was reduced (65%, $p < 0.02$, n=5) after reduction of ACh stores in cardiac parasympathetic neurons (continual bilateral vagus nerve stimulation in the presence of HC-3, 3 mg/kg i.v.). The neostigmine-induced bradycardia was blocked by the muscarinic antagonist atropine (ED_{50} 0.005 mg/kg i.v., n=5) and by pancuronium (ED_{50} 0.02 mg/kg i.v., n=6). Also, it was blocked by the nicotinic antagonist C6 (ED_{50} 8.0 mg/kg i.v., n=5). C6, however, had no effect on the bradycardia produced by the muscarinic agonist methacholine (100-300 μg/kg/min i.v., n=4). These observations suggest that neostigmine evokes bradycardia via stimulation of C6-sensitive receptors resulting in ACh release and activation of cardiac inhibitory muscarinic receptors (Figure 1, insert). The C6-sensitive receptors involved are likely on the postganglionic neuron, rather than on the preganglionic axon terminal, because the neostigmine-induced bradycardia was not significantly attenuated after vagus nerve terminal degeneration (80-100 hrs post bilateral vagotomy).

DISCUSSION

These data suggest that the mechanism proposed by Baraka [1] to account for anticholinesterase-induced bradycardia may be inadequate. In the absence of tonic autonomic input to the heart, neostigmine evoked a powerful bradycardia at clinically relevant doses. In comparison, the bradycardia evoked by edrophonium was modest, and these findings may help to explain the clinical observation that less muscarinic antagonist is required to blunt the bradycardia evoked by edrophonium of neostigmine when reversing muscle paralysis. These findings are of potential interest to heart transplant patients: it is suggested that anticholinesterases may evoke bradycardia in the presence of cardiac denervation, thus changes in heart rate upon reversing muscle paralysis should be anticipated in this subset of patients. With MRC & QHF support.

REFERENCES

1. Br J Anaesth 40: 30-36, 1968.
2. Goodman and Gilman's The Pharmacological Basis of Therapeutics pp. 110-129, 1985.

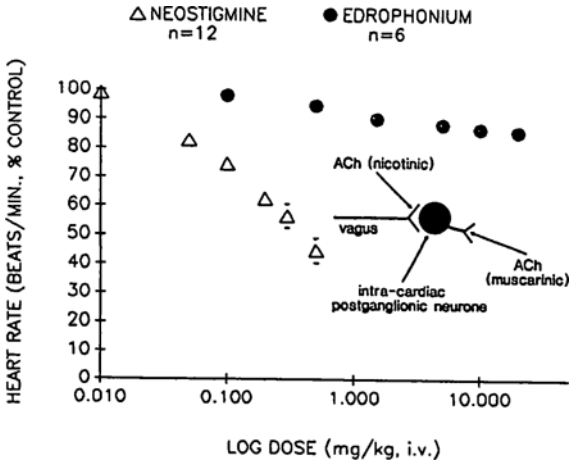


Fig. 1. Decrease in heart rate produced by neostigmine and edrophonium. Values are plotted as % of control heart rate. Error bars: SEM. Insert: Schematic diagram of parasympathetic innervation of the heart.

EFFECTS OF ANAESTHESIA ON TUMOUR METASTASIS

G.C. Koudgil, M.D.,* B. Frame, B.Sc., M.A. Blajchman, M.D., D.P. Singal, Ph.D.
Departments of Anaesthesia* and Pathology, McMaster University Medical Center, 1200 Main Street West, Hamilton, Ontario, Canada L8N 3Z5

INTRODUCTION

Despite continued advances in medical, surgical, and anaesthetic skills, most deaths from cancer are still caused by tumour metastasis.[1] While an intact immune response is essential for combating tumour growth and metastatic dispersal, its integrity may be compromised by a wide variety of factors including anaesthesia. Evidence showing a suppression of immune response has been reviewed by different workers recently.[2-3] Previously, we have reported that equipotent concentrations of different volatile agents produce varying degrees of depression of leucocyte chemotactic migration.[4] Since anaesthetic intervention is essential for surgery, it is conceivable that different anaesthetic agents may produce varying degrees of suppression of immune response. Hence, in order to select an optimal anaesthetic agent, it is important that we define the comparative effects of different anaesthetic agents on the tumour dispersal and metastasis. Therefore, we have investigated the effects of equipotent concentrations of Halothane and Isoflurane on pulmonary metastasis from B_{16} melanoma.

METHODS

Adult mice of C57Bl/6J strain were obtained from the Jackson Laboratory, Bar Harbor, Maine, U.S.A. and were randomly divided into two groups. Groups of animals were anaesthetized with either 1% Halothane or 1.5% Isoflurane (approximately 1.3 MAC) for 1.0 hour, while the control group had O_2 alone under identical conditions. During anaesthesia, animal temperature was maintained by a source of radiant heat. Fifteen minutes following anaesthesia, all animals were given $1x10^5$ B_{16} melanoma cells intravenously through the tail vein. Twenty-one days after tumour inoculation, the animals were sacrificed and tumour metastasis in the lungs were counted under a dissecting microscope following intratracheal fixation with Bouins solution. The difference in numbers of pulmonay metastasis between control and different anaesthetic groups was analyzed for significance by the Mann Whitney-U-test.

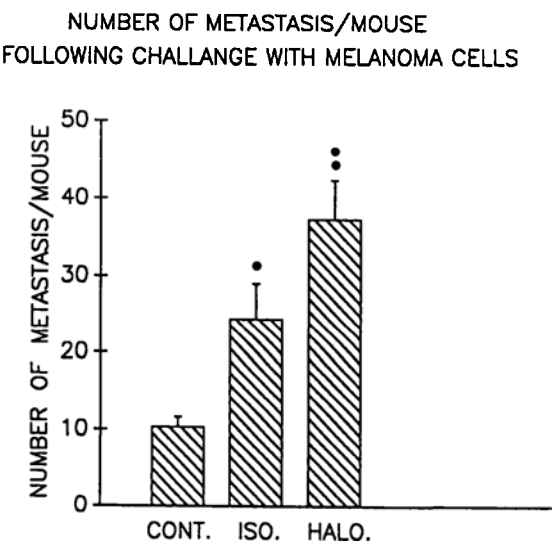
RESULTS

Primary melanoma B_{16} tumours were observed in lungs of all animals twenty days following tail vein inoculation of $1x10^5$ melanoma cells/mouse. However, the mean number of tumours was significantly higher in animals that had approximately 1.3 MAC hours of anaesthesia with Halothane ($p < 0.00001$) or Isoflurane ($p < 0.0014$) compared with the control group of animals that had no anaesthesia (Figure 1). Although the number of tumours was much higher in the Halothane group compared with Isoflurane group, a statistically significant level between these two groups could not be reached.

DISCUSSION

These results demonstrate that anaesthesia significantly enhanced the incidence of pulmonary metastasis in C57Bl/6J mice following inoculation with B_{16} melanoma cells. We have previously presented evidence that several anaesthetic agents may induce a suppression of immune response.[2] Thus, it is likely that an enhancement of pulmonary metastasis may have resulted from a suppression of immune response in the anaesthetized animals. While a higher incidence of tumours was observed in the Halothane group compared to Isoflurane group, this difference was not significant. This may have been due to a smaller number of animals in the Isoflurane groups (n=19) compared to the Halothane groups (n=32). While these data clearly demonstrate that anaesthesia alone may enhance pulmonary metastasis, further studies are required to select an optimal anaesthetic and to define the mechanisms whereby anaesthetic agents may enhance the incidence of metastasis.

Figure 1



REFERENCES

1. *Curr Probl Surg* 24:137-209, 1987.
2. *Can Anaesth Soc J* 33:S54-S60, 1986.
3. *Anesthesiology* 72:542-552, 1990.
4. *Can Anaesth Soc J* 31:631-637, 1984.

EFFECT OF HALOTHANE ON NITRIC OXIDE-INDUCED VASODILATATION

J-F. Albert, MD, G.A. Blaise, MD

Department of Anesthesiology, Notre-Dame Hospital, 1560 Sherbrooke Street East, Montreal, Quebec, H2L 4M1

INTRODUCTION

The endothelium plays an important role in the control of vascular tone.[1] Many vasodilators and vasoconstrictors are synthesized by the endothelium.[2] One vasodilator is EDRF (endothelium-derived relaxing factor), which has been identified as nitric oxide (NO),[3] or a compound containing NO.[4] NO is synthesized from L-arginine by the endothelial cell. Volatile anesthetics are known to modify vascular smooth muscle tone. It has been shown that halothane attenuates EDRF-mediated vasodilation in isolated canine femoral and carotid artery rings and rabbit aorta rings precontracted with norepinephrine.[5] In this research project, we determined the effect of halothane on the vasodilation induced by NO.

METHODS

Ten New-Zealand rabbits (1.0-2.0 Kg) were desanguinated. The thoracic aorta was dissected and cut into 5 millimeter rings. The endothelium was mechanically removed. The rings were suspended between two stirrups in a 25 cc organ chamber filled with oxygenated Krebs-Ringer solution maintained at 37 degrees celsius and attached to an isometric force transducer and recorder. All the vessels were brought to their optimum passive tension and allowed to relax for at least thirty minutes, then contracted with phenylephrine ($1x10^{-7}$ M). Half the vessels were treated with halothane 2.5%. Various concentrations of NO in liquid solution, previously prepared by injecting NO gas into deoxygenated water,[3] were added in a dose-response manner ($1x10^{-8}$ to $1x10^{-5}$ M). Papaverine ($1x10^{-4}$ M) was then used to determine the maximal level of the ring relaxation.

RESULTS

Nitric oxide induced a dose-dependent relaxation of the denuded precontracted vessels. Halothane significantly attenuated the vasodilation induced by NO ($p<0.05$, Student's paired t-test) (Fig. 1).

DISCUSSION

These data suggest that halothane's attenuation of endothelium-dependent relaxation is not only due to a reduction of EDRF/NO release,[5] but also to a decrease of NO action at the vascular smooth muscle level and/or an alteration of NO stability (half-life). These mechanisms explain some of the vasoactive properties of halothane.

REFERENCES

1. Furchgott and Zawadzki. *Nature* 1980; 288: 373-376.
2. Vane et al. *N Engl J Med* 1990; 2: 27-36.
3. Palmer et al. *Nature* 1987; 327: 524-526.
4. Myers et al. *Nature* 1990; 345: 161-163.
5. Muldoon et al. *Anesthesiology* 1988; 68: 31-37.

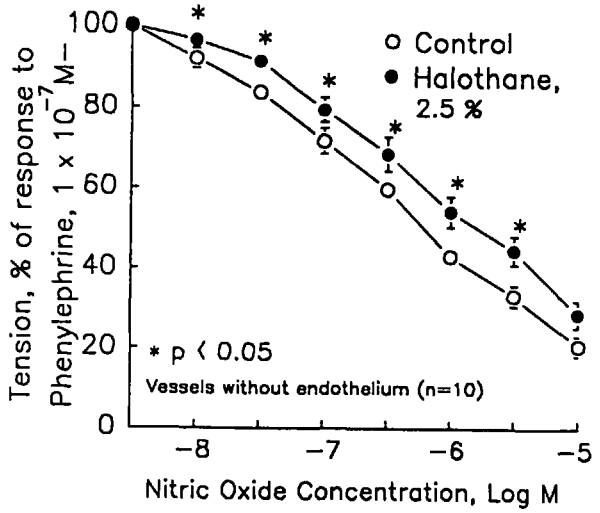


Figure 1. Effect of 2.5 % halothane on vasodilation of precontracted isolated denuded rabbit aorta rings.

NEUROMUSCULAR RECOVERY FOLLOWING SHORT AND LONG INFUSIONS OF ATRACURIUM AND VECURONIUM

A.Ratcliff MB, J-C.Law Min MB, F.Donati MD, D.R.Bevan MB.
Departments of Anesthesia, Royal Victoria Hospital & McGill University, Montreal,PQ.

INTRODUCTION

The rate of recovery of neuromuscular function following single bolus doses of atracurium or vecuronium is rapid. Infusions of atracurium and vecuronium of approximately one hour's duration have been compared but there is little information of the relative rates of recovery from atracurium and vecuronium infusions of longer duration.

The purpose of this study was to compare the rates of spontaneous and induced recovery after either short (1 hr) or long (>21/2 hr) infusions of atracurium or vecuronium.

METHODS

Forty-eight ASA I or II, adult patients were included in the study which was approved by the Hospital Ethics Committee. Anaesthesia was induced with thiopentone, 4-7 $mg.kg^{-1}$, and fentanyl, 1-5 $g.kg^{-1}$, and maintained with N_2O/O_2/isoflurane. The lungs were ventilated to maintain $P_{ET}CO_2$ at 30-35 mmHg. A Datex Relaxograph was used to record the evoked compound EMG of the adductor pollicis in response to supramaximal train-of-four stimulation (40-70ma) of the ulnar nerve at a frequency of 2Hz every 20 sec.

Patients were randomized into two groups to receive either atracurium or vecuronium. Initial bolus doses (atracurium 0.3 $mg.kg^{-1}$, vecuronium 0.06 $mg.kg^{-1}$) were followed by continuous infusions to maintain T1 twitch height at approximately 10% of control using a Bard Infusor pump. Towards the end of the surgical procedure the infusion was stopped. Ten minutes later neuromuscular blockade was either allowed to recover spontaneously or edrophonium 0.5 $mg.kg^{-1}$ was given with atropine 0.6 mg. Times to recovery of T1 to 25, 50 and 75% of control and the time taken to achieve TOF of 0.7 were recorded. Short infusions lasted for about one hour and long infusions for >2 1/2 hr.

Differences between groups were analyzed using ANOVA and student's t test with the Bonferroni correction. Results are expressed as mean ± SEM.

RESULTS

The mean duration of the short infusions was 62.8 ± 6.1 min and of the long infusions was 200.6 ± 13.1 min. There were no differences in the duration of block among the groups receiving either the short or long infusions (Table). The T1 twitch height 10 min after stopping the infusions was similar for both relaxants (atracurium 22.2±2.9% (short) and 30.3±4.6% (long) vs 30.4±3.8 and 26.5±2.5% for vecuronium).

Recovery times for atracurium and vecuronium were similar both during spontaneous and assisted recovery. Although there was a slight increase in the spontaneous recovery times in the longer infusions for vecuronium this was not statistically significant. Recovery after edrophonium was rapid and similar in all groups.

DISCUSSION

These results demonstrate that in infusions lasting up to three hours the recovery of neuromuscular activity is similar for atracurium and vecuronium during both spontaneous and assisted recovery. The rapid recovery after atracurium is due to metabolism whereas that of vecuronium follows redistribution. It might be anticipated that with prolonged infusions of vecuronium the sites of redistribution may become replete and lead to more prolonged recovery. If this mechanism occurs it does not appear to be important for infusions lasting up to three hours.

TABLE

	n	Duration (min)	Recovery Index (min)	TOF 0.7 (min)
Spontaneous				
Atracurium	6	70.3 ± 12.9	13.7 ± 1.1	36.3 ± 2.4
	6	168.5 ± 3.9	15.2 ± 3.3	31.6 ± 5.7
Vecuronium	6	73.5 ± 13.6	15.5 ± 2.0	39.0 ± 3.1
	6	198.3 ± 15.2	20.2 ± 4.1	42.6 ± 2.7
Edrophonium				
Atracurium	6	44.0 ± 10.4	-	21.0 ± 2.5
	6	219.4 ± 32.8	-	20.7 ± 3.4
Vecuronium	6	63.3 ± 11.0	-	17.6 ± 2.1
	6	216.7 ± 39.1	-	19.0 ± 3.4

The Pharmacokinetics of Propofol vs Age

JB Dyck MD, J Varvel MD, O Hung MD, SL Shafer MD

Stanford University, Palo Alto, CA 94305

Introduction: It has been shown that the dose of thiopental required for induction of anesthesia is inversely related to age.[1,2] The induction dose of propofol has also been shown to diminish with age.[3] We examined the changes in the pharmacokinetics of propofol that occur with age.

Methods: Informed consent was obtained from 60 healthy male patients covering a range of ages from 23-82 years. An arterial line was placed in the left radial artery, an intravenous was inserted with normal saline running at 2 ml/kg/hr, and EEG electrodes were attached. Propofol 0.5 mg/kg/min IV was administered as a zero order infusion until 3 seconds of burst suppression was present on the EEG. Blood was sampled at 1, 1.5, 2, 2.5, 3, 4, 5, 6, 8, 10, 12, 15, 20, 30, 45, 60, 90, 120, 180, 240, 360, 480, 600, 900, 1440 min. The extended least squares nonlinear regression package, MKMODEL, was used to simultaneously fit the observations for all 60 patients to a single best estimate of the pharmacokinetic parameters for the entire population. Log likelihood (LL) was the objective function used to evaluate the goodness of fit. Weight, height, age, dose, body surface area, and lean body mass were tried as covariates of each volume and clearance parameter in the model to improve the goodness of fit. If the difference between $-2*LL > 4(\sim X^2_{0.05}[1])$, the more complex model was considered preferable. The percent performance error of the model is defined as %PE = 100(Meas-Pred)/Pred. The median absolute performance error (MDAPE) is the median of the performance errors for all the samples in the population. A computer simulation using the average infusion rate of 41.6 mg/min and the final kinetic model was undertaken to ensure that the covariates do indeed explain the relationship between age and dose.

Results: From Fig. 1 it can be seen that the dose of propofol required to produce 3 seconds of EEG burst suppression is inversely related to age.

Table 1 shows the pharmacokinetic model both with and without the appropriate covariates.

Table 1

Parameter	No Covariates	Covariates
V1 (l)	5.94	-0.0404 * Age + 8.266
V2 (l)	12.6	12.03
V3 (l)	268.	266.0
Cl1 (l/hr)	2.11	0.01429 * Weight + .9383
CL2 (l/hr)	1.70	1.567
CL3 (l/hr)	1.80	-0.01193 * Age + 2.436

Fig. 2 shows the percent error over time that results from application of the final model to each individual data set. The MDAPE improved from 25.1% to 23.8% with the addition of the covariates.

Fig. 3 shows Fig. 1 superimposed with our prediction of the dose vs age required to reach burst suppression given that the average plasma concentration of propofol at the time of burst suppression was 9.0 mcg/ml.

Discussion: The initial volume of distribution for thiopental declines with age.[1] It has also been shown that the rapid intercompartmental clearance of thiopental declines with age.[2] We have shown that both the initial volume of distribution and the slow intercompartmental clearance of propofol decline with age and this kinetic difference is able to explain the apparent increase in sensitivity of the elderly to propofol.

References:

1. Homer TD, Stanski DR: The effect of increasing age on thiopental anesthetic requirement and disposition. Anesthesiology 62: 714-724, 1985.

2. Stanski DR, Maitre PO: Population pharmacokinetics and pharmacodynamics of thiopental: the effect of age revisited. Anesthesiology 72:412-422, 1990.

3. Dundee JW, Robinson FP, McCollum JSC, Patterson CC: Sensitivity to propofol in the elderly. Anaesthesia 41:482-485, 1986.

** Available from Nicholas Holford, M.Sc., M.R.C.P.(UK), F.R.A.C.P., Department of Pharmacology and Clinical Pharmacology, University of Auckland School of Medicine, Private Bag, Auckland, New Zealand.

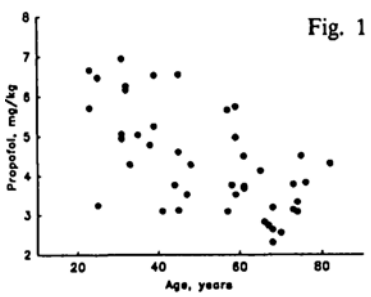


Fig. 1

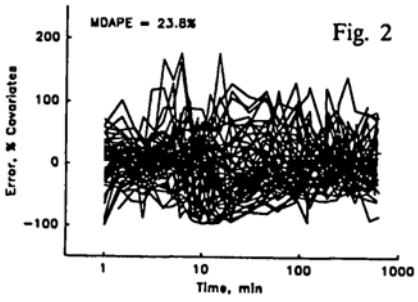


Fig. 2

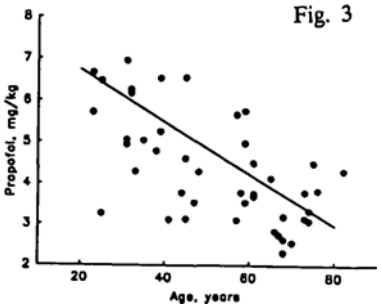


Fig. 3

VECURONIUM DOSE-RESPONSE CURVES: MECHANICAL AND ELECTROMYOGRAPHIC RESPONSES COMPARED

P. Fiset MD FRCPC, F. Donati PhD MD FRCPC, P. Balendran MB, D.R. Bevan MB.
Departments of Anaesthesia, Royal Victoria Hospital & McGill University, Montreal, H3A 1A1.

INTRODUCTION

There is usually a good correlation between the electromyographic (EMG) and mechanomyographic (MMG) response in the presence of non-depolarizing neuromuscular blockers. However, very few dose-response studies have compared both methods, and only one study reported the ED_{50} and ED_{95} based on adductor pollicis EMG and MMG response to cumulative doses of d-tubocurarine [1]. This study was designed to evaluate adductor pollicis EMG and MMG responses with single doses of vecuronium administered to obtain dose-response curves.

METHODS

The protocol was approved by the Hospital's Ethics Committee. Forty-seven ASA physical status I or II adults, aged 18-75 yrs, were given thiopentone, 5-10 $mg.kg^{-1}$, and fentanyl, 1-2 $\mu g.kg^{-1}$, for induction of anaesthesia. Then, the lungs were ventilated via a mask with N_2O_2, up to 70%, in oxygen. Supramaximal train-of-four stimulation was applied to the ulnar nerve at the wrist every 20 s. The integrated EMG response was recorded via two surface electrodes located on the belly of the adductor pollicis muscle in the palmar surface of the hand and near the metacarpo-phalangeal joint of the thumb, respectively. Electrical integration of the signal was performed by a Datex NMT-221 EMG recorder. Mechanical response was measured with by a Grass FT-10 force displacement transducer. Patients received vecuronium, 20, 30 or 40 $\mu g.kg^{-1}$ by random allocation. Maximal first twitch (T1) response was recorded. Logit-log dose response curves were constructed. In addition, maximal EMG and MMG responses were compared by linear regression. A $P < 0.05$ was considered to indicate statistically significant differences.

RESULTS

Supramaximal stimulation required (mean $\pm$ SD) 54.7 $\pm$ 6.4 mA, and the peak to peak amplitude of the EMG signal was 12.2 $\pm$ 5.1 mV. The ED_{50}, ED_{90} and ED_{95} are listed in Table 1. The EMG values were greater than MMG values for deep blockade, whereas the opposite situation occurred for less intense degrees of block ($P < 0.05$) (Figure 1).

DISCUSSION

This study indicates that the ED_{50} obtained by MMG and EMG of the adductor pollicis are almost identical. However, the similarity between MMG and EMG responses is less for blocks approaching 0 and 100%. Thus, the ED_{95} obtained by EMG was 12% greater than the corresponding MMG estimate. These differences, although statistically significant, are clinically unimportant.

REFERENCE

1. Anesthesiology 69: 1003-5, 1988.

TABLE 1

- Potency Estimates -
($\mu g.kg^{-1}$)

	MMG	EMG
ED_{50}	26.0	24.7
ED_{90}	43.0	46.4
ED_{95}	51.1	57.3

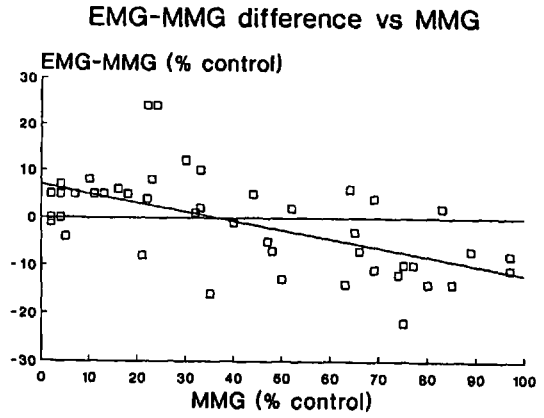


Figure 1: Difference between EMG and MMG T1 value (EMG-MMG) versus MMG T1 height, at maximum effect of vecuronium.

MIDAZOLAM PHARMACOKINETICS IN PATIENTS UNDERGOING AORTIC RECONSTRUCTIVE SURGERY

Robert J. Hudson, MD, FRCPC, P.M. Burgess

Department of Anesthesia, University of Manitoba, St. Boniface General Hospital, Winnipeg, Manitoba

Introduction

Opioid-based anesthesia may lower the incidence of complications in patients undergoing thoracoabdominal or abdominal aortic surgery.[1] The combination of benzodiazepines and opioids is sympatholytic,[2] and acts synergistically for induction of anaesthesia.[3] Therefore, midazolam is potentially a valuable adjunct to opioids in patients undergoing major vascular surgery. As the pharmacokinetics of opioids are altered in these patients,[4,5,6] we determined the pharmacokinetics of midazolam in patients undergoing elective abdominal aortic surgery.

Methods

After approval from the faculty human studies committee, informed consent was obtained from 12 patients undergoing elective abdominal aortic surgery. Morphine 0.15 $mg \cdot kg^{-1}$ IM and scopolamine 0.006 $mg \cdot kg^{-1}$ IM were given preoperatively. Anesthesia was induced with midazolam 0.25 $mg \cdot kg^{-1}$ given over 5 seconds and sufentanil 1.25 $\mu g \cdot kg^{-1}$ given over 2 minutes. Pancuronium 0.14 $mg \cdot kg^{-1}$ was given concurrently. Anesthesia was maintained with a continuous infusion of sufentanil, titrated according to individual patients' requirements. Additional neuromuscular blockers, isoflurane, and vasoactive agents were administered at the discretion of the attending anaesthetist. Intravenous fluids were given to maintain pulmonary artery wedge pressure near the preinduction value, and packed red blood cells were transfused as indicated. Starting 1 minute after the injection of midazolam, arterial blood samples were drawn at increasing intervals for the next 24 hours. The serum was separated and stored at -20°C. Midazolam concentrations were determined by gas-liquid chromatography using an iodinated benzodiazepine (Ro 77949) for the internal standard.[7] Two and three-compartment pharmacokinetic models were fitted to the concentration versus time data by nonlinear regression and pharmacokinetic variables were calculated using standard formulae.[8]

Results

Eight men and four women were studied. Their mean (± SD) age was 66.8 ± 9.2 years and their mean weight was 74.3 ± 12.7 kg. In all patients, a three-compartment model was required to adequately characterize the concentration versus time data.[9] The volume of the central compartment was 0.077 ± 0.064 $l \cdot kg^{-1}$ and the volume of distribution at steady-state was 1.635 ± 1.047 $l \cdot kg^{-1}$. Total midazolam clearance was 5.1 ± 1.9 $ml \cdot min^{-1} \cdot kg^{-1}$. The rapid and slow distribution half-times were 1.0 ± 0.7 and 22.6 ± min respectively. The elimination half-time was 6.3 ± 3.6 hours.

Discussion

Most previous reports indicate that the elimination half-time of midazolam is 4 hours or less.[10] The mean clearance in our patients is near the lower end of the range of previously reported values of 6-11 $ml \cdot min^{-1} \cdot kg^{-1}$, and the volume of distribution in our patients is at the upper end of the range reported by other investigators. Therefore, the longer elimination half-time observed in our patients appears to be due to the combination of relatively slow clearance and a relatively large distribution volume. Like the opioids, the pharmacokinetics of midazolam are different in patients undergoing abdominal aortic surgery. This must be considered when these drugs are used in patients undergoing major vascular surgery.

References

1. Benefiel DJ, Roizen MF, Lampe GH *et al.* Morbidity after aortic surgery with sufentanil vs isoflurane anesthesia. (abstract) Anesthesiology 1986; 65:A516.
2. Tomicheck RC, Rosow CE, Philbin DM, *et al.* Diazepam-fentanyl interaction - hemodynamic and hormonal effects in coronary artery surgery. Anesth Analg 1983; 62:881-4.
3. Ben-Shlomo I, Abd-el-Khalim H, Ezry J, Zohar S, *et al.* Midazolam acts synergistically with fentanyl for induction of anaesthesia. Br J Anaesth 1990; 64:45-7.
4. Hudson RJ, Thomson IR, Cannon JE, *et al.* Pharmacokinetics of fentanyl in patients undergoing abdominal aortic surgery. Anesthesiology 1986; 64:334-38.
5. Hudson RJ, Bergstrom RG, Thomson IR, *et al.* Pharmacokinetics of sufentanil in patients undergoing abdominal aortic surgery. Anesthesiology 1989; 70:426-31.
6. Hudson RJ, Thomson IR, Burgess PM, Rosenbloom M. Alfentanil pharmacokinetics in patients undergoing abdominal aortic surgery. Can J Anaesth 1991; in press.
7. Greenblatt DJ, Locniskar A, Ochs HR, Lauven PM. Automated gas chromatography for studies of midazolam pharmacokinetics. Anesthesiology 1981; 55:176-9.
8. Gibaldi M, Perrier D: Pharmacokinetics (2nd edition). New York, Marcel Dekker, 1982, pp 45-112.
9. Boxembaum HG, Reigelman S, Elashoff RM: Statistical estimations in pharmacokinetics. J Pharmacokinet Biopharm 1974; 2:123-48.
10. Reves JG, Fragen RJ, Vinik HR, Greenblatt DJ. Midazolam: Pharmacology and uses. Anesthesiology 1985; 62:310-24.

EFFECT OF ORAL CLONIDINE ON KETAMINE INDUCTION OF ANAESTHESIA IN HUMANS

G. J. Doak MD FRCP(C), P. C. Duke FRCP(C)
Department of Anaesthesia, University of Manitoba, Winnipeg, Manitoba

INTRODUCTION: Clonidine (C) has been shown to interact favorably with a number of anaesthetic regimes by reducing anaesthetic requirements and reducing hemodynamic variability (1,2). This study compares the hemodynamic characteristics of induction of anaesthesia with ketamine (K) in healthy patients orally premedicated with either (C) 0.005 mg/kg, diazepam (D) 0.15 mg/kg, or a placebo (P).

METHODS: Institutional ethical approval and patient consent was obtained in 42 patient volunteers (ASA 1 or 2), age range 18-45 yrs. Ninety minutes prior to surgery, patients received the premedication, either C, D, or P, in a randomized, double-blinded fashion. Prior to induction, phasic and mean blood pressure (MBP) was measured non-invasively using the Finapres finger plethysmograph and heart rate (HR) determined from the EKG. Anaesthesia was induced with a K infusion of 1.0 mg/kg/min until loss of conciousness. No patient received more than 3.0 mg/kg of K. Following tracheal intubation, all patients were maintained on N2O/O2 (2:1). Isoflurane was added after the first 3 minutes only if indicated to control hypertension and/or depth of anaesthesia.

Hemodynamic measurements were obtained prior to the premedication (PREOP), on arrival to the operating room (T0), prior to induction (T1), at 1 min post induction (T2), and at 1, 3, 5, and 7 min post intubation (T3-6, respectively). Final values were obtained upon discharge from the recovery room (PARR).

Data were analyzed using ANOVA for repeated measures to detect differences between groups at each time. Bonnferoni's correction was used to compensate for multiple comparisons.

RESULTS: There were no differences in demographic data among the groups (Chi-square test). Figures 1 and 2 show the changes in HR and MBP in each group for the various study times. Because there were no differences among the groups prior to receiving the study drug (PREOP), this was taken as baseline to which other values were compared (Table). Increases in HR and MBP that are usually seen in patients given ketamine were significantly less in those patients given C preoperatively vs D or P (eg. T3).

DISCUSSION: The attenuation of the hyperdynamic effects of intravenous K by C premedication may be secondary to the general sedating effect of C. Alternatively, this may represent physiologic antagonism of K's centrally mediated sympathetic discharge by C, which is known to be inhibitory at the locus cereolus and vasomotor centres of the brain. This attenuation of the hyperdynamic response associated with K anaesthesia may be clinically useful. Newer, more potent alpha-2 adrenergic agonists may be more effective in completely attenuating the K effects.

REFERENCES:

1. Anesth Analg 1982;61:741-5
2. Anesthesiology 1986;64:36-42

TABLE PREOP HR and MBP (mean +/- SD)

	C	D	P
MBP mmhg	88.4 +/-11.5	87.9 +/-9.2	88.1 +/-8.4
HR bpm	69.3 +/-6.7	69.6 +/-10.8	70.3 +/-10.6

FIGURE 1. Heart rate changes expressed as a per cent change from baseline (PREOP).

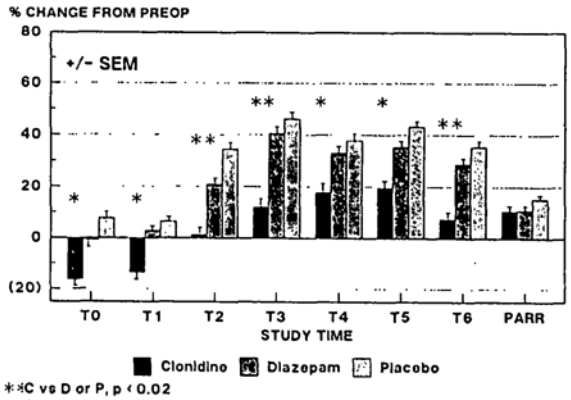
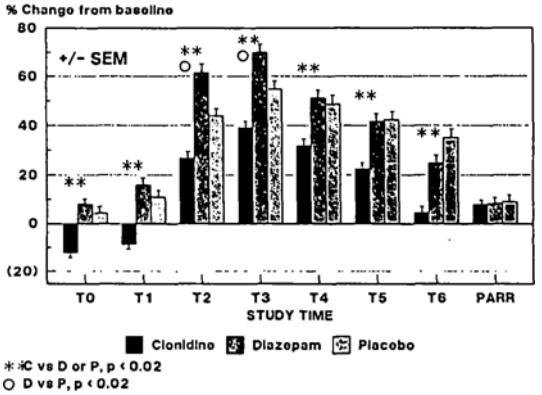


FIGURE 2. Mean blood pressure expressed as a per cent change from baseline (PREOP).



MORPHINE PHARMACOKINETICS: DISPOSITION IN SHEEP TISSUES AT STEADY-STATE.

PA Sloan MD, LE Mather PhD, CF McLean DChem, AJ Rutten BSc, RL Nation PhD, RW Milne BSc, WB Runciman MD, AA Somoggi PhD.
Department of Anaesthesia, Flinders Medical Centre, Adelaide, Australia.

INTRODUCTION

The physiological disposition of morphine is poorly understood, despite its long history and widespread clinical use. The partitioning of morphine into body tissues is incompletely understood, with most studies using a bolus morphine dose experimental design. The aim of this study was to determine the disposition of morphine in sheep tissues under steady-state conditions.

METHODS

Approval was given by the institutional Ethics Review Committee for this study to be performed in sheep previously prepared with chronic intravascular catheters to enable drug infusion, cardiovascular monitoring and regional blood sampling for morphine and blood flow indicator analyses [1]. Four studies were completed using four sheep. Morphine sulfate was given as a two-stage intravenous infusion into a right atrial catheter in each conscious, unrestrained sheep. Loading doses of 8 times the maintenance dose rate infused for 15 minutes, and maintenance doses of 2.5, 5.0, 10.0 or 20.0 mg/hr for 345 minutes were given.

During the last 60 minutes of the maintenance infusion, the steady-state period, 5 arterial blood samples at 15-minute intervals were obtained. Upon completion of blood sampling period, the animal was anaesthetized with a right atrial bolus of propofol (200 mg) and immediately sacrificed with KCl solution at which time the morphine infusion was stopped. Tissue samples were then obtained within 10 minutes from the whole brain, lung, left ventricle, liver, small bowel, kidney, hindquarter muscle and fat for morphine analysis.

Blood and tissue samples were stored at -20°C until batch assay to determine morphine concentrations by high performance liquid chromatography (HPLC). The calculated morphine partition coefficient kp = C_T/C_B, where C_T and C_B are the morphine concentrations in tissue and blood respectively, were determined at steady-state. For tissues in which clearance occurred, the partition coefficient was determined as kp = $(1 + Cl_T/Q_T) \cdot C_T/C_B$, where Cl_T is the tissue clearance, and Q_T is the tissue blood flow [2]. The linearity of regional morphine kinetics was examined using repeated measures of analysis of variance, by partitioning of treatment effects into trend components.

RESULTS

Tissue morphine concentrations and the calculated tissue:blood partition coefficients for the four morphine infusion rates are given in the Table. The mean ± SD partition coefficients were lung 6.0 (± 2.5), brain 2.1 (± 0.9), heart 2.2 (± 0.4), liver 9.0 (± 6.1), small bowel 20.0 (± 2.4), kidney 4.0 (± 1.6), hindquarter muscle 2.8 (± 0.8), and hindquarter fat 0.2 (± 0.1). There was no evidence of dose dependent tissue:blood partitioning of morphine in any region.

DISCUSSION

The calculated tissue:blood morphine partition coefficients were high in all tissues except hindquarter fat. The low kp in fat is consistant with the poor lipid solubility of morphine. The mean brain:blood kp of 2.1 is higher than has been found in humans [3], dogs and rats, which may be due to species' differences and experimental design. The partition coefficients in the sheep given 10 mg/h maintenance morphine infusion were consistently the lowest values among sheep in all tissues, suggesting inter-individual variation in tissue binding contributes to inter-individual pharmacokinetic differences. Since there was no evidence of dose-dependent tissue:blood partitioning, blood morphine concentration at steady-state will, in general, reflect the morphine tissue concentration.

REFERENCES

1. Br J Anaesth 56: 1015, 1984.
2. J Pharmaco Biopharm 11: 147, 1983.
3. J Anal Tox 1: 166, 1977.

TABLE 1

Arterial Blood and Tissue Morphine Concentrations at Steady-State (the calculated tissue:blood partition coefficients are given in parenthesis)

Sample	Morphine Sulfate Maintenance Infusion Rate (Mg/h)			
	2.5	5.0	10.0	20.0
	(ng/ml blood or ng/g tissue as morphine base)			
Arterial blood	31	19	93	169
Lung	191 (6.2)	169 (8.9)	260 (2.8)	1066 (6.3)
Brain	48 (1.6)	62 (3.2)	113 (1.2)	447 (2.6)
Heart	65 (2.0)	69 (2.6)	138 (1.5)	554 (2.6)
Liver	189 (11.5)	186 (15.4)	38 (1.0)	844 (8.2)
Gut (small bowel)	320 (10.4)	219 (11.5)	188 (2.0)	9471 (55.9)
Kidney	73 (4.0)	83 (6.1)	126 (2.3)	387 (3.5)
Hindquarter muscle	92 (3.0)	64 (3.4)	145 (1.6)	562 (3.3)
Hindquarter fat	5 (0.2)	5 (0.3)	14 (0.2)	17 (0.1)

The Bioavailability and Absorption Rate of Transdermal Fentanyl

Pierre Fiset, M.D., Carol Haack, R.N., Steven L. Shafer, M.D.
Department of Anesthesia, Stanford University Medical Center, Stanford California
and Anesthesiology Service, Palo Alto VA Medical Center, Palo Alto, California

Introduction: This study was designed to determine the bioavailability and absorption rate of a new fentanyl transdermal delivery system (TDS, Anaquest, protocol #32,828-10).

Methods: After approval from Stanford University IRB and informed consent, we studied four patients, ASA I-III undergoing a variety of surgical procedures. Prior to induction of anesthesia, the patients received an infusion of fentanyl, 150 μg/min for 5 min. On the first postoperative day (24 hrs after iv fentanyl administration), a TDS was placed on the anterior chest for 24 hrs.

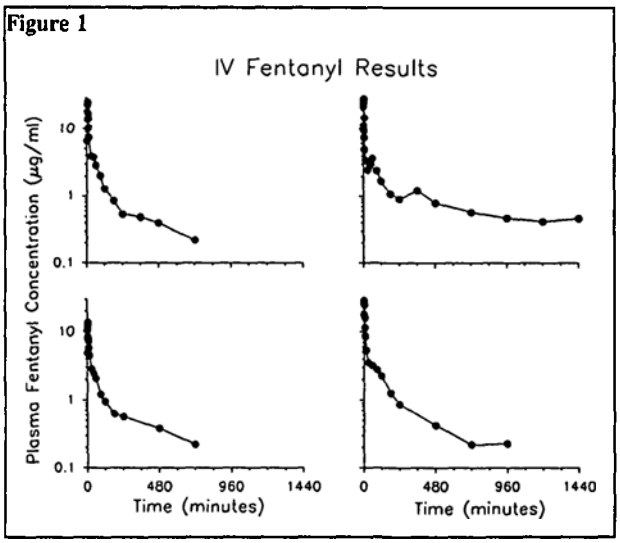
Following iv fentanyl administration, blood samples were taken at 1, 2, 3, 4, 5, 6, 7, 8, 10, 15, 30, 45, 60 min, and at 1.5, 2, 3, 4, 6, 8, 12, 18, and 24 h. Following TDS application, blood samples were taken at 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 30, 36, 48, 60 and 72 h. Fentanyl concentrations were determined by RIA (quantitation limit = 0.2 ng/ml, ± 5% CV). The residual TDS fentanyl content was assayed to determine bioavailability.

The area under the plasma concentration vs time curve following iv administration (AUC_{iv}) was calculated from the observed concentrations and the extrapolated terminal slope. Clearance (Cl_{iv}) was calculated as dose/AUC_{iv}.

The area under the plasma concentration vs time curve following TDS application (AUC_{TDS}) was calculated from the observed concentrations and the extrapolated terminal slope. The total dose administered by the TDS was calculated as the AUC_{TDS} times CL_{iv}. The bioavailability was calculated as the dose administered by the TDS/(initial TDS fentanyl - residual TDS fentanyl).

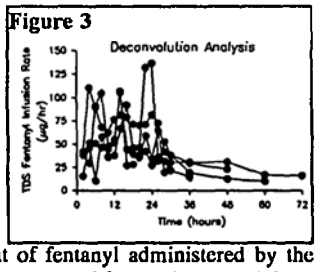
The disposition function was calculated for each patient by constrained numerical deconvolution of the observed fentanyl concentrations following iv administration against the iv fentanyl infusion rate. The rate of absorption from the TDS was then calculated by constrained numerical deconvolution of the observed fentanyl concentrations following TDS application against the calculated disposition function.

Figure 1



Results: Figures 1 and 2 below show the observed plasma concentrations following iv and TDS fentanyl administration. The clearance, TDS fentanyl delivered, fentanyl depleted from the TDS (determined by residual analysis) and bioavailability are shown in table 1. The average amount of fentanyl administered by the TDS was 2.3 mg. The average amount of fentanyl depleted from the TDS over the 24 h period was 5.4 mg. The average apparent bioavailability of the TDS fentanyl was 46%. Figure 3 above shows the rate of absorption over time from the TDS, as determined by numerical deconvolution.

Figure 3



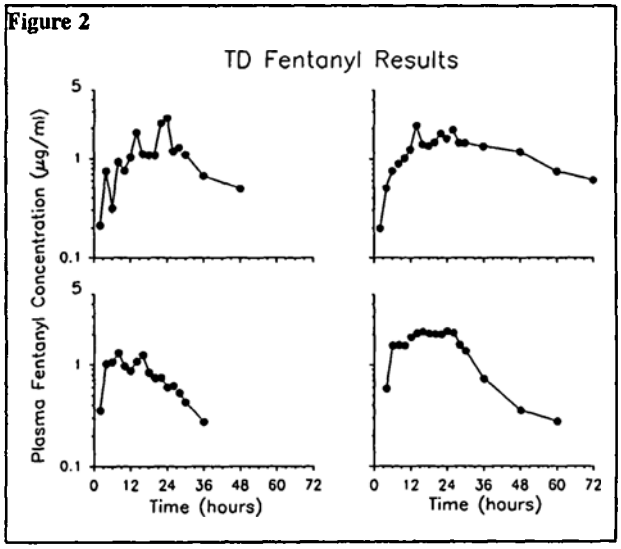
Discussion: The TDS system was intended to maintain plasma fentanyl concentrations of 1.5 to 3.0 ng/ml for the period from 12 to 24 hours. The anticipated peak rate of fentanyl delivery was approximately 100 μg/h. These goals have apparently been met, although the variability is fairly high. Although the rate of absorption determined by numeric deconvolution varies widely over time, numeric deconvolution techniques can magnify apparent variability, and further patients will need to be studied to determine if this fluctuating absorption is a real phenomona or an artifact of the analysis. The apparent bioavailability of 46% is less than previously reported for a different transdermal fentanyl device.[1]

Table 1

Patient:	1	2	3	4
Clearance (l/m)	49.4	20.7	44.0	39.9
TDS fent delivered (mg)	2.7	2.4	1.3	2.7
Initial - residual TDS fent (mg)	3.5	6.7	4.5	6.8
Bioavailability (%)	77	36	29	40

Reference: 1. Anesthesiology 70:928-934, 1989

Figure 2



EFFECT OF NITROUS OXIDE ON IMPAIRED WOUND HEALING IN MICE

Craig L. Irish, Louis Weisleider, C. David Mazer, Robert S. Bell
Depts. of Anaesthesia and Orthopedic Surgery, St. Michael's Hospital, University of Toronto, Toronto, Canada M5B 1W8

INTRODUCTION: Prolonged exposure to nitrous oxide may have a deleterious effect on wound healing by the oxidation of vitamin B12 and subsequent inhibition of methionine synthase.[1] Previous investigations of normal wound healing have failed to confirm this hypothesis.[2] In this study, we examined the effects of nitrous oxide on wound healing in a murine model of impaired wound healing.

METHODS: Ninety female Swiss-Webster mice were randomized to receive 0, 15, or 20 Gy radiation to the left leg in single fractions. Each of these groups was further randomized to receive exposure to nitrous oxide:oxygen (70:30) or air:oxygen (FiO_2 0.30). Sixty days after radiation the mice underwent a standardized surgical incision and removal of subcutaneous tissue from the previously radiated left thigh under isoflurane (1.5-2.0%) anesthesia. The surgery was preceded by a one hour exposure in a controlled environmental chamber to the respective gas mixtures (nitrous oxide or no nitrous oxide), and was followed by a further 3 hour exposure. Postoperatively, the mice were further exposed to either nitrous oxide:oxygen or air:oxygen for 1 hour each day. The clinical appearance of the surgical wound was assessed 3 times weekly using the Wound Integrity Index (WII), with 0 being the best and 20 the worst healing. On the 14th post-op day the animals were sacrificed and the wounds were harvested and analyzed for tensile strength using a materials testing machine. The tensile strength measurements were normalized for wound cross sectional area. The early skin response (ESR) was used to clinically assess the effects of radiation on the skin prior to surgery, with 0 being no skin abnormality. After the surgical wounds were harvested, the liver and brain were frozen for later analysis of methionine synthase activity using methods previously described.[3] Statistical analysis was performed using ANOVA.

RESULTS: Animals receiving the highest dose of pre-operative radiation had the greatest skin response (peak ESR) prior to surgery and had the highest peak clinical scoring (peak WII) of poor wound healing (Table 1). Methionine synthase activity was significantly lower in both the liver and the brain of animals exposed to nitrous oxide (Table 2). However, there was no significant difference in tensile strength or in peak WII in animals who received nitrous oxide ($+N_2O$) compared to those that did not ($-N_2O$).

DISCUSSION: Exposure to nitrous oxide in both animals and humans has been shown to inhibit methionine synthase activity, and thus interfere with DNA and protein synthesis because of impaired folate metabolism. Despite the inhibition of methionine synthase activity seen in this model, nitrous oxide did not impair wound healing. Whether nitrous oxide affects wound healing in humans remains to be determined.

REFERENCES:

1. Br. J. Anaesth. 59:3-13, 1987.
2. Anesth. Analg. 57:527-533, 1978.
3. Anesthesiology 54:318-324, 1981.

TABLE I

Radiation (Gy)	n		Wound Strength (kPa)		Peak WII		Peak ESR	
	$-N_2O$	$+N_2O$	$-N_2O$	$+N_2O$	$-N_2O$	$+N_2O$	$-N_2O$	$+N_2O$
0	10	12	1093±495	950±282	9.5±2.4	8.8±3.7	0.2±0.1	0.2±0.1
15	13	11	1178±545	1347±423	10.4±4.1	10.9±4.5	1.3±0.4†	1.4±0.4†
20	12	11	1079±325	1003±453	11.5±3.5	11.3±4.5	2.2±0.7†	2.4±0.6†

* $p < 0.05$ different from N_2O compared to no N_2O values = mean ± sd
ESR: early skin response using method of Douglas and Fowler
WII: wound integrity index: (higher score implies poor wound healing)
† $p < 0.05$ compared to 0 radiation

TABLE II - METHIONINE SYNTHASE ACTIVITY ($nmoles.hr^{-1}.g^{-1}$)

Radiation (Gy)	Brain		Liver	
	$-N_2O$	$+N_2O$	$-N_2O$	$+N_2O$
0	127±20.0	79.3±10.5 *	194±16	119±28 *
15	138±19.9	83.9± 9.1 *	160±18	124±15 *
20	141±18.1	88.5±11.0 *	181±16	123±23 *

* $p < 0.05$ significantly different from no N_2O values = mean ± sd

COMPARISON BETWEEN ON DEMAND AND PREVENTIVE BUPRENORPHINE AFTER ABDOMINAL SURGERY

M. Dejonckheere MD, M. Levarlet MD, A. d'Hollander MD, PhD.
Department of Anaesthesiology, Hopital Erasme, Free University of Brussels (ULB), Route de Lennik 808, 1070 Brussels, Belgium.

INTRODUCTION.

In this double blind study we compared the efficacy of IM buprenorphine (BUP) when administered either before pain at the end of surgery (group B) or to treat established pain (group P) after abdominal surgery.

MATERIAL AND METHODS.

Following approval from our local ethic committee and written informed consent, 60 patients scheduled for major abdominal surgery were included in this study and divided in two groups.
After premedication with diazepam, anaesthesia was induced with thiopentone, 3 to 5 mg/Kg and maintained with isoflurane in oxygen and nitrous oxide. No opioid was given. Atracurium was given before tracheal intubation and for muscle relaxation during surgery. During skin closure, all the patients received a first injection in the deltoid muscle: group B patients were given 0.3 mg of BUP while group P patients were given saline . Residual muscle relaxation was antagonized with neostigmine and atropine. Patients were then ventilated with 100% oxygen , extubated and transferred to the recovery room. Pain was assessed every hour by patient response using a numerical pain rating scale (0=no pain; 10=excruciating pain) (1). Whenever the patients of both groups requested , they were given 0.3 mg of BUP IM (second injection). The study was completed when the patients required a third injection (BUP 0.3 mg).
Numerical pain scores were summarized using Area Under the Curve (AUC) (O-tn); average AUC per hour and duration of action, as measured by the time period between successive injections, were compared between treatment regimes using one way analysis of variance. Overall impression of the treatment (recorded at the end of the study period by the nurse, physician and patient) was rated on a scale ranging from 1 to 5 (1=very poor; 5= very good) and analyzed using a Wilcoxon two-sample test.
A p value less than 0.05 was considered statistically significant.

RESULTS.

The interval between first and second injection was significantly ($p<0.001$) longer in group B (5h18 vs 1h03). AUC/h was significantly ($p<0.01$) lower following first injection in group B. These results were expected since it is a direct comparison between active and placebo medication.
There was no statistically significant difference in duration of action (5h18 vs 4h34) and in AUC/h following BUP given either at wound closure (group B; first injection) or on first demand (group P; second injection).
The interval between second and third injection was significantly ($p>0.01$) longer in group B than in group P (6h50 vs 4h34). Although in this case the medication used for the second injection was the same in both groups (i.e. 0.3 mg IM BUP), patients in group B would have low plasmatic levels of BUP from the first dose and this would probably have an additive effect with the drug from the second dose.
Overall impression scores recorded at the end of the study were significantly better for group B than for group P ($p<0,05$) when rated by the physician (4.00 vs 3.00) and the nurse (4.23 vs 3.17) but not by the patient (4.03 vs 3.40).
Time from first injection to extubation and respiratory rates on arrival in the recovery room were not statistically different in group B and P. No respiratory rate below 12/min was noted at any time in any group.

DISCUSSION.

The duration of action and the efficacy of intramuscular buprenorphine was found to be no different if administered at wound closure (before pain) or on first postoperative demand (to treat established pain). However, overall impression of postoperative analgesia was better when a first dose of buprenorphine was given preventively.
Moreover, buprenorphine given at wound closure does not delay extubation following isoflurane anaesthesia.

References

1. Anesthesiology 70:742-746,1989

Minimum Alveolar Concentration of Desflurane and Hemodynamic Responses in Infants and Children

Dept of Anaesthesia and Research Institute, The Hospital for Sick Children, University of Toronto, Toronto, J. Lerman MD, FRCPC, RH Taylor MB, FFARCS, N. Sikich RN.

INTRODUCTION: Desflurane (I-653) is a new methyl ethyl ether anaesthetic similar in structure to isoflurane except for the substitution of fluoride for chloride on the alpha carbon. This single substitution confers physical chemical properties that differ from other inhalational anaesthetics including a low blood/gas solubility (0.42), low tissue/blood solubilities and a low boiling point (25°C). These properties, together with its mild pungent odour suggest that desflurane may have an important role in pediatric anaesthesia. Therefore, we measured the minimum alveolar concentration (MAC) of desflurane and the hemodynamic responses in infants and children.

METHODS: With approval from the hospital Ethics committee, informed written consent was obtained from the parents of 72 ASA P/S 1 or 2, unpremedicated neonates, infants and children scheduled for minor surgery. The patients were divided into six groups according to age (n=12/group): neonates, 1-6 months, 6-12 months, 1-3, 3-5, and 5-12 years. Anaesthesia was induced with desflurane and oxygen (neonates were intubated awake) and the trachea was intubated without a muscle relaxant. Anticholinergics were not administered. Anaesthesia was maintained at a predetermined end-tidal concentration of desflurane in oxygen (and air for neonates) for at least 10 minutes before skin incision. The concentration of desflurane administered was based on the move/no move response of the previous patient in that age group. All patients were supine, horizontal during the period of equilibration. MAC was determined using the "up and down technique" described previously by Dixon.[1] Heart rate and systolic arterial pressure were measured: awake; before incision at ≈1 MAC; at the peak responses after incision at ≈1 MAC. Data were analyzed by one-way or repeated-measures ANOVA, and the Newman-Keuls test. Statistical significance of $p < 0.05$ was accepted.

RESULTS: We found that the MAC of desflurane in the six age groups varied with age: it increased as age decreased reaching a zenith in infants 6-12 months of age (9.92 ± 0.44%) and decreased thereafter (Figure 1--MAC data for adults was obtained from Rampil et al[2]). Heart rate decreased 16% before skin incision in infants 6-12 months of age and children 1-3 and 3-5 years ($p < 0.05$) but did not change significantly in neonates, infants 1-6 months and children 5-12 years. Systolic arterial pressure decreased significantly in all groups before incision ($p < 0.05$) (Figure 2). The overall incidence of hypotension (>30% decrease in systolic arterial pressure before incision) was 38%.

DISCUSSION: While the relationship between age and the MAC of desflurane in infants and children is similar to that reported previously for halothane and isoflurane,[3,4] it differs from previous data in two specific respects. First, the MAC of desflurane in neonates is only 8% less than that in older infants whereas for halothane the difference is 27% and for isoflurane it is 17%.

These differences between the MAC in neonates and the peak MAC in infancy may be explained by differences in the oil/gas solubility of these anaesthetics. Second, the MAC in infancy reaches a zenith in older infants 6-12 months of age whereas that for halothane and isoflurane occurs in infants 1-6 months. We cannot explain why the peak MAC in infancy with desflurane occurs in older infants. We conclude that the MAC of desflurane depends on age in infants and children and that at ≈1 MAC, heart rate and systolic arterial pressure are maintained in all age groups to a similar extent as other inhalational anaesthetics.

ACKNOWLEDGEMENT: This study was supported in part with a grant from Anaquest BOC, Inc.

REFERENCES:

1. Dixon WJ. Statistics in Endocrinology, MIT Press, 1970, pp 251-267
2. Rampil IJ, Lockhart SH, Zwass MS, Eger EI II. Anesth Analg 70:S319, 1990
3. Lerman J, Robinson S, Willis MM, Gregory GA. Anesthesiology 59:421-424, 1983
4. Cameron CB, Robinson S, Gregory GA. Anesth Analg 63:418-420, 1984

Figure 1

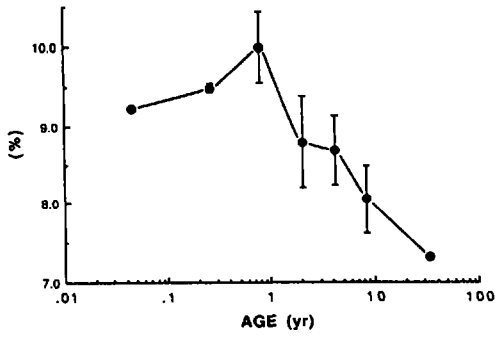
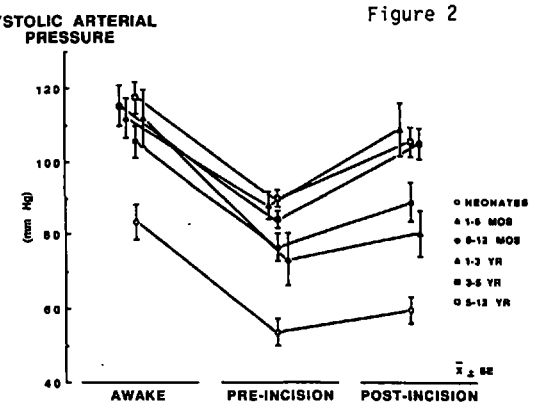


Figure 2



NON-INVASIVE MONITORING OF END-TIDAL CO_2 IN INFANTS AND CHILDREN IN THE RECOVERY ROOM

F. Campbell MD, M.E. McLeod MD, B. Bissonnette MD, J. Swartz MD.

The Hospital for Sick Children, University of Toronto, Toronto, Ontario.

Introduction

End-tidal CO_2 ($PetCO_2$) monitoring has become a standard of care for intubated anaesthetized patients. Techniques for monitoring $PetCO_2$ in non-intubated adults have also been described.[1] This study was undertaken to determine the usefulness of post-operative $PetCO_2$ measurements in non-intubated infants and children.

Methods

After approval from the Human Studies Review Committee, 21 infants and children were studied in the recovery room. Patients were divided into two groups according to weight: group I <12 kg and group II ≥12 kg.[2] Arterial cannulae were inserted intraoperatively for clinical indications. Patients with respiratory disease or right-to-left cardiac shunts were excluded. In the recovery room, all patients received supplementary oxygen (O_2) by face mask or hood. A 16 gauge intravenous cannula was taped just below an external naris and connected to the aspirating catheter of a Puritan-Bennett Datex oximeter/capnometer (model 255) and 2 channel chart recorder (model DR 103). $PetCO_2$ and O_2 saturation (SaO_2) were measured continuously during the study. If a plateau was not observed in the $PetCO_2$ waveform, the O_2 flow was gradually reduced until a plateau appeared, or a minimum flow of 2 $l.min^{-1}$ was reached. After a stable recording was achieved, $PetCO_2$ and arterial CO_2 ($PaCO_2$), respiratory rate, fresh gas flow and SaO_2 were recorded. The arterial to end-tidal difference ($P(a\text{-}et)CO_2$) was calculated. Values are reported as mean ± SD. Analysis was by linear regression and unpaired t-test.

Results

The ages, weights, respiratory rates and fresh gas flows were significantly different between the groups. There were no significant differences in SaO_2, $PaCO_2$, $PetCO_2$ or $P(a\text{-}et)CO_2$ between the groups. The coefficient of determination, r^2, for the linear regression between $PetCO_2$ and $PaCO_2$ for group I was 0.64 (figure 1) and for group II was 0.59 (figure 2). The difference between r^2 for the 2 groups was significant ($p<0.05$). There were no complications as a result of the study. One patient could not be included because of nasal obstruction.

Discussion

The $PetCO_2$ correlated well with the $PaCO_2$ in both groups, and this agrees with previous studies in intubated patients.[3] The increased accuracy with this technique in group I may be attributed in part to the lower fresh gas flows and to infants being obligate nose breathers. This method of end-tidal gas sampling provides a non-invasive continuous monitor of ventilation and a good estimate of $PaCO_2$ in infants and children. In addition to post-operative monitoring of ventilation, this technique may prove useful during conscious sedation, and neurolept and regional anaesthesia.

References

1. Anesth. 67: 606, 1987.
2. Anesth Analg 66: 959-64, 1987.
3. Anesth. 69: 112-6, 1988.

Table

	Group I (< 12 kg)	Group II (≥ 12 kg)
No. of patients	9	12
Age (months)	15.8±12.6**	83.1±25.9
Weight (kg^{-1})	9.1±2.6**	25.3±8.2
Resp. rate (min^{-1})	35.7±10.0*	24.6±7.0
FGF ($l.min^{-1}$)	4.0±0.9*	6.2±2.0
O_2 saturation	99.3±0.7	99.0±0.8
$PaCO_2$ (mmHg)	41.1±4.5	40.2±4.7
$PetCO_2$ (mmHg)	39.4±3.6	40.3±4.6
$P(a\text{-}et)CO_2$	2.4±1.9	2.7±1.8

Data expressed as mean ± SD
* $p < 0.05$ compared to group 2
** $p < 0.001$ compared to group 2

We acknowledge the Puritan Bennett Corporation for their support of this study.

Figure 1. Group I (<12kg)

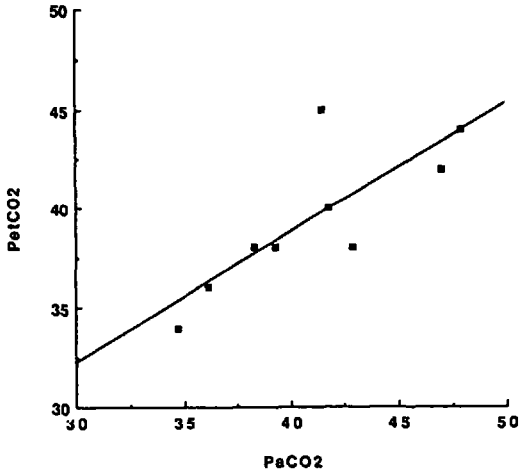
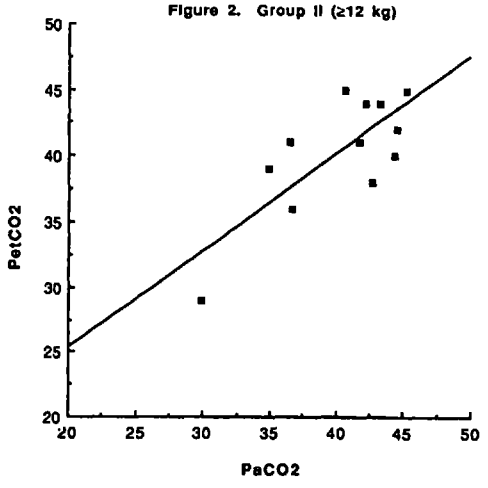


Figure 2. Group II (≥12 kg)



UTILITÉ DE L'ANALYSE URINAIRE PRÉ-OPÉRATOIRE EN CHIRURGIE PÉDIATRIQUE AMBULATOIRE

I Spahr-Schopfer, MD; S Kemp, MD; BG McIntyre; MD; WL Roy, MD
Department of Anaesthesia, The Hospital for Sick Children and University of Toronto, Toronto, Ontario

Introduction: L'analyse des urines a longtemps été considérée comme un point important du bilan pré-opératoire[1,2]. Divers hôpitaux requièrent une analyse urinaire à l'admission[3] et certaines lois provinciales[4] exigent que les résultats de l'analyse urinaire pré-opératoire figurent dans le dossier du patient avant toute anesthésie. Cette étude a pour but de déterminer la valeur de cet examen de routine notamment pour la protéinurie et la glycosurie, et d'établir comment ces résultats influencent la conduite de l'anesthésie et de l'intervention chirurgicale dans une unité de chirurgie ambulatoire.

Méthode: Après approbation de l'institution, nous avons évalué 2021 patients classés ASA I et II et âgés de 1 mois à 19 ans, qui se sont présenté entre le 1er janvier et le 31 mai 1990 dans notre unité de soins ambulatoire en vue d'une intervention mineure. Les patients entrant avec des résultats d'analyse urinaire obtenus dans un laboratoire extérieur, ainsi que ceux n'ayant pas fourni un échantillon analysable ont également été inclus dans l'étude; ceci afin d'étudier la prise en charge clinique de ces patients. Seuls les résultats positifs de protéinurie [i.e., ≥ 0.3,1(1+), 3(2+), ≥ 20(3+) g/L] et de glycosurie [14(1+), 28(2+), 56(3+) mmol/L] ont été pris en considération. Les résultats "trace" ont été considérés comme normaux. Les dossiers des patients avec un résultat d'analyse urinaire pathologique ont été revus ultérieurement afin de mettre en évidence l'attitude prise (renvoi éventuel) et l'évolution per- et post-opératoire. Les anesthésistes de cette unité n'étaient pas au courant de l'étude en cours.

Résultats: 2021 patients ont été inclus dans l'étude, dont 1184(58.6%) mâles et 837(41.4%) femelles. L'âge moyen est de 5.6 ans (SD=4.3) avec des extrêmes de 01 à 18.9 ans. Sur les 2021 patients étudiés, 334 n'ont pas fourni d'échantillon d'urine, et cependant l'anesthésie et l'intervention n'ont pas été repoussées. Des résultats négatifs de protéinurie et de glycosurie ont été relevés chez 1669 (98.9 %) et 1680 (99.6 %) enfants, respectivement. 18 analyses(1.07%) ont montrés une protéinurie (0.3 g/L-3+), et 7(0.4%) une glycosurie (1+ à 3+). Tous ces patients avec des résultats positifs ont été anesthésiés et opérés sans complication.

Discussion: La valeur de l'analyse d'urine de routine dans le bilan pré-opératoire a récemment été remise en question[2,3], ceci également chez les patients d'âge pédiatrique[3,6]. Certaines études ont montré que, même en présence de résultats d'analyse urinaire pathologiques, la conduite de l'anesthésie n'est pas modifiée. Nos résultats sont similaires à ceux obtenus lors de précédentes études de patients ambulatoires[3]. L'information de résultats anormaux n'entraîne que rarement un changement d'attitude. En effet, aucun des patients ayant un résultat positif n'a été récusé. De plus, ils ont subi l'anesthésie et l'intervention sans complication. Les résultats anormaux ont été soit considérés comme non significatifs, soit ont même échappé à notre attention; de même, ces valeurs pathologiques ne sont pas investiguées par la suite (hormis un seul cas dans notre série). La valeur de cette analyse urinaire pré-opératoire est de plus affaiblie par le fait qu'un grand nombre de patients n'a pas fourni un échantillon d'urine adéquat. Aucun effort supplémentaire n'a été fait pour l'obtention d'urine, et néanmoins tous les patients ont été endormis. Bien que le coût de l'analyse urinaire soit modeste($6.00), les inconvénients liés à la prise de l'échantillon et l'enregistrement des résultats sont des dépenses non chiffrées. En conclusion, nous pensons que les patients d'âge pédiatrique en bonne santé, pour lesquels une intervention chirurgicale mineure est prévue, ne nécessitent pas d'analyse urinaire pré-opératoire de routine. Nous proposons qu'une telle analyse soit demandée sélectivement afin d'augmenter son efficacité.

References:

1- Steward, Manual of Pediatric Anesthesia, Churchill Livingstone, 1985.
2- Arch. Intern. Med. 1988; 148:1370.
3- Pediatrics. 1990; 86(3):345.
4- Lois refondues de l'Ontario 1980, Sept 1988, Ministère du Procureur General.
5- Postgraduate Medical Journal., 1986. 62:925
6- Anesth Analg. 1990; 70:176.
7- Personal communication. (Laboratory Services, The Hospital for Sick Children, Toronto).

EEG BURST SUPPRESSION AND HAEMODYNAMIC EFFECTS WITH PROPOFOL DURING CARDIOPULMONARY BYPASS IN CHILDREN.

GJA Laycock FFARCS, IM Mitchell FRCS, NS Morton FFARCS, RW Logan FRCP(GLAS).
ROYAL HOSPITAL FOR SICK CHILDREN, GLASGOW, SCOTLAND.

INTRODUCTION

EEG suppression with thiopentone during cardiopulmonary bypass (CPB) has been associated with a reduction in the incidence of post bypass neurological damage [1]. Because of its prolonged elimination half life leading to cardiovascular depression and delayed extubation, thiopentone may not be the most suitable agent for cerebral protection. Propofol has a short half life and when given by infusion, has been shown to suppress the EEG during CPB in adults [2]. In an animal model propofol improved recovery after cerebral ischaemia [3]. The aim of this study was to establish the infusion rates and blood concentrations of propofol required to maintain burst suppression throughout CPB in children and to monitor the resultant haemodynamic effects and recovery times.

METHODS

The study was approved by the hospital ethics committee and informed consent was obtained from the parents of twenty children undergoing elective open heart surgery (excluding complex cyanotic abnormalities and age<1). Anaesthesia was standardised, based on fentanyl 50 ug/kg and enflurane before bypass, and midazolam 0.1 mg/kg at the onset of CPB. On a random basis half the patients also received propofol during CPB. Phenoxybenzamine was given at the discretion of the anaesthetist prior to CPB. Moderate hypothermia (25-28C), non-pulsatile perfusion and pH stat acid-base management were employed. Pump flows were 2.4 l/min/m2 reducing to 1.2-1.6 l/min/m2 during stable hypothermia. The EEG was continuously monitored throughout CPB using a cerebral function analysing monitor (CFAM). In the propofol group, a bolus of 3 mg/kg at the start of CPB was immediately followed by an infusion adjusted to maintain burst suppression and continued to the end of CPB. A further supplemental bolus of propofol 1.5 mg/kg was given at the start of rewarming. Infusion rates and mean arterial pressure were noted at specific stages during CPB and blood samples were aspirated from the venous port of the oxygenator. Data were analysed using Students t tests and analysis of variance for repeated measures as appropriate. A significance level of 5% was used.

RESULTS

There were no significant differences between the two groups with respect to age, weight or duration of CPB (table 1). Mean arterial pressures (MAP) were not significantly different between the two groups during CPB (table 2). Phenoxybenzamine was given to 7 patients in each group.It did not significantly affect MAP in either group overall,however of those **not** receiving phenoxybezamine, the propofol group had higher MAP when "warm" than the controls ($P<0.05$). This result may be spurious due to the small numbers in these sub-groups. 5 children in the control and 6 children in the propofol group received dopamine when coming off CPB. 2 children in the control group had hypotension in the ITU post operatively and 1 child had right upper lobe collapse, otherwise recovery was uneventful in both groups. There were no significant differences between the two groups in time to awakening, time to extubation, or time to discharge from the ITU.

TABLE 1 [mean(SD)]	CONTROL	PROPOFOL
n	10	10
Age (yrs)	5.9 (4.6)	6.4 (5.6)
Weight (kg)	22.3 (14.8)	23.8 (21.3)
CPB (mins)	50.8 (20.6)	48.6 (11.6)

TABLE 2 [mean(SD)]	COOLING	COLD	WARM
Prop.infusion rate (mg.kg/hr)	17(4.9)	13(5.5)*	30(8.4)**
Venous propofol conc. (ug/ml)		3.75(1.2)	8.44(2.7)**
M.A.P.cont.gp. (mmHg)	27(4.5)	24(3.9)	32(9.0)
M.A.P.prop.gp. (mmHg)	29(3.9)	27(5.8)	39(9.0)

*p<0.05 **p<0.001 (comparison between stages)

DISCUSSION

As with the previous study in adults [2], EEG burst suppression was readily induced minutes after the onset of CPB, and maintained during hypothermia; however in some patients in both studies, burst suppression was difficult to maintain during rewarming despite large increases in the propofol infusion rates. The infusion rates in children were much higher than the adult rates on a weight basis. This may be explained by the increasing volume of the bypass circuit in relation to the child's own blood volume. Also the volume of the central compartment is 50% higher and propofol clearance is 25% higher in children [4]. The blood concentrations of propofol needed to achieve burst suppression in children were higher than those in adults [2], however different sampling sites were used in the two studies. In this study the EEG returned to normal 5-15 minutes after the end of CPB. There was no evidence of significant vasodilation during CPB [5], increased inotrope requirement or prolonged recovery in the propofol group.

REFERENCES

1. Anesthesiology 1986;64:165-70.
2. J.Cardiothoracic Anesthesia (in press).
3. J. Neurosurg. Anesthesiol. 1989;1:284-9.
4. Br.J.Anaesth. (in press).
5. Br.J.Anaesth. 1990;65:184-189.

CAUDAL FENTANYL AND BUPIVACAINE FOR POSTOPERATIVE ANALGESIA IN CHILDREN

F. Campbell FCAnaes, S. M. Yentis FCAnaes, D. Fear FRCPC, B. Bissonnette FRCPC.

Department of Anaesthesia, Hospital for Sick Children, 555 University Ave., Toronto, Ontario M5G 1X8.

Introduction
A single caudal injection of local anaesthetic is a common regional technique in paediatrics.[1] Bupivacaine is most commonly used, but only provides analgesia for up to 6-8 hours.[2] Epidural fentanyl may prolong analgesia provided by bupivacaine in adults[3] and children.[4] Our purpose is to compare the analgesia provided by a fentanyl-bupivacaine mixture with that provided by bupivacaine alone. We also propose to evaluate the safety of this technique, with particular regard to respiratory depression.

Methods
After Human Subjects Review Committee approval, informed consent was obtained from the parents of seven children of ASA physical status I or II, aged 1-10 years and scheduled for lower abdominal surgery. The children were randomly assigned to one of two groups for this double-blind controlled study. No premedication was given. Anaesthesia was induced with thiopentone 5.0 mg.kg^{-1}, atropine 0.02 mg.kg^{-1} and succinylcholine 1.5 mg.kg^{-1}. Following tracheal intubation, the lungs were ventilated with nitrous oxide 66% and halothane 0.5-1.5% in oxygen. A caudal block was performed in all patients, using 1.0 ml.kg^{-1} bupivacaine 0.125% with 1:400,000 epinephrine. In addition, patients received either fentanyl 1.0 µg.kg^{-1} in a volume of 1.0 ml (group BF), or 1.0 ml of sterile water (group B). Patients remained in the recovery room for 6 hours following the caudal injection. Pain was assessed by the Objective-Pain-Discomfort Scale (OPS).[5] Morphine 0.05 mg.kg^{-1} was given postoperatively if the OPS exceeded 6. Narcotic requirements for 24 hours post-operatively were recorded. Respiratory rate, end-tidal CO_2 ($P_{et}CO_2$), oxygen saturation (SaO_2), and the incidence of pruritus, urinary retention, shivering and vomiting were also recorded. Sedation was assessed using a 4 point scale (1=alert, 2=drowsy, 3=asleep but rousable, 4=unrousable). Statistical significance ($p<0.05$) was determined using the unpaired t-test, Fisher exact test and Mann-Whitney U test.

Results
Patient characteristics and number of patients requiring narcotics are shown in the table. Pain scores were lower in group BF, but not significantly different. There was no respiratory depression as defined by a respiratory rate of less than 10/min, or $P_{et}CO_2$ above 50 mmHg. One patient in each group had nausea, and one patient in group B shivered. No pruritus occurred in either group. Sedation scores did not significantly differ between groups.

Discussion
The addition of fentanyl to bupivacaine significantly reduced the requirement for supplementary narcotic analgesics during the first eight hours following administration. Although the requirements in the subsequent 16 hours were also reduced, this is not significant, perhaps due to insufficient sample size. It is too early to comment on the incidence of side effects, which have so far been mild and not required treatment. In particular, respiratory depression has not occurred. Fentanyl is very lipid soluble and is rapidly absorbed into the spinal cord, therefore leaving less drug available to spread rostrally. This should make fentanyl less likely than other opioids to cause respiratory depression.[6]

References
1. Anesth Analg 1989; 68: 645.
2. Anesthesiology 1988; 69: 102.
3. Anesthesiology 1986; 65: 331.
4. Anesthesiology 1989; 71: A1017.
5. Anesthesiology 1988; 69: A770.
6. Can J Anaesth 1989; 36: 165.

Table

	Groups	
	B	BF
No. of patients	4	3
Age (yrs)‡	6.0 ± 5.2	6.9 ± 4.5
Weight (kg)‡	20.3 ± 9.6	25.0 ± 10.5
No. requiring morphine		
1st 8 hours	4	0*
2nd 8 hours	3	1
3rd 8 hours	3	1

‡mean ± SD
*$p<0.05$

DOES THE INDUCTION TECHNIQUE AFFECT RECALL IN CHILDREN UNDERGOING MINOR DAY SURGERY?

L. Halpern, MD, J. Lerman MD FRCPC
Department of Anaesthesia, Hospital for Sick Children, Toronto, Ontario

Introduction: Previous studies have shown that general anaesthesia and surgery do not produce retrograde amnesia for preoperative events in unpremedicated adults.[1,2] In contrast, studies in children have suggested that general anaesthesia and surgery alone may produce retrograde amnesia.[3,4] In the latter studies the induction technique was not controlled. To investigate the influence of the induction technique on amnesia for preoperative events and a picture shown prior to induction, we conducted a prospective, randomized, single-blinded study of recall in children scheduled for minor ambulatory surgery.

Methods: Following institutional approval and informed consent, 64 unpremedicated, fasted children (ASA 1 or 2) scheduled for minor outpatient surgery less than 2 hours in duration were randomized to receive either an intravenous (IV) or inhalational (mask) induction. All inductions were performed by staff anaesthetists. Immediately prior to induction of anaesthesia, an observer assessed the child's level of anxiety on a linear analogue scale. Each child was then shown one of four possible pictures (house, airplane, pencil or light bulb) selected at random and asked to name the picture. The time interval from when the child identified the picture to when the eyelash reflex was lost was recorded. As soon as the picture was identified, anaesthesia was induced by either an inhalational induction that included nitrous oxide (70%) in oxygen for 45 seconds followed by stepwise increases (0.5% every 3 breaths) in the inspired concentration of halothane until 4% or an intravenous induction that included thiopental (5 mg/kg) and atropine (0.02 mg/kg) administered through a #25 gauge butterfly. Anaesthesia was maintained in an identical manner in both groups: halothane and nitrous oxide in oxygen (70%) with muscle relaxants as necessary. The following day the children were interviewed by a nurse who was blinded to the induction technique used. All children were asked to recall the events leading up to their surgery and the picture shown in the operating room. The children were not prompted if they could not recall spontaneously. Parents were then interviewed to confirm what the child had recalled. Thirty-two age matched children who presented to the orthopaedics clinic (controls) were shown one of the same set of pictures and telephoned the next day to determine their incidence of recall. Statistical analysis was performed using the Fisher's Exact test. Statistical significance of $p<0.05$ was accepted .

Results: Age, sex and the duration of surgery were similar in both groups. The incidence of amnesia for the picture in the children who received general anaesthesia (inhalational and intravenous combined) (10/64 (15.6%)) was significantly greater than that in the control group (0/32 (0%); $p<0.05$). Seventeen of the 64 children (26.5%) who received a general anaesthetic had amnesia for the induction technique. This was independent of the method of induction (mask 8/32(25%) vs IV 9/32(28%);p=NS). All children who had amnesia for the induction technique and/or the picture were 8 years of age or less. The incidence of amnesia for the picture in anxious children was nearly twice that of calm children (5/22(22.7%) vs 5/42(12%); p=NS). The incidence of amnesia for the picture in the mask group was more than twice that of the intravenous group (mask 7/32(22%) vs IV 3/32 (9.3%);p=NS). The time from showing of the picture until loss of eyelash reflex in the intravenous group was greater than 19 seconds in all patients and did not correlate with the incidence of amnesia.

Discussion: Amnesia of the immediate preoperative period is desirable for children.[5] The results of this study demonstrate that general anaesthesia alone may produce significant retrograde amnesia for the preoperative period in unpremedicated children undergoing minor ambulatory surgery. While the amnesia for the method of induction is independent of the technique, it may depend on the age of the patient and the level of anxiety immediately before induction. The time interval from registration of the memory trace until initiation of anaesthesia may also be important. This is suggested by the two fold greater amnesia for the picture in the inhalation group. These children received nitrous oxide immediately after naming the picture, whereas the intravenous group did not lose their eyelash reflex for at least 19 seconds. This is consistent with current theories of memory that a shorter duration and decreased consolidation of a memory trace increases the likelihood of amnesia for that trace.[6] We conclude that both the inhalational and intravenous induction lead to a 25% incidence of amnesia in children for the immediate preinduction period.

REFERENCES:
1. Anesthesiology, 71;200, 1989.
2. Anesthesiology, 45:411,1976.
3. Br. J. Anaesth, 58:490, 1986.
4. W.I. Med J., 32:77, 1983.
5. Anasth Analg, 65:936,1986.
6. Psychological Medicine, 14:260,1984.

Table 1. The incidence of amnesia for a picture in children receiving a general anaesthetic (GA) versus a control group.

PATIENT GROUP	AMNESIA	NO AMNESIA
GA	10/64(15.6%)*	54/64(84.4%)
CONTROL	0/32(0%)	32/32(100%)

*$p<0.05$ compared to controls.

NEUROMUSCULAR BLOCKADE: COMBINING VECURONIUM AND ATRACURIUM IN CHILDREN

M. Sloan, M.D., J. Lerman, M.D., B. Bissonnette, M.D.
Department of Anaesthesia and the Research Institute
The Hospital for Sick Children, University of Toronto, Toronto, Ontario, Canada M5G 1X8

Introduction: Previous studies have documented synergy when pancuronium and metocurine are combined.[1] Vecuronium is a steroidal compound similar in structure to pancuronium, and atracurium is similar to metocurine. Thus the potential for synergism exists when vecuronium and atracurium are combined. However, there is no consensus on the exact nature of the combined effects of vecuronium and atracurium.[2-4] Furthermore, there are no reports of the use of this combination of drugs in children. Therefore, we undertook this study to determine whether vecuronium and atracurium act synergistically in children anaesthetized with halothane.

Methods: After obtaining ethical committee approval and informed consent, 30 fasting and unpremedicated children, 2-9 years of age were studied. All children were ASA I or II and scheduled for minor elective surgery. Children with a history of renal, hepatic or neuromuscular disease, or in whom a difficult intubation was anticipated were excluded from the study. Patients were randomly assigned to one of three groups to receive 2xED_{95} of vecuronium, 2xED_{95} of atracurium, or a combination of 1xED_{95} of vecuronium + 1xED_{95} of atracurium. The ED_{95}s for vecuronium and atracurium were determined previously under similar anaesthetic conditions.[5] Anaesthesia was induced with thiopentone 5.0 mg/kg and fentanyl 2.0 µg/kg, and intubation performed under halothane anaesthesia without muscle relaxants. Anaesthesia was maintained with 70% N_2O in O_2, halothane (1 MAC end-tidal concentration), and incremental doses of narcotics. After a stable end-tidal halothane concentration was maintained for at least 10 min, the ulnar nerve in the forearm was stimulated via surface electrodes using a Datex Relaxograph EMG monitor which delivered a supramaximal train-of-four (2 Hz for 2 sec) stimulus every 10 sec. The degree of neuromuscular blockade was determined by the height of the first twitch (T1) of the train-of-four as compared to the control twitch, and the response of the adductor pollicis brevis muscle was recorded with a PSION LZ64 computer.[6] When a stable EMG baseline was obtained, the designated dose of vecuronium, atracurium, or the combination was administered. Recovery from neuromuscular blockade was then allowed to proceed spontaneously. The onset of paralysis (time when the height of the first twitch (T1) reached 5% of control), the duration of action (interval between 95% depression of the first twitch and the return of T1 to 25% of control), and the recovery index (25-75% recovery of T1) were determined from the recorded EMG responses. Statistical analysis ($p<0.05$) was performed using one way ANOVA and the Student-Newman-Keuls test.

Results: There were no significant differences in the ages and weights of the three groups of patients. The speed of onset was faster and the duration of action was longer with atracurium alone and with the combination than when compared with vecuronium alone (table). There was no significant difference between atracurium and the combination. The recovery index was similar for all three groups.

Discussion: These results indicate that the neuromuscular effects of vecuronium and atracurium are additive. While vecuronium has a shorter duration of action than atracurium, this attribute is not apparent when it is combined with atracurium in equipotent doses. Recovery is rapid and not prolonged when these two drugs are combined.

References:

1. Anesthesiology 63:4, 1985
2. Euro J Anesthesiol 2:29, 1985
3. Anesth Analg 76:240, 1988
4. Anesth Analg 70:S124, 1990
5. Anesth Analg 1990 in press
6. Can J Anaesth 37:386, 1990

Table: Pharmacodynamics of Vecuronium (VEC) and Atracurium (ATR) and their combination

Group	Dose (mg/kg)	Speed of Onset (sec)	Duration of Action (min)	Recovery Index (min)
VEC	0.074	91 ± 13	25.3 ± 6.1	11.3 ± 4.2
ATR	0.6	55 ± 10*	39.5 ± 8.3*	11.0 ± 2.9
ATR + VEC	0.3 + 0.037	62 ± 15*	39.8 ± 4.8*	13.0 ± 3.8

Data are mean ± SD
* $p<0.001$ compared to vecuronium

DOES AXIAL DISPERSION OF CARBON DIOXIDE OCCUR IN THE LONG SAMPLING LINES USED IN PEDIATRIC CAPNOGRAPHY?

J. MICHAEL BADGWELL, M.D., SAM KLEINMAN, M.D., DEPARTMENT OF ANESTHESIOLOGY, TEXAS TECH UNIVERSITY HEALTH SCIENCES CENTER, 3601 4TH STREET, #1C-282, LUBBOCK, TEXAS 79430

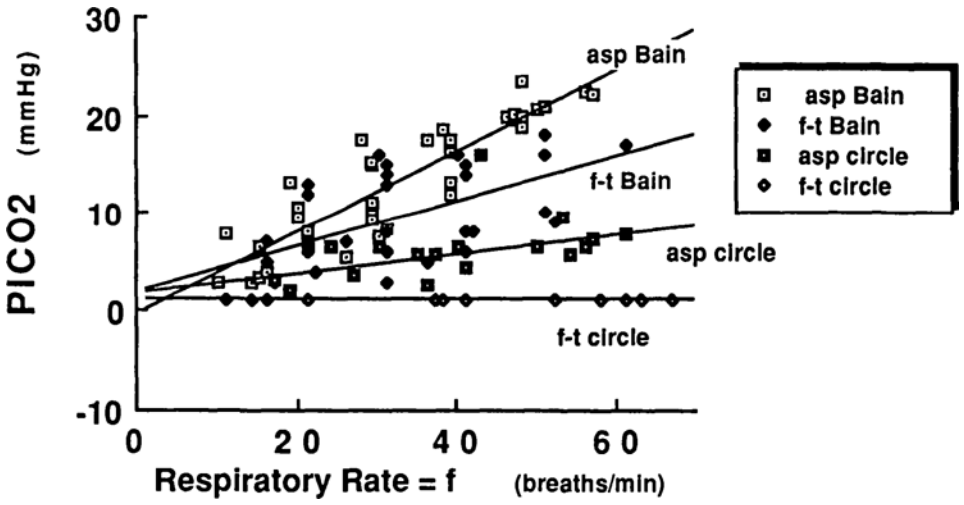
Introduction: The capnographic baseline is elevated when respiratory rate increases in pediatric patients ventilated through a partial rebreathing circuit [1]. In a parallel study of aspiration capnography, we were surprised to observe an elevated baseline in infants ventilated through a circle breathing system (a non-rebreathing circuit). To determine whether this elevation represents true rebreathing or axial dispersion ("slurring") of expired CO_2 boluses in the sampling line used for aspirating capnography, we measured inspired and expired PCO_2 (P_ICO_2, $P_{ET}CO_2$) using both aspirating (asp) and flow-through (f-t) capnography in small infants ventilated through either a partial rebreathing (Bain) or a non-rebreathing (semi-closed circle) system.

Methods: After IRB approval, we studied 10 paralyzed infants during general anesthesia for elective surgery. Six infants (mean $\pm$ SD body weight = 6.8 $\pm$ 3.2 kg) were ventilated using a Sechrist Infant Ventilator and a Bain circuit with constant fresh gas flows of ~250 ml/kg/min. Four infants (3.9 $\pm$ 1.5 kg) were ventilated using an Ohmeda 7810 ventilator with 300 ml bellows and a pediatic circle breathing system with fresh gas flows of 6 L/min. In all 10 infants, peak inspiratory/ end-expiratory pressures were ~20/2 and respiratory rates (f) were varied from 9-66 breaths/min. P_ICO_2 and $P_{ET}CO_2$ were measured 1) using mass spectrometric analysis of gas aspirated from the middle of the endotracheal tube (ETT) at a sample flow rate of 240 ml/min (PCO_2asp) and 2) using infrared analysis of gas flowing through a cuvette placed between the ETT and the breathing circuit (PCO_2f-t). Respiratory rate was compared to both P_ICO_2 and change in $P_{ET}CO_2$ from slowest f ($\Delta P_{ET}CO_2$) using linear regression analysis and the coefficient of determination (r^2).

Results: As f increased, P_ICO_2 increased more in the Bain groups than in the circle groups as per the following order: asp Bain > f-t Bain > asp circle > f-t circle (Figure). For the Bain groups, $P_ICO_2$asp = -0.86 + 0.42 f, r^2 = 0.81 and P_ICO_2 f-t = 1.0 + 0.23 f, r^2 = 0.37. For the circle groups, $P_ICO_2$asp = 0.88 + 9.73 - 2 f, r^2 = 0.48 and P_ICO_2 f-t = 0.0 + 0.0 f, r^2 = undefined. For the Bain groups, $P_{ET}CO_2$ did not change significantly when f increased ($\Delta P_{ET}CO_2$asp = 0.48 -3.83e - 2f, r^2 = 0.05 and $\Delta P_{ET}CO_2$ f-t = -0.51 + 2.63e - f, r^2 = 0.01). For the circle groups, $P_{ET}CO_2$ decreased when f increased ($\Delta P_{ET}CO_2$asp = 4.30-0.18 f, r^2 = 0.71 and $\Delta P_{ET}CO_2$ f-t = 2.25-0.15 f, r^2 = 0.34).

Discussion: The observations that $P_ICO_2$asp increased more than P_ICO_2f-t, in the Bain groups and that baseline elevation occurred in the asp circle group suggest that axial dispersion of CO_2 occurred in the long sampling lines used in aspiration capnography. In the figure, the asp Bain line represents rebreathing plus axial dispersion, the f-t Bain line represents rebreathing alone, the asp circle line represents axial dispersion alone, and the f-t circle line represents non-rebreathing. In the circle group, decreased $P_{ET}CO_2$ (as f increased) was the result of increased minute ventilation. In the Bain groups, unchanging $P_{ET}CO_2$ despite increasing P_ICO_2 agrees with existing data [1] and suggests that rebreathing CO_2 may not affect the adequacy of ventilation in infants ventilated through a partial rebreathing system.

Reference: [1] Can J Anaesth 35:581-6, 1988.



PAEDIATRIC STRABISMUS REPAIR: ACUPUNCTURE, DROPERIDOL AND POSTOPERATIVE VOMITING

S. M. Yentis FCAnaes, B. Bissonnette FRCPC.

Department of Anaesthesia, Hospital for Sick Children, 555 University Avenue, Toronto, Ontario M5G 1X8.

Introduction: Vomiting is common after paediatric strabismus surgery, occurring in up to 85% patients unless antiemetic drugs such as droperidol are given.[1] Acupuncture at the wrist (P6 or "Neiguan" point) reduces nausea and vomiting following surgery or chemotherapy in adults, but has not been studied in children.[2] We compared the antiemetic effect of acupuncture with those of droperidol in paediatric outpatient strabismus surgery.

Methods: After Human Review Committee approval, informed written consent was obtained from the parents of 65 children of ASA physical status I or II presenting for elective outpatient strabismus surgery. The children were randomly divided into three groups, to receive acupuncture (group A), intravenous droperidol (group D), or both (group AD), following induction of anaesthesia. No premedication was given. Anaesthesia was induced with intravenous thiopentone 5.0 mg•kg^{-1}, atropine 0.02 mg•kg^{-1}, and succinylcholine 1.5 mg•kg^{-1}. Patients in groups D and AD also received intravenous droperidol 75 μg•kg^{-1}. Manual inflation of the lungs, taking care to avoid gastric inflation, was followed by tracheal intubation and spontaneous ventilation with halothane 1.5-2.0% and N_2O 66% in O_2. Before surgery, patients in groups A and AD received acupuncture at the P6 point on the right side with 5 minutes' manual stimulation, using 0.2 mm diameter acupuncture needles. Estimated fluid deficit and maintenance requirements were replaced with intravenous Ringer's lactate solution. The incidence of vomiting and/or retching was recorded in the recovery room and ward. The nursing staff, patients and parents were unaware of the treatment received. Intramuscular dimenhydrinate 1.0 mg•kg^{-1} was given if vomiting exceeded three episodes during any one hour period. Oral acetaminophen 10.0 mg•kg^{-1} or intramuscular codeine phosphate 1.0 mg•kg^{-1} was given postoperatively as required for pain. Other data collected included age, sex, duration of anaesthesia, number of muscles repaired, duration of stay in the recovery room, recovery scores at 0, 15 and 30 minutes,[3] whether patients were irritable or difficult to settle, time to drinking fluids and time to discharge from hospital. The parents were contacted 48 hours postoperatively, to ascertain the incidence of vomiting at home. Statistical significance ($p < 0.05$) was determined using analysis of variance, and Student-Neuman-Keuls, chi-squared and Kruskal-Wallis tests.

Results: Age, weight, number of muscles repaired, duration of anaesthesia, recovery scores, length of stay in the recovery room, analgesic requirements and times to drinking and discharge from hospital were not significantly different between groups. The incidence of vomiting also did not significantly differ (see table). 35% of children in group A were irritable or difficult to settle postoperatively, compared with 65% in group D and 68% in group AD. No children required admission overnight.

Discussion: The influence of general anaesthesia on the antiemetic effect of acupuncture is unclear, although the timing of the acupuncture with respect to the emetic stimulus is thought to be more important.[4] The incidence of vomiting in the droperidol group (25% pre-discharge, 40% total) is higher than that previously reported for the same dosage (10% and 16% respectively).[5] The only difference in technique in the present study is the use of spontaneous ventilation, which has been shown not to increase vomiting significantly after strabismus surgery when compared with controlled ventilation.[6] In previous studies, 41-85% patients who did not receive an antiemetic vomited before discharge from hospital.[1,5-7] When vomiting after discharge was included, the incidence was 56-60%.[5,7] Although duration of postoperative recovery is not significantly different between the groups, this study confirms our clinical impression that children who receive droperidol are more likely to be irritable or difficult to settle afterwards; this is not the case with acupuncture.

References:
1. Anesthesiology 1983; 59: 579.
2. Br J Anaesth 1989; 63: 612.
3. Can Anaesth Soc J 1975; 22: 111.
4. Br Med J 1988; 296: 135.
5. Anesthesiology 1986; 65: 322.
6. Can J Anaesth 1988; 35: 31.
7. Can Anaesth Soc J 1986; 33: 57.

Table

	Groups		
	D	AD	A
Number of patients	20	22	23
Age (yrs)*	5.3 ± 4.4	5.6 ± 3.7	5.9 ± 3.3
No. muscles repaired†	2 (1-4)	2 (1-4)	2 (1-4)
Duration of anaesthesia (min)*	37 ± 14	39 ± 12	39 ± 13
Vomiting before discharge‡	5 (25)	4 (18)	9 (39)
Total incidence of vomiting‡	8 (40)	9 (41)	13 (57)
Irritability‡	13 (65)	15 (68)	8 (35)§

*mean ± SD
†median (range)
‡number (percentage)
§ $p < 0.05$ when compared with groups D and AD

COMPARISON OF INDUCTION AND RECOVERY CHARACTERISTICS OF PROPOFOL, THIOPENTAL AND HALOTHANE IN CHILDREN

J.T. Britton, M.D., R.S. Hannallah, M.D., FRCP(C), P.G. Schafer, M.D., and J.M. Norden, MSN
Departments of Anesthesiology and Pediatrics, Children's National Medical Center and George Washington University, Washington, D.C. 20010, USA.

INTRODUCTION: Propofol is a new short-acting intravenous anaesthetic with high lipid solubility and short elimination half-life. The drug has been investigated extensively for anaesthesia induction in adults, but experience with this new agent in children is limited.[1,2]

The objectives of this study are to evaluate the safety, effectiveness, as well as the speed and quality of recovery when propofol is used for induction and maintenance of anaesthesia compared to alternative anaesthetic combinations (propofol/halothane, thiopental/halothane, and halothane/halothane) in paediatric patients undergoing a variety of surgical procedures of one hour or greater duration.

METHODS: Institutional approval was obtained to study one hundred, otherwise healthy (ASA PS 1 or 2) 3-12 yr old children scheduled for ambulatory surgery of one hour duration or longer.

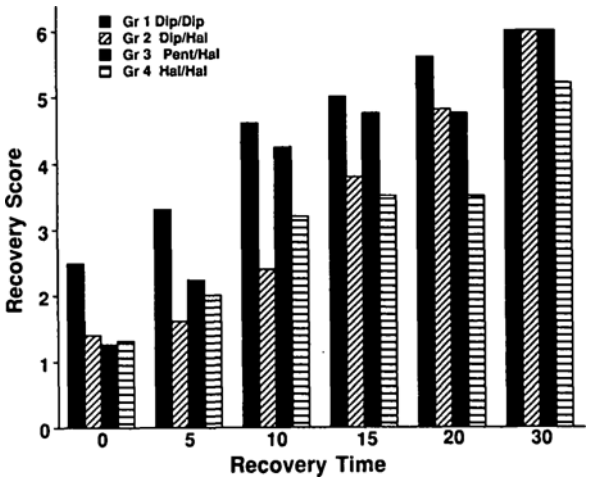
To encourage parental consent and children's acceptance of the study, a 24 gauge catheter was inserted by the anaesthesiologist in an antecubital vein, and used for preoperative blood drawing (CBC) instead of sending the child to the lab. The catheter was then flushed with heparin solution and later used to inject the induction drug without the need for a separate venipuncture.

No preoperative sedation was used. The children were randomized to receive one of four possible induction/maintenance combinations: group 1 patients received propofol 3.0 mg/kg for induction followed by propofol infusion 50-500 mcg/kg/min, group 2 patients received the same propofol induction dose followed by halothane 0.5-2%. Group 3 patients received thiopental induction 5 mg/kg followed by halothane 0.5-2% for maintenance. Patients in group 4 received halothane for both anaesthesia induction and maintenance. Succinylcholine 1.5 mg/kg was used to facilitate tracheal intubation and nitrous oxide (60%) and oxygen were used as the carrier gases in each case. All maintenance drugs were titrated according to the clinical response of the patient to prevent patient's movement and maintain BP $\pm$ 20% of baseline value.

At the conclusion of surgery, the anaesthetic agents were discontinued, and the trachea was extubated when the child was fully awake. Post anaesthesia recovery time was objectively evaluated by observing the time required to reach a score of six on the Steward recovery score[3] in the PACU, and the time to meet home discharge criteria in the Short Stay Recovery Unit (SSRU). A postoperative telephone follow-up was made to the parents the day following discharge to inquire about the recovery at home.

Awakening (extubation), recovery and discharge times were compared among the four groups using analysis of variance. The median recovery scores were compared using the Mann-Whitney test.

RESULTS: Demographic variables, duration of anaesthesia and surgery were not significantly different among patients studied to date. Full data will be presented at the meeting. When no muscle relaxants were used during surgery, the mean propofol dose required to prevent patient movement was 290 mcg/kg/min, (vs. 220 mcg/kg/min when relaxants were used). Awakening (extubation) times were not different among the four groups. Children who received propofol for both induction and maintenance (group 1) recovered faster (figure) and were ready for discharge sooner than all others ($P < .02$). One patient who received propofol expressed discomfort during injection. There were no serious complications or adverse postoperative sequelae in any of the patients in the study.



DISCUSSION: Anaesthesiologists continue to search for an intravenous induction agent that produces rapid onset of anaesthesia and quick recovery. Our findings so far suggest that the use of propofol as an induction agent followed by halothane in longer procedures (> 1 hr) results in similar recovery characteristics to thiopental, and that both are not significantly different from halothane. This study shows that continuous infusion of propofol is a safe and effective anaesthetic technique in children, and is associated with faster recovery and discharge than when halothane is used.

REFERENCES:

1. Morton NS, Wee M, Christie G, et al. Propofol for induction of anesthesia in children. A comparison with thiopentone and halothane inhalational induction. Anaesthesia 1988; 43:350-5.
2. Borgeat A, Popovic V, Meier D, et al: Comparison of propofol and thiopental/halothane for short-duration ENT surgical procedures in children. Anesth Analg 1990; 71:511-5.
3. Steward DJ: A simplified scoring system for postoperative recovery room. Canad Anaesth Soc J 1975; 22:111-3.

THE EFFECT OF ALFENTANIL ON THIOPENTAL REQUIREMENTS IN CHILDREN

WM Splinter, MD, FRCP, EA Menard, MD, FRCP
Children's Hospital of Eastern Ontario and University of Ottawa, Ottawa, Ontario

Introduction: Alfentanil is a short-acting, potent narcotic administered to children and adults during the perioperative period. In adults, low-dose alfentanil decreases the requirements for general anaesthetics. We investigated the effect of alfentanil on thiopental requirements in children during induction of anaesthesia.

Methods: With the approval of our Hospital Ethics Committee and parental consent, healthy children, ages 2-12 years undergoing elective surgery, who preferred an IV induction were studied. Patients were excluded from study if they had respiratory or cardiac disease, or a study drug was contraindicated. The study design and the calculated ED_{50} followed the "up and down method" described by Dixon and used previously in children.[1,2] After establishing appropriate monitoring and IV access, the subjects underwent an IV anesthetic induction. During both phases of the study the subjects were administered a precalculated dose of thiopental as a bolus over approximately 5 seconds into a proximal port of the rapidly flowing IV. In Phase I (induction without alfentanil) the first patient in each group was given 5.0 mg/kg of thiopental ($=10^{0.7}$ mg/kg). Forty-five seconds after injection, the lid reflex was evaluated by gently stroking the eyelashes 2 times to test for movement of the lid. If the lash reflex was present, the dose for the next patient was increased by 12% ($=10^{0.75}$ mg/kg), and if the lash reflex was absent the dose was decreased by 11% ($=10^{0.65}$ mg/kg). Six groups of patients with a "nominal sample size" of 2 were studied in Phase I. The patients were studied identically in Phase II except 20 mcg/kg of alfentanil was administered IV 1 min before the lash reflex was tested and the first patient in each group was given 4.0 mg/kg of thiopental ($=10^{0.6}$ mg/kg). Data was analyzed using paired and unpaired Student's t test where appropriate. Differences were significant when $P<0.05$. Values are listed as mean$\pm$SD.

Results: There were 13 patients in Phase I (control group) and 13 subjects in the alfentanil-treated group. The subjects within each phase were similar with respect to age, weight and gender. The ED_{50} for thiopental was 5.2$\pm$0.5 mg/kg for the control group and 3.9$\pm$0.4 mg/kg for the alfentanil-treated group, $P<0.0001$ (Table).

TABLE

Phase	Dose of Thiopental mean$\pm$SD
Phase I (Thiopental only)	5.2$\pm$0.5 mg/kg
Phase II (Thiopental plus Alfentanil)	3.9$\pm$0.4 mg/kg*

*$P<0.0001$

Discussion: Low-dose alfentanil reduces thiopental requirements in children by 25%. This potent sedative effect of alfentanil has been observed in adults.

References: 1. Anesthesiology 1989; 71: 344-346. 2. Anesthesiology 1983; 59: 421-424.

Constant Rate Drug Infusion Using A Drug Balloon Reservoir

D. John Doyle
Department of Anaesthesia, Toronto General Hospital, Toronto

INTRODUCTION Constant flow rate drug infusions are commonly employed in anaesthesia and critical care medicine, examples being intravenous narcotic infusions and epidural local anaesthetic infusions. While volumetric infusion pumps and syringe pumps serve such purposes well, they entail a high capital cost. Buretrol systems can be useful but they are not true constant flow devices as the flow rate varies with the amount of fluid in the Buretrol chamber. Here we describe a novel disposable drug infusion system based on a drug reservoir principle.

DESCRIPTION Figure 1 illustrates the system when empty (A) and when filled with drug (B). In clinical use, the balloon may be protected with a foam enclosure. The drug reservoir balloon is filled using a syringe in a manner similar to inflating an endotracheal tube cuff. Similarly, a one-way valve prevents loss of fluid upon removal of the syringe. The drug exits the device through a flow restrictor built into the Luer-lock end of the device. If the pressure in the balloon is P and the flow restrictor has resistance R then the flow of drug exiting the device is given by $F = P/R$ (assuming laminar flow and no back pressure). Information from the manufacturer (DIB International Co., Tokyo; distributed by Vitaid, Toronto) indicates that a volume of 20 ml of drug will ordinarily be discharged over 3 hours. (Models offering other flow rates are available).

EVALUATION Pressure-volume characteristics of the balloon device were studied in the laboratory using a 60 ml B-D syringe and a Bio-Tek Universal Pressure Meter. These results are shown in Figure 2. Flow characteristics for the device were determined using a stopwatch and graduated cylinder and are given in Table 1.

DISCUSSION This device is based on a constant pressure drug reservoir principle. As long as the flow restrictor resistance is much larger than the patient catheter resistance, flow will depend principally on the ratio of P and R. By design, the flow restrictor resistance R is constant (at least at the low flow conditions employed here), so that constant flow is possible only if the balloon pressure P is constant. However, as can be seen from Figure 2, P is indeed constant over the range up to 20 ml specified by the manufacturer.

The flow performance data presented in Table 1 suggests that the unit performs its task reasonably well. However, the system has several disadvantages. First, at a unit cost of $12.00 the device is not inexpensive. Furthermore, the device is not reusable. Second, the flow rate is not adjustable. Third, the volume of drug remaining in the balloon reservoir is not easily determined quantitatively. Finally, the flow will be reduced in situations where significant backpressure is present, such as may be encountered when the balloon device is "piggy-backed" into an existing intravenous infusion. (In this case the back-pressure (in cm H_2O) equals the height of the intravenous bag fluid level above the site for the balloon catheter connection). Nevertheless, where moderately accurate constant flow infusions are needed this device may prove handy. Possible applications include the slow infusion of toxic drugs such as vancomycin, IV infusions of narcotic analgesics such as morphine, and epidural infusions of local anaesthetics.

Trial	IV Catheter	Epidural Catheter
1	9.24	8.29
2	7.65	7.40
3	7.78	7.50
4	8.00	7.60
5	6.80	7.55
mean	7.89	7.67
st dev	0.88	0.36

Table 1: Flow rates in ml/hour for a sample balloon drug infusion system with a #20 gauge intravenous catheter and with an epidural catheter attached. The nominal infusion rate is 20 ml over 3 hours. The difference between means is not statistically significant (Students' t-test: t=0.53, df=8, n=0.3)

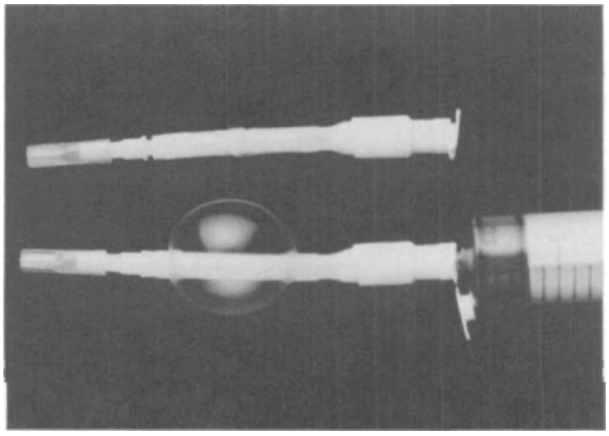


Figure 1: Drug-infusion balloon in deflated mode *(top)*, and while being filled using a syringe *(bottom)*. In clinical use the unit is enclosed in a foam protection device.

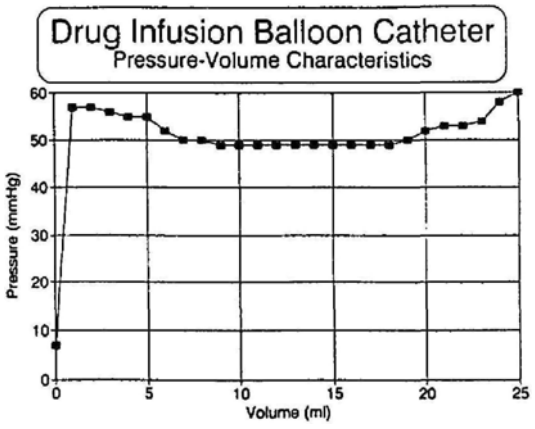


Figure 2: Pressure-volume characteristics for a sample drug-infusion balloon. The balloon maintains a pressure of about 50 mm Hg when filled up to the recommended maximum volume of 20 ml.

CARDIAC SARCOLEMMA IN MHS PIGS

JB Derdemezi FRCPC, JG Church PhD, BA Britt FRCPC, IC Radde MD, PhD.

Department of Anaesthesia, Toronto General Hospital, Toronto, Ontario, Canada M5G 2C4
Department of Pharmacology, University of Toronto, Toronto, Ontario, Canada M5S 1A8

INTRODUCTION

Malignant hyperthermia (MH) is a genetic disorder which affects humans and certain animal species. It is characterized by hypermetabolic reactions precipitated by succinylcholine and inhalational agents. Cardiac signs (tachycardia and ventricular arrhythmias) appear early during MH reactions as well as during the latent phase of the disorder. It is controversial as to whether cardiac signs are due to a primary defect of the heart muscle or are secondary to sympathetic overactivity. We have therefore studied isolated cardiac sarcolemma from MHS pigs and normal pigs.

METHODS

Cardiac sarcolemma was prepared from 9 normal and 10 MHS pigs by differential and sucrose gradient centrifugation as has been described by Jones[1] and his colleagues. The protein concentration of the isolated vesicles was determined by the method of Lowry[2] and his associates. Moreover, cardiac sarcolemma was characterized enzymatically by measuring the activities of $(Ca^{2+}Mg^{2+})$ATPase and $(Na^{+}K^{+})$ATPase by the methods of Church and Sen[3], and Post and Sen[4] respectively. Further assays were performed, including: ^{3}H-ouabain binding which was assessed by a filtration technique described by Lichtstein and Samuelov[5] and protein kinase activities which were determined by the methods of Gill and Walton[6]. Statistical analysis of the results was done by means of student's unpaired T-tests and analysis of variance.

RESULTS

Following the differential and sucrose gradient centrifugation steps, the sarcolemmal vesicles exhibited a protein content of 6.4 +/- 0.98 mg (n=9) and 7.81 +/- 0.89 (n=10), per 100g of cardiac ventricular muscle from normal and MHS pigs respectively. No differences between the two groups were noted. The $(Ca^{2+}Mg^{2+})$ATPase was in the expected normal range and there were no differences between the two groups of animals. However, the $(Na^{+}K^{+})$ATPase activity was lower in the MHS group than in the normal group (Table 1). Ouabain binding and protein kinase activities were similar in normal and MHS groups.

DISCUSSION

The cardiac SL prepared from MHS pigs exhibited a lower $(Na^{+}K^{+})$ATPase activity. This is a significant finding since low $(Na^{+}K^{+})$ATPase activity can indirectly increase myoplasmic Ca^{2+}. Thus, when the activity of Na^{+} pump is reduced, Na^{+} increases intracellularly and leads to the following: a. decrease Ca^{2+} efflux via the Na^{+}/Ca^{2+} exchange mechanism, and b. depolarization of the sarcolemma. The latter further influences myoplasmic calcium by: a. opening voltage dependent calcium channels, and by b. probably causing Ca^{2+} release from the SR. In general, enzyme activity is determined by: 1. the turnover rate of the active enzyme units and 2. the number of enzyme units per membrane. The turnover rate is governed by pH, temperature, substrate concentration, and the presence of regulatory proteins which may interact with the enzyme. A decreased $(Na^{+}K^{+})$ATPase activity in MHS pigs may result either from a lower turnover rate or a lower concentration of $(Na^{+}K^{+})$ATPase units. It was to test the latter that the ouabain binding studies were undertaken. Since no significant difference was noted between the two groups, the reduced $(Na^{+}K^{+})$ATPase activity could not have been due to a reduction in the number of the enzyme units. Aside from structural alterations, changes in $(Na^{+}K^{+})$ATPase activity may occur due to: cyclic nucleotide alterations and membrane lipid alterations. It is now established that cyclic nucleotides can modulate the activities of many enzymes via activation of protein kinases. However, protein kinase activity was found to be similar in the two groups. Therefore, the finding that $Na^{+}K^{+}$ATPase activity was lower in MHS than normal sarcolemma supports the hypothesis that a primary defect may exist in MHS sarcolemma leading to increase in cytosolic Ca^{2+}.

REFERENCES

1. J Biol Chem 255:9971-9979, 1980
2. J Biol Chem 193:265-275, 1951
3. Biochem Biophys Acta 728:191-200, 1983
4. Methods in Enzymology, Vol. 10, Academic Press, New York, NY. pp. 762-768, 1967.
5. Biochem. Biophys. Res. Commun. 96:1518-1523, 1980.
6. Advances in Cyclic Nucleotide Research, vol 10. Raven Press, New York, pp.93, 1979.

TABLE I: $(Na^{+}K^{+})$ATPase ACTIVITY OF PORCINE CARDIAC SARCOLEMMA
(Imol Pi/mg protein/hr.)

Normal Pigs	MHS Pigs
19.0 +/- 1.9 (n=8)	14.3 +/- 0.6 (n=8)

$t = 2.26$
$p < 0.05$

METAL ANAESTHESIA CIRCUIT COMPONENTS STOP LASER FIRES

M. Sosis, M.D., Ph.D., B. Braverman, Ph.D., A.D. Ivankovich, M.D.
Department of Anesthesiology Rush-Presbyterian-St. Luke's Medical Center Chicago, Illinois

The surgical laser can convert a conventional endotracheal tube into a "blow-torch" during airway surgery because of the close proximity of the laser to combustible endotracheal tubes which may have an anaesthetic mixture passing through them which supports combustion.[1] This combustion can quickly be propagated in a retrograde fashion towards the anaesthesia machine and may cause the combustion of disposable anaesthesia breathing circuits.[2] This study was undertaken to determine if non-disposable metal anaesthesia circuit components would prevent the progression of a laser induced endotracheal tube fire to the plastic corrugated breathing hoses of a circle anaesthesia system.

Methods:

A Sharplan (Tel Aviv, Israel) Nd-YAG laser, set to 10 watts of power output in the continuous mode of operation, was delivered perpendicularly through a fiber to size 7.0 mm internal diameter polyvinylchloride endotracheal tubes (Mallinckrodt Hi-Lo, Argyle, New York, USA). The endotracheal tubes had been trimmed to a length of 2.5 cm and each segment was connected to one of two circle anaesthesia systems for the study. The circle system consisted of either: 1) a disposable plastic anaesthesia breathing circuit (No. 16013 Dryden Corp., Indianapolis, Indiana, USA); or 2) a circuit consisting of a reuseable metal Y-piece and "elbow" with plastic disposable corrugated 22 mm hoses. The anaesthesia circuit and attached endotracheal tube segment were connected to an anaesthesia machine and were flushed with 5 liters/minute of 100% oxygen continuously. They were surrounded by air and rested on wet towels during the experiment. The laser's output was directed onto the black printing on the endotracheal tube until a sustained blow-torch fire resulted. The time for the sustained endotracheal tube fire to spread in a retrograde manner from the endotracheal tube along the "elbow" and Y-piece and to burn through the plastic 22 mm corrugated hoses was recorded. Five trials with each type of anaesthesia circuit were undertaken.

Results:

In all five trials with the disposable anaesthesia circuit components, flames from the burning endotracheal tube were propagated in a retrograde manner to the plastic 22 mm hoses. The time required was 49.37 $\pm$ 7.98 seconds. (Mean $\pm$ standard deviation) with a range of 42.05 - 63.09 seconds. The times for the retrograde combustion are listed in Table 1. In none of the five trials employing the metal Y piece and "elbow" were the flames propagated retrograde beyond the polyvinylchloride endotracheal tube 15 mm adapter.

Discussion:

The surgical laser can convert a combustible endotracheal tube into a veritable blow-torch and cause serious burns to a patient.[1] This is due to the extremely high energy density of the laser and its proximity to combustible endotracheal tubes during laser airway surgery. Also contributing to these fires is the fact that the anaesthetic mixtures usually employed will support or enhance combustion. A survey of otolaryngologists active in laser airway surgery has shown that such endotracheal tube fires and explosions are the most common serious complication of these procedures.[3] Their incidence has been estimated at 0.57%, making them one of the most frequent serious complications in clinical anaesthesia.[4] This has led to efforts to reduce the incidence of these fires by techniques such as the wrapping of combustible endotracheal tubes with the appropriate metallic foil tape, the use of specially manufactured endotracheal tubes designed for laser airway surgery and the use of the minimum possible concentration of oxygen with the remainder consisting of helium or nitrogen. Protection of the endotracheal tube cuffs is afforded by filling them with saline which contains a small amount of blue dye such as methylene blue and packing them off with wet pledgets.

A case report of an endotracheal tube fire during laser airway surgery noted that the fire quickly spread to the disposable anaesthesia circuit.[5] The present study shows that by employing a reuseable metallic Y-piece and "elbow", endotracheal tube combustion will not spread to the anaesthesia breathing circuit. Thus, noncombustible circuit components should improve patient safety during laser surgery.

References:

1. Cozine K, Rosenbaum LM, Ashkanazi J, Rosenbaum SH: Laser-induced endotracheal fire. Anesthesiology 55:583-585, 1981.
2. Wolf GL, Sidebotham GW: Tracheal tube intraluminal flame spread in opposed flow oxidant: helium versus nitrogen dilutions (abstract). Anesth Analg 70:S438, 1990.
3. Fried MP: Complications of CO_2 laser surgery of the larynx. Laryngoscope 93:275-278, 1983.
4. Snow JC, Norton ML, Saluja TS, Estanislao AF: Fire hazard during CO_2 laser microsurgery of the larynx and trachea. Anesth Analg 55:146-147, 1976.
5. Sosis M: Airway fire during laser surgery using a Xomed laser endotracheal tube. Anesthesiology 72:747-749, 1990.

Table 1
Time (seconds) to Retrograde Combustion of the 22mm Corrugated Plastic Hoses.

Trial	Time
1	43.22
2	42.05
3	63.09
4	53.66
5	44.81
Mean $\pm$ S.D.	49.37 $\pm$ 7.98

A Quantitative Study of Venous Congestion on Pulse Oximetry

Y. James Kao, M.D., Richard G. Norton, M.D.

Texas Tech University Health Sciences Center, Dept. of Anesthesiology, Lubbock, TX 79430

INTRODUCTION: Pulse oximetry has rapidly become one of the most important monitors used in anesthesia practice. It provides reference information on the functions of both the cardiovascular and the respiratory system. Nevertheless, pulse oximetry was found to be inaccurate in several clinical situations. In patients presenting with methemoglobinemin or receiving intravenous methylene blue, the arterial oxygen saturation has been found to be underestimated. Patients with carboxyhemoglobinemia, on the other hand, may present with an erroneously high value. Other conditions include peripheral vasoconstriction, increased central venous pressure, position of the sampling site relative to the heart, and the existence of arterial veno shunts; all have been associated with incorrect results.[1] Venous congestion secondary to patient position has the potential to produce inaccurate pulse oximeter readings. We characterized the relationships between venous occlusion and the accuracy of pulse oximetry.

Method: One of the authors with blood pressure of 135/90 was studied. In a sitting position, the cuff of a sphygmomanometer was used to create venous congestion in the right arm. Two oximeter probes (Nellcor, N-25) were used, one wrapped around the distal end of the small finger and the other wrapped around the metacarpal-proximal phalangeal joint. The arterial oxygen saturation (A-Osat) was measured and recorded with two pulse oximeters, (Nellcor Model N-10). The measurements were started 2 minutes after the inflation of the blood pressure cuff to the desired level. A third pulse oximeter (Nellcor model N-200), continuosly measured A-Osat of the left thumb. The study was repeated five times.

Result: Venous congestion caused a reduction of A-Osat as reported by the pulse oximeter. The decreases of A-Osat were found to be dependent upon the degree of the venous congestion (Table). The position of the oximeter probe (fingertip vs. palmar-digit joint) applied also affected the A-Osat determination. The error of A-Osat caused by venous congestion is less than when the probe is applied at the fingertip than at the more proximal metacarpal-phalangeal joint (Fig.).

Discussion: Pulse oximetry measures the arterial oxygen saturation by continuously measuring optical density at two wavelengths. The rhythmic variation of the optical densities of the sampled tissue was used to calculate volume variation of the arterial pulsation. The ratio between oxygenated hemoglobin and deoxygenated hemoglobin was therefore obtained and presented as arterial oxygen saturation.[2] Venous congestion caused the accumulation of the desaturated venous blood at the sampling site. Consequently, venous blood volume fluctuation derived from arterial pulsation generated erroneous pulse oximeter measurements. Distal fingers, with limited venous capacitance vessel, is relatively resistant to this artifact.

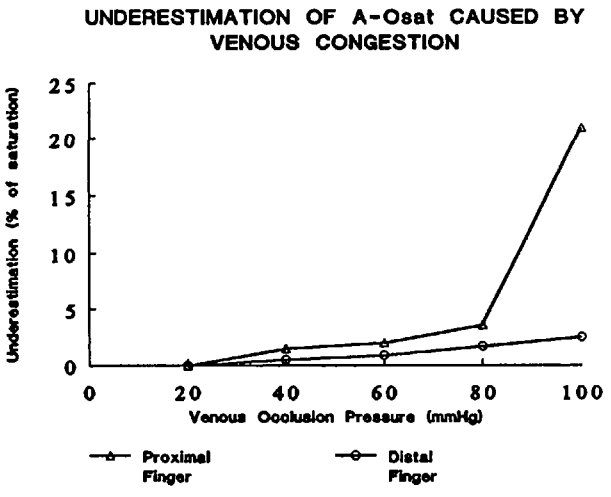
Conclusion: Venous congestion affects the accuracy of pulse oximetry regardless whether the probe is placed at the distal or proximal part of the finger. However, the effect was smaller when the probe was placed at the distal part of the finger than when the probe was placed at the proximal end.

References:
1. Barker SJ, Tremper KK: Physics applied to anesthesia. In: Barash PG, Cullen BF and Stoelting RK, eds. Clinical anesthesia, Ch. 3. pp 44-68, 1989. Lippincott, Philadelphia.
2. Alexander CM, Teller LE, Gross JB. Principles of pulse oximetry. Theoretical and practical consideration. Anal & Anesth, 1989, pp 68-376.

Table. A-Osat as Reported by Pulse Oximeters

Venous Occlusion Pressure (mmHg)	Proximal Digit	Distal Digit	Control*
0	96.6±1.36	95.5±1.12	95.5±1.79
20	96.6±1.36	95.5±1.12	96.4±1.63
40	95.6±2.06	95.0±0.89	95.8±1.27
60	95.2±1.72	94.6±0.80	96.2±1.33
80	93.0±3.29	93.8±1.17	96.5±1.62
100	75.6±4.88	93.0±1.10	95.7±1.28

*left distal digit, no venous occlusion



THE EFFECT OF SKIN PIGMENTATION ON THE ACCURACY OF PULSE OXIMETRY; AN IN VITRO STUDY

G.A.Volgyesi, PEng, I. Spahr-Schopfer, MD, B. Bissonnette, MD.
Department of Anaesthesia and the Research Institute, The Hospital For Sick Children and the University of Toronto,Toronto,Ontario.

Introduction

The pulse oximeter has become one of the most useful clinical monitors in the modern practice of anaesthesia. It estimates arterial oxygen saturation by solving an equation that involves the pulsatile component of the differential absorption of specific red and infrared wavelengths by transilluminated tissue. Since the contribution of all non pulsatile absorbers are cancelled mathematically, variables such as skin pigmentation should not affect the measurement.
In order to test this basic assumption we have performed experiments on a finger model, using blue filters to simulate the absorption characteristics of dark skin pigmentation.

Methods

The finger model or Manual Pulse Simulator (MPS) was assembled as previously described.[1,2] Blood was obtained from one of the authors, and the samples of different saturations were prepared by tonometry.[3]The filter used was a narrow strip (1cm*5cm) of blue plastic film (Letraset Project-a-Film, PAF 9), which was previously found to approximate the red absorption characteristics of moderately dark skin.[4] The oxygen saturation (SpO_2) of each sample was estimated three different ways using a Nellcor (N 200) pulse oximeter. For the first estimation the MPS only was used; for the second , the MPS and one filter, and for the third, the MPS and two filters were used. Each estimation was repeated several times in random order and the person recording the SpO2 readings was blinded to the order. A portion of the blood in the tube was then removed anaerobically, and its oxygen saturation (SaO2) and hemoglobin concentration (Hb) measured with a Hemoximeter. The SpO2 readings obtained with one or two filters were compared to the SpO2 values obtained without filter (reference values) using linear correlation analysis. Statistical analysis was performed to determine if the slopes were significantly different from each other. The % error (or % difference) resulting from using one or two filters was calculated from differences between the lines thus obtained and the reference line(a line passing through the points of each reference value plotted against itself)

Results

When two filters were used, SpO2 estimations could not be obtained below 45%.The slopes of the lines obtained with one or two filters were significantly different from each other and that of the reference line (Fig1). The results indicate that the presence of the blue filter, simulating dark skin pigmentation causes the pulse oximeter to overestimate the oxygen saturation of the blood (Fig 2). The magnitude of the overestimation seems to depend both on the number of filters (simulating the darkness of the skin) and on the degree of desaturation of the blood.

Discussion

According to widely accepted theory, skin pigmentation has no effect on the accuracy of pulse oximetry.[5] The results of this experiment indicate, however, that skin pigmentation may affect the accuracy of pulse oximetry significantly, especially at low saturations.

The effect of skin pigmentation on the accuracy of pulse oximetry observed in this in vitro experiment, if corraborated in vivo, may have important clinical implications.

References

1.Can J Anaesth 1990;37(4):S67
2.Can J Anaesth 1990;37(4):S88
3.Anesthesiol. 1990:37(3A):A427
4.Volgyesi GA, personal observation
5. Anesthesiol.1983:59:349

Figure 1

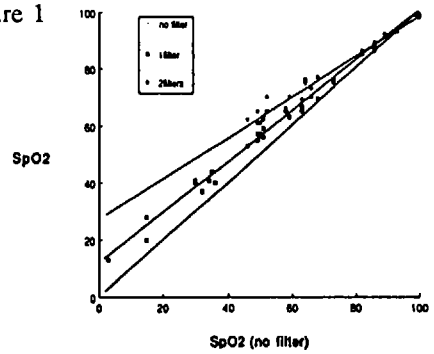
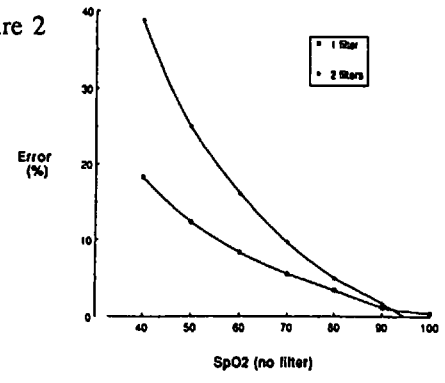


Figure 2



EVALUATION OF A NEW LASER RESISTANT FOAM COVERED SILVER FOIL WRAPPED ENDOTRACHEAL TUBE

M. Sosis, M.D., Ph.D., B. Braverman, Ph.D., A.D. Ivankovich, M.D.
Rush-Presbyterian St. Luke's Medical Center, Chicago, Illinois

Laser-induced endotracheal tube combusion poses a serious patient hazard during airway surgery. A survey of otolaryngologists involved in these cases noted that endotracheal tube fires and explosions were the most common serious complication of laser airway surgery.(1) This study was designed to evaluate a new foam covered silver foil coated polyvinylchloride endotracheal tube manufactured for laser use.

Methods: Size 7.0 mm internal diameter polyvinylchloride endotracheal tubes (Sheridan Catheter Co., Argyle, New York, USA) that were fabricated with the Laser Guard protective coating (Merocel Corp., Mystic, Connecticut, USA) applied were evaluated in this study. They were compared to plain (bare) size 8.0 mm internal diameter polyvinylchloride endotracheal tubes (Mallinckrodt Critical Care "Hi-Lo," Glens Falls, New York, USA) that were studied as received from the manufacturer and also after wrapping the endotracheal tube's shaft with Venture (Rockland, Massachusetts, USA) 0.25 inch, 1 mil thick, copper foil tape. The metallic foil tape was applied in an overlapping spiral manner using a continuous strip starting just above the cuff.

The endotracheal tubes under study were placed on wet towels in air and had 5 liters/minute of oxygen flowing through them. The tubes were subjected to either continuous laser radiation at 30 watts from a Sharplan (Tel Aviv, Israel) 733 carbon dioxide laser positioned perpendicularly 17.5 cm above the endotracheal tube or 34 watts of continuous output from a LaserSonics (Santa Clara, California, USA) model 8000 Nd-YAG laser. The Nd-YAG laser was propagated via a 600 micron fiber bundle and directed perpendicularly at the endotracheal tube to be studied. The laser's output was continued until a blow-torch fire occurred or 60 or 90 seconds had elapsed for the carbon dioxide and Nd-YAG studies respectively.

Results: The carbon dioxide laser did not ignite any of the five Laser-Guard covered polyvinylchloride endotracheal tubes tested. Steam was noted at the site of laser contact; however, the foam covering was otherwise unaffected. Sixty seconds of laser application to the five Venture copper foil wrapped polyvinylchloride endotracheal tubes tested showed that they were also not affected by the carbon dioxide laser. Blowtorch ignition of all five plain polyvinylchloride endotracheal tubes tested occurred after 1.24 $\pm$ 0.40 seconds (mean $\pm$ S.D.) of carbon dioxide laser fire. Ninety-five seconds of Nd-YAG laser contact with the Laser-Guard covered polyvinylchloride endotracheal tubes caused blow-torch ignition in four out of five endotracheal tubes tested after 10.93 $\pm$ 6.69 (mean $\pm$ S.D.) seconds. The Venture copper foil wrapped endotracheal tubes were unaffected by 90 seconds of Nd-YAG laser radiation. Blowtorch ignition occurred in evaluating all five of the plain (bare) polyvinylchloride endotracheal tubes with the Nd-YAG laser after 1.70 $\pm$ 0.55 seconds (mean $\pm$ S.D.). The time to Nd-YAG laser combusion of the Laser-Guard protected polyvinylchloride endotracheal tube was significantly ($P<0.03$) longer than that for the plain polyvinylchloride endotracheal tubes as determined by the Student's t-test.

Discussion: The high energy density of the surgical laser, combined with its proximity to combustible endotracheal tubes during laser airway surgery, has resulted in catastrophic airway fires that have seriously injured patients. In a survey of otolaryngologists active in laser airway surgery, Fried determined that such endotracheal tube fires and explosions are the most common serious complications occurring in those cases.(1)

A variety of techniques have been developed to protect endotracheal tubes from the laser. The use of metallic foil wrapping to protect endotracheal tube shafts from the carbon dioxide laser has been shown to be highly effective when the correct foil wrap is carefully applied.(3) However, none of the foil tapes has been approved for this application by government regulating bodies. Also, specially manufactured endotracheal tubes have been developed for these applications. Comparative evaluations by our group have shown only one such endotracheal tube to be unaffected by the carbon dioxide laser operating at high power.(4) None of the specially manufactured endotracheal tubes tested provided satisfactory protection from the Nd-YAG laser set to high power.(5)

The Sheridan/Merocel laser endotracheal tube is constructed from polyvinylchloride that has been coated with a laser resistant covering at the factory. The covering consists of a rectangular sheet of embossed silver foil covered by foam. Silver is used since this metal has a high thermal conductance. The foam coating, when moistened, results in a smooth exterior and also serves as a heat sink. This product has been approved for laser airway surgery by government regulating bodies. Our results show that under the conditions of this study, the Sheridan/Merocel endotracheal tube's shaft is resistant to the carbon dioxide laser. It is not recommended for use with the Nd-YAG laser.

References

1. Fried MP: Complications of CO_2 laser surgery of the larynx. Laryngoscope 93:275-278, 1983.
2. Snow JC: Norton ML, Saluja TS, Estanislao AF: Fire hazard during CO_2 laser microsurgery of the larynx and trachea. Anesth Analg 55:146-147, 1976.
3. Sosis MB: Evaluation of five metallic tapes for protection of endotracheal tubes during CO_2 laser surgery. Anesth Analg 68:392-393, 1989.
4. Sosis M, Heller S: A comparison of special endotracheal tubes for use with the CO_2 laser (abstract) Anesthesiology 69:A251, 1988.
5. Sosis MB: What is the safest endotracheal tube for Nd-YAG laser surgery? Anesth Analg 69:802-804, 1989.

Resonance Properties of Regular and Oximetric PA Catheters

D. John Doyle and Mark Plum
Department of Anaesthesia, Toronto General Hospital, Toronto

INTRODUCTION A number of technical considerations exist that are important in obtaining accurate pressure recordings from invasive arterial catheters. Such pressure recording systems are catheter-transducer assemblies which are best modelled as a distributed system, but are well approximated as a simple lumped second-order system in clinical use. Specifically, such systems may be characterized as an "underdamped, second order dynamic system" defined by two measurable parameters: the resonant (natural) frequency and the damping coefficient [1]. The resonant frequency "refers to how rapidly the system oscillates" while the damping coefficient "refers how quickly the system comes to rest" [1]. Of these two parameters, the resonant frequency is especially important in ensuring an accurate pressure recording system. Other technical factors, such as linearity, temperature stability and freedom from drift are also important, but pertain primarily to the electronic portion of the recording setup.

PREVIOUS STUDIES In a study by Gardner [1] the measurement errors associated with clinical catheter-transducer systems for radial artery pressure measurement were investigated. Two major error types were found: (1) "overestimation of systolic pressure by as much as 15-30 torr", and (2) "amplification of artifact in the measurement system such as catheter whip" [1]. These errors are multifactorial in origin, but are strongly influenced by the length of tubing from the catheter to the transducer [2,3]. (The resonant frequency is reduced with long lines, with the result that the low-frequency energy of the cardiac pressure waveform (in the range of 1-10 Hz) induces resonance-caused distortion.)

As an example, in a study by Hunziker [4] patient-mounted transducers (12-inch tubing) were compared with pole-mounted transducers (60-inch tubing). On average, the pole-mounted systems exhibiting larger resonant frequencies produced resonace-related systolic overshoot values five times that of the shorter patient-mounted systems.

EXPERIMENT The objective of this study was to compare the resonance characteristics of two pulmonary artery catherers: the Abbott 110 cm unit (regular Abbott PA line) and a special unit used for continuous mixed venous oximetry (Abbott Opticath), also 110 cm long. The experimental setup included a variable frequency sine-wave electrical signal (Simpson model 420 function generator) as the driving input to a Bio-Tek model 601A blood pressure simulator. Luer-lock connections were attached to the distal ends of the catheters under test using epoxy resin glue. The proximal end of the catheters went to a Cobe disposable pressure transducer (resonant frequency > 100 Hz, linearity +/- 1.5 percent), the output which was amplified by a precision amplifier (Dynamics model 890 Bio-Instrumentation Amplifier) set for a gain of 4000. The amplifier output was then displayed on an oscilloscope and fed to a frequency counter. Extreme care was employed to ensure that fluid-filled path was free from all air bubbles.

The excitation frequency which provided the maximum signal amplitude was taken as the resonant frequency [1,4]. Ten of each catheter type were studied. For each catheter, the highest of three repeated resonance frequency measurements was used in the analysis. The results are given in the Table 1. The difference in mean resonance frequency is significant at the $p < 0.01$ level (two-tailed t-test; $t = 10.49$; $df = 18$).

DISCUSSION Gardner [1] emphasized that "a major requirement of any catheter-transducer recording system is that it have a high natural (resonant) frequency to allow for the largest latitude in damping coefficient." This is because the resonant frequency of underdamped second order systems cannot easily be increased, while the damping coefficient can be increased to improve waveform fidelity by using a damping device such as an Accudynamic(R) [4,5]. Previous studies by the author suggest that shorter 85 cm pulmonary artery catheters are superior to the usual 110 cm units from a resonance frequency perspective [6]. In this study we were curious as to whether the more complex oximetric catheters would behave differently compared to standard catheters of identical length produced by the same manufacturer. The results obtained suggest the oximetric catheters have a somewhat smaller (less favourable) resonance frequency as compared to the regular catheters. However, while the difference in mean resonance frequency is statistically significant, both catheters have sufficiently high resonance frequencies that the difference is not believed to have clinical significance, ie, both catheters should yield adequate waveform fidelity.

	Regular Abbott PA Catheter	Opticath
N	10	10
mean	34.3	26.6
st dev	0.781	2.06

Table 1 : Resonance frequency test results (in Hertz) comparing regular Abbott 110 cm pulmonary artery catheters with Abbott Opticath 110 cm units.

REFERENCES

1. Gardner RM. Direct pressure measurement - dynamic response requirement. Anesthesiology 1981; 54: 227-236.

2. Gravensteinn JS, Paulus DA. Clinical Monitoring Practice, 2nd Ed, Philadelphia: Lippincott (1987)

3. Fry DL. Physiologic monitoring by modern instruments with particular reference to pressure recording. Physiol Rev, 1960; 40:753

4. Hunziker P. Accuracy and dynamic response of disposable pressure transducer-tubing systems. Canadian Journal of Anaesthesia, 1987; 34: 409-414.

5. Abrams JH, Olson ML, Marino JA, Cerra FB. Use of a needle valve resistor to improve invasive blood pressure monitoring. Crit Care Med, 1984; 12: 978-982.

6. Doyle DJ. Resonance properties of 85-cm and 110-cm pulmonary artery catheters. Journal of Cardiothoracic Anesthesia, 1990; 4:781-782.

DETERMINATION OF THE OUTPUT OF MIXTURES OF ENFLURANE AND ISOFLURANE FROM A CALIBRATED VAPOURIZER

M. Sosis, M.D.,Ph.D., B. Braverman, Ph.D., A. Ivankovich, M.D.
Department of Anesthesiology, Rush-Presbyterian-St. Luke's Medical Center, Chicago, Illinois

An incorrect volatile anaesthetic agent can be poured into an agent specific anaesthesia vapourizer with the result that the patient receives an unknown and perhaps hazardous concentration of volatile anaesthetics. Thus, it has been noted in practice that mixtures of volatile anaesthetic agents are sometimes discovered in vapourizers designed for use with a single halogenated anaesthetic.[1] However, the output of mixed anaesthetic agents from a calibrated vapourizer had not been systematically investigated prior to this study. Such information may have important clinical relevance and may contribute to improved patient safety.

Methods:

The output from an agent-specific (Enfluratek, Cyprane, Yorkshire, England) vapourizer mounted on an anaesthesia machine (Boyle 50, Harris-Lake, Cleveland, Ohio, USA) was determined at the common gas outlet of the machine with 6 liters/minute of oxygen passing through the vapourizer. A Nellcor (Hayward, California, USA) model 2500 anaesthesia safety monitor was used for the measurements. The vapourizer was completely drained and then flushed with a high flow of oxygen for more than 40 minutes between determinations with different anaesthetic mixtures. This procedure was noted to decrease the output of enflurane to 0.01% as determined by mass spectrometry after 100% enflurane was drained from the vapourizer. The vapourizer was then completely filled with the agent(s) under study. All determinants were done at 22°C. The vapourizer's output was determined at nominal dial settings of 1, 2, 3, and 4% when the vapourizer was filled with 100% enflurane; 100% isoflurane; 25.3% enflurane/74.7% isoflurane; 50.4% enflurane/49.6% isoflurane; and 73.2% enflurane/26.8% isoflurane. The anaesthetic mixtures were gravimetrically prepared from our normal stock of the liquid anaesthetics obtained from Anaquest (Madison, Wisconsin, USA). The results of the study are summarized in table 1.

Table 1: MEASURED OUTPUT FROM ENFLURANE VAPORIZER CONTAINING KNOWN MIXTURES OF ENFLURANE AND ISOFLURANE

MIXTURE(%) (ENFLURANE/ ISOFLURANE)	ENFLURANE VAPOURIZER DIAL SETTING (%) 1	2	3	4
100/0	1.1/-	2.15/-	3.3/-	4.1/-
0/100	-/1.4	-/3.0	-/4.3	-/5.1
25.3/74.7	0.3/1.2	0.6/2.5	0.95/3.6	1.2/4.3
50.4/49.6	0.6/0.8	1.2/1.7	1.8/2.5	2.3/3.1
73.2/26.8	0.8/0.4	1.7/0.8	1.9/0.9	3.0/1.5

Discussion:

The erroneous filling of an anaesthetic vapourizer may be injurious to a patient since a high concentration of a potent volatile agent may be administered unknowingly. Such a mix-up is possible, since the agent-specific anaesthesia vapourizers currently in use are colour coded, however, they are often otherwise indistinguishable. In an effort to prevent substitutions of volatile halogenated anaesthetics, a "pin-indexed" system of agent specific filling spouts has been developed. These spouts are designed to screw onto only bottles of the volatile anaesthetic selected. However, problems have been reported[2] wherein the collar on the anaesthetic bottle with which the filling spout mates has either been omitted or inserted backwards so that mix-ups are possible. Bruce and Linde[3] used gas chromatography to examine the vapour pressures of isoflurane-halothane and enflurane-halothane mixtures in the range of 0-100%. They were unable to separate isoflurane from enflurane using their analytical technique, and they did not systematically examine the output of mixtures of volatile anaesthetic agents from calibrated vapourizers.

This study is the first to simulate a mix-up of volatile anaesthetics involving an agent specific vapourizer using known mixtures in the vapourizer and employing a new commercially available anaesthesia monitoring device to determine its output. The Nellcor agent analyzer used in this study is capable of measuring the concentrations of enflurane and isoflurane simultaneously from mixtures of these volatile anaesthetic agents over the range of 0.2 to 6% with a response time of 175 milliseconds. Its rated accuracy is 0.1% over the range of 0-2% and 5% of the measured value for concentrations greater than 2%. When 100% isoflurane was placed in the empty enflurane vaporizer, its output was found to be considerably higher than the vaporizer dial settings due to its higher vapor pressure. In fact, the measured output of isoflurane was as much as 50% greater than the dial setting on the enflurane vaporizer. This could cause significant patient morbidity or mortality. No significant deviation from linearity was noted when the measured concentration of either agent was plotted as a function of the percentage of that agent in the liquid anesthetic mixtures. However, the measured output of isoflurane was less than the calculated value[3] when the vaporizer was filled with 100% isoflurane. It is concluded that there is no significant interaction between isoflurane or enflurane when they are combined which would affect their vaporization. The use of an anaesthetic monitor capable of determining the output of a vapourizer which might contain a mixture of volatile anaesthetics is recommended.

References:

1. Karis, JH, Menzel DB: Inadvertent change of volatile anesthetics in anesthesia machines. Anesth Analg 61:53-55, 1982.
2. George TM: Failure of keyed agent specific filling devices. Anesthesiology 61:228-229, 1984.
3. Bruce DL, Linde HW: Vaporization of mixed anesthetic liquids. Anesthesiology 60:342-346, 1984.

DOSE-RESPONSE RELATIONSHIPS OF DOBUTAMINE AND DOPAMINE IN HEMODILUTED DOGS

CE Smith MD, FRCPC, AC Pinchak MD, PhD, JF Hagen BA, DE Hancock AEET

Department of Anesthesia, MetroHealth Medical Center,
Case Western Reserve University, Cleveland, OH 44109

Introduction. Inotropic agents may be employed to improve contractility and oxygen metabolism. However, little is known of the comparative effects of these agents during hemodilution. The study was designed to evaluate the effect of hemodilution on the response to dobutamine and dopamine. Cardiac contractility was estimated using left ventricular dP/dt and compared with accelerometry.

Methods. Ten adult dogs were anesthetized with 30 mg/kg i.v. Na pentobarbital bolus followed by 3 mg/kg/hr. Animals were mechanically ventilated with room air. Catheters were placed for measurement of arterial, left ventricular (Millar), central venous and pulmonary artery pressures, and thermodilution cardiac output. A biaxial accelerometer (flat frequency response from 0 - 300 Hz) placed in the lower esophagus allowed measurement of peak to peak cardiac accelerations (A1x, A1y)[1]. Animals were randomly divided into hemodiluted (group 1, hematocrit= 25±2%, n=5) and non hemodiluted (group 2, hematocrit= 39±2%, n=5) groups. Normovolemic hemodilution was induced by the simultaneous withdrawal of blood and infusion of a similar volume of hetastarch at a rate of 20 mL/min. The total volume exchanged was 45 mL/kg. One hour after hemodilution, the inotrope was infused at 5, 10, 20 and 40 ug/kg/min for periods of 10 min each, followed by a 30 min washout period between drugs. Five dogs received dobutamine first and 5 received dopamine first, the order being random. Arterial and mixed venous blood were sampled for pH, pCO2, pO2, hemoglobin and hematocrit. Rectal temperature was maintained at 38°C. Hemodynamics, oxygen delivery (DO2), consumption (VO2) and extraction ratio (ER=VO2/DO2*100) were measured prior to and after hemodilution, and during and after infusion of the study drugs. Correlation coefficients between dose of inotrope and dependent variable were calculated and slopes were compared by testing for overlap of 95% confidence limits. The relationship between dP/dt and accelerometry was also determined. Results are expressed as means ± SEM. P < 0.05 was considered significant.

Results. Dobutamine and dopamine caused similar dose-dependent increases in contractility (dP/dt) and oxygen metabolism (DO2, VO2) in both groups. The ER was reduced in a dose-dependent fashion in the dopamine, but not the dobutamine groups (Table 1). There was good correlation between the 2 contractility measures (dP/dt and accelerometry: A1X, Figure 1).

Discussion The ability of the circulatory system to respond to inotropic stimulation does not appear to be affected by hemodilution in this animal model. Intra-esophageal accelerometry provided reliable, noninvasive estimates of cardiac contractility.

References

1. J Biomech Eng 1981; 103:160-7

Table 1. Correlation coefficients and slopes for hemodiluted (1) and non hemodiluted (2) dogs. Dependent variables at 2 doses (0 and 40 ug/kg/min) are presented.

	Dobutamine 0	40	Slope	R	Dopamine 0	40	Slope	R
DO2 (mL/min)								
1	377±72*	1005±139	10.4±4	.5	581±68	1184±180	15.7±4	.7
2	732±78	1329±150	10.9±6	NS	755±56	1224±156	11.4±5	.4
VO2 (mL/min)								
1	101±5	152±5	1.2±.2	.8	105±9	143±13	1.1±.3	.6
2	90±5	123±6	0.7±.2	.5	93±18	119±7	0.7±.3	.5
ER (%)								
1	21±2*	17±2*	-.06±.08	NS	19±2*	13±1	-.13±.04	.5
2	13±2	10±1	-.06±.05	NS	13±1	10±1	-.06±.03	NS
dP/dt (10^3mmHg/sec)								
1	3.9±.4	8.5±.6	.10±.04	.5	4.3±.3	9.0±1	.12±.03	.7
2	3.7±.4	8.6±.8	.10±.03	.6	3.5±.3	10.1±.6	.16±.03	.8
A1x (G units)								
1	.52±.1	1.6±.5	.02±.01	NS	.53±.05	2.2±.31	.04±.01	.7
2	.28±.1	1.8±.6	.02±.01	.6	.34±.11	1.3±.53	.04±.01	.7

Means±SEM, *p<0.05 group 1 vs 2 (unpaired t with Bonferroni correction). The slopes were similar between groups. NS: F-ratio of regression not significant.

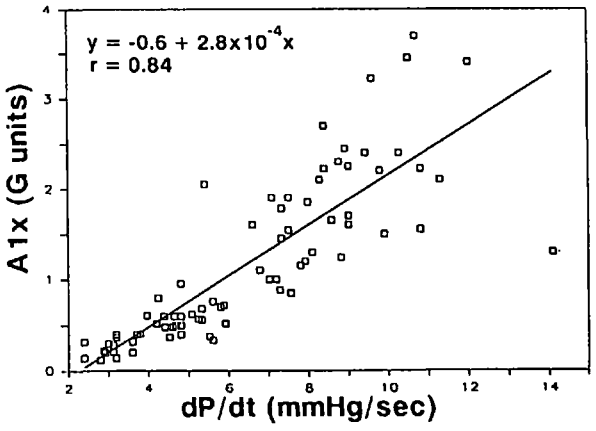


Figure 1. Plot of left ventricular dP/dt vs cardiac acceleration in groups 1 and 2.

Synchronous Averaging of the Blood Pressure Wave: Demonstration of a Variability Wave

D. John Doyle
Department of Anaesthesia, Toronto General Hospital, Toronto

INTRODUCTION

Although synchronous averaging methods have been used in the neurophysiological laboratory for many years, the use of this technique in cardiovascular investigation has been limited. We report here on some preliminary findings in applying this method to the arterial blood pressure wave.

METHODS

With institutional approval, EKG (lead II) and invasive radial artery blood pressure signals were obtained intraoperatively from the back of existing monitors in patients requiring invasive arterial monitoring for their clinical management. Signals were digitized at 1000 samples/second with 12 bits resolution using a 10 MHz AT compatible computer with a DT-2801A data acquisition subsystem. Epochs up to 90 seconds were collected, the time restriction being due to a maximum floppy disc capacity of 1.2 Mbytes. Custom software was used to segment the acquired data into cardiac cycles using digital differentiation and thresholding of the ECG. The mean and standard deviation of the blood pressure wave (BPW) was then obtained for each time point following computer detection of the QRS complex. The resulting signals, known as the *mean blood pressure wave* and the *blood pressure variability wave* respectively, were then plotted for further analysis.

RESULTS

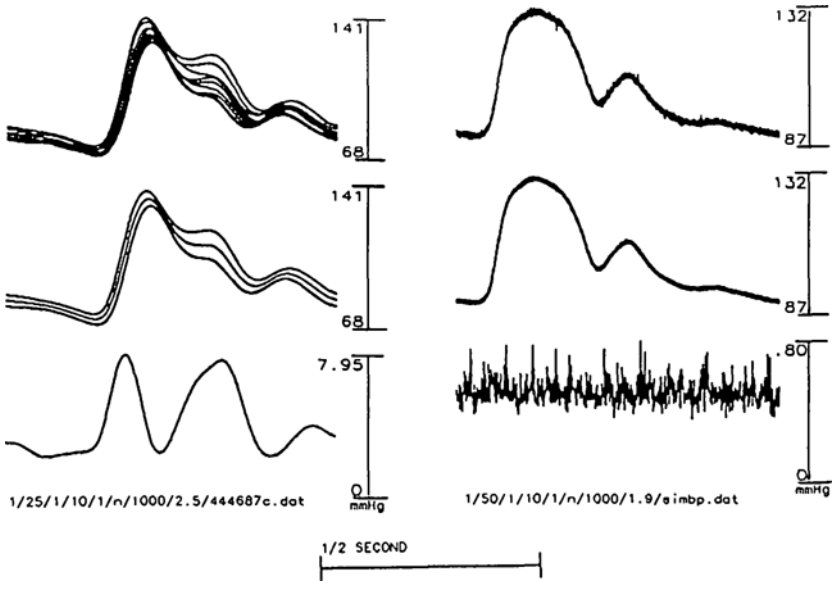
Figure 1 (a) illustrates a typical result from a patient undergoing anaesthesia with positive pressure ventilation. Note the clear variation in the variability (standard deviation) over the cardiac cycle. Figure 1 (b) illustrates the result when a Biotek Model 601-A blood pressure simulator was used instead. Note that in this instance the blood pressure variability wave disappears (standard deviation is relatively constant and much smaller). Similar blood pressure variability waves to that shown in Figure 1(a) were obtained in all of five other patients studied.

DISCUSSION

Although the physiological basis for the blood pressure variability wave is not immediately clear and has not to our knowledge, been previously described, failure to obtain similar waves from an electromechanical simulator sugest that the finding is genuine rather than artifactual. Nevertheless, the origin and significance of these findings are unclear at this time. Possible explanations for this phenomenon include: variation in preload over the respiratory cycle (unlikely, as the phenomenon also exists under apneic conditions); variations in QRS morphology over the respiratory cycle (also unlikely for the same reason); variability in "electromechanical activation time" due to, for example, variation in the speed of depolarization waves in the ventricles; and variation in the reflection of blood pressure waves from the periphery. Pacing studies on an animal model would likely help identify the physiological source of this phenomenon.

Figure 1 (a): [Left]. Demonstration of the "blood pressure variability wave" in an anaesthetized patient undergoing positive pressure ventilation. *Top*: Superimposition of the first 10 blood pressure waves aligned starting with the QRS complex. *Middle*: Mean blood pressure wave +/- one standard deviation plotted for each time point, based on 25 cardiac cycles. *Bottom*: Standard deviation (variability wave) following the QRS complex, based on 25 cardiac cycles.

Figure 1(b): [Right]. Demonstration of the absence of variability waves in an electromechanical blood pressure simulator (BioTek 601A). *Top*: Superimposition of the first 10 cycles. *Middle*: Mean +/- one standard deviation based on 50 cardiac cycles. *Bottom*: (Absent) variability wave based on analysis of 50 cardiac cycles. Note that the scale for this last signal is one tenth that for the Figure 1(a).



SHORT TERM COMPLICATIONS OF MYOCARDIAL INFARCTION POST CORONARY ARTERY BYPASS

D. Johnson, M.D.C.M., P. Owen, M.D., J. McMeekin, M.D., S. Hanson, B.Sc., B. Cujec, M.D.
Departments of Anaesthesia and Medicine, Royal University Hospital, University of Saskatchewan, Saskatoon, Saskatchewan

INTRODUCTION

The incidence of myocardial infarction (MI) post coronary artery bypass surgery (CABG) has been estimated to range between 2.8% to 31% with a mortality between 3% to 34% (1). This wide range in incidence of MI is due in part to the difficulty in diagnosis. The criteria for diagnosis include new Q waves on electrocardiogram (ECG), accelerated creatinine phosphokinase release, and myocardial uptake of technetium pyrophosphate (TcPy). Changes in these diagnostic modalities may be mimicked by non infarction surgical and regional myocardial necrosis or unmasking of an old infarction. The presence of MI post CABG as diagnosed by these criteria has not been associated with long term mortality at 6 months (2). We wished to assess the utility of standard criteria for assessment of MI in predicting short term (72 hours) morbidity and mortality in the intensive care unit.

METHODS

The study was approved by the University Ethics Committee. Eighty-seven consecutive patients scheduled for elective CABG were recruited. Demographic data including age, sex, smoking history, history of previous MI or CABG, presence of diabetes, angiography score of coronary anatomy, ejection fraction, New York Heart Association functional classification and frequency of chest pain per week was collected on each patient. Data was also collected concerning number of vessels grafted, cross clamp time, and total heart-lung pump time. On admission to the intensive care unit ECG were obtained at 0, 6, 24, 48 and 72 hours post admission. Total creatinine phosphokinase (CPK) and creatinine phosphokinase - myocardial fraction (CPK-MB) were analyzed at 6, 24, 48 and 72 hours postoperatively. In 56 patients TcPy scans were obtained between 24 to 48 hours postoperatively. Morbidity in the intensive care unit was assessed as total duration of stay, length of time until discharge home, presence of intra-aortic balloon pump, ventricular or superventricular arrhythmias that required intervention, use of vasopressor drugs post 6 hours admission, and congestive heart failure diagnosed as interstial or alveolar changes on daily portable chest x-ray.

Criteria for MI

MI was diagnosed on the basis of two out of three abnormal diagnostic criteria. Definitions of abnormal were:

ECG: New Q wave greater than .04 msecs in two adjacent leads in the absence of conduction abnormalities or marked QRS shift. Non specific changes included ST depression or elevation greater than 2 mm in two or more adjacent leads or T wave inversion of more than 3 mm. Non-specific changes were only included if after onset they remained constant throughout the intensive care unit stay.

Cardiac Enzymes: CPK was measured by modified CK-NAC technique using Boehringer Mannheim agents and CPK-MB was determined by agarose gel electrophoresis. Abnormality was defined as CPK-MB fraction greater than 10% of total CPK.

Technetium pyrophosphate: Scans were obtained 1 to 2 hours post injection of 15 mCi of technetium ^{99} pyrophosphate. Projections in anterior, lateral and oblique planes were obtained and care was taken to distinguish myocardial from sternal uptake.

STATISTICS

Data was analyzed by discriminate analysis using BMPD statistical software^{R} with an F exclusion value of 4. Significance was assessed as $p<0.05$.

RESULTS

A total of 7 MI were diagnosed. MI did not predict the incidence of inotrope usage (N=20), presence of arrhythmias (N=56), congestive heart failure (N=10) hours intubated (27 $\pm$ 3 hours), length of intensive care unit stay (3 $\pm$ 1 days), days until discharge home (7 $\pm$ 2 days) or readmission to the ICU (N=2). Discriminate analysis of each separate diagnostic test for myocardial infarction revealed that elevated CPK-MB predicted death (N=4) and ECG changes predicted congestive heart failure. Furthermore the only demographic data that correlated with death was the presence of previous myocardial infarction.

CONCLUSIONS

We conclude that myocardial infarction post CABG as defined by diagnostic changes in any two of electrocardiogram, creatinine phosphokinase and technetium pyrophosphate does not predict short term patient outcome in the intensive care unit.

1. Gardner MJ, et al: Perioperative Myocardial Infarction with Coronary Artery Surgery. Can J Cardiol 3:336-340, 1987.
2. Weintraub WS, et al: Determinants of Prolonged Length of Hospital Stay After Coronary Bypass Surgery. Circulation 80:276-284, 1988.

This study was supported by the Canadian Heart and Stroke Foundation.

POST-ISCHEMIA HEMODYNAMIC ALTERATION AND MALDISTRIBUTION OF MYOCARDIAL BLOOD FLOW BY NIFEDIPINE VS METOPROLOL IN A CHRONIC SWINE MODEL

D.C.H. Cheng, FRCPC; C.M. Feindel, FRCSC; J. Cruz, MD; P. Boylen, BSc; D. Ong, MD
Departments of Anaesthesia and Surgery, University of Toronto, The Toronto Hospital, Toronto Western Division, Toronto, Ontario, M5T 2S8

Introduction: Beta-adrenergic blockers have been shown to lower the incidence of perioperative myocardial ischemia in patients when compared with calcium entry blockers (1). This study compared the effects of metoprolol and nifedipine on post-ischemia hemodynamic changes and myocardial blood flow in a swine model of collateralized coronary vessels under isoflurane anaesthesia.

Methods: After institutional approval, eight piglets between 6-8 kg were operated via a left thoracotomy. The left anterior descending coronary artery (LAD) was banded to induce collateralized vessels. Ten weeks later, the pigs (approx. 30 kg) were anaesthetized with isoflurane/oxygen only with controlled ventilation. Post-sternotomy, the constriction band on the LAD was identified and ligated to ensure total occlusion. Coronary perfusion pressure (DBP minus LVEDP) was maintained at 40 mmHg. Baseline coronary blood flow (CBF) was determined by Sn-113 microspheres injected via the left atrium, and baseline hemodynamic parameters were recorded. Animals were randomized to receive either metoprolol (10 ug/kg/min) or nifedipine (5 ug/kg/min) infusion for 20 min. At the same CPP, the circumflex coronary artery that supplied the collateral vessels was occluded for a 30 sec duration to induce ischemia. Post-ischemia CBF was measured immediately by Ce-141 microspheres injection and hemodynamic parameters were recorded. Using triphenyl tetrazolium chloride staining, the collateral dependent zone (CD) distal to the LAD occlusion, and the control zone (CNT) distal to the circumflex artery were identified for regional myocardial blood flow measurements by radioactive counting.

Results: There were no significant differences within and between the metoprolol and nifedipine groups post-ischemia in CPP, SBP, DBP, LVEDP, SPAP, DPAP, PaCO2, PaO2 or PH (table 1). However, post-ischemia HR is significantly higher in the nifedipine group than in the metoprolol group (figure 1). Regional myocardial blood flow was well maintained in the metoprolol group post-ischemia. However, the post-ischemia transmural subendocardial to epicardial blood flow ratio (SE/EPI) in the CD zone was significantly lower in the nifedipine group. When compared to the metoprolol group, the post-ischemia intercoronary (CD/CNT) blood flow ratio in both SE and EPI regions was significantly lower in the nifedipine group (table 2).

Table 1:

PARAMETERS	METO (n=4) PRE	METO (n=4) POST	NIFE (n=4) PRE	NIFE (n=4) POST
CPP (mmHg)	41.7 ±1.3	41.2 ±1.5	40.7 ±1.5	36.4 ±2.5
SBP (mmHg)	93 ±5	92 ±9	89 ±6	84 ±2
DBP (mmHg)	54 ±8	60 ±11	56 ±5	53 ±5
LVEDP (mmHg)	12.3 ±7.4	18.8 ±9.5	15.3 ±4.2	16.6 ±4.7
SPAP (mmHg)	21.2 ±4.3	22.5 ±5.3	30.7 ±6.9	31.7 ±11.7
DPAP (mmHg)	14.7 ±3.7	15.5 ±3.7	18.0 ±2.8	19.7 ±3.6
pCO_2 (mmHg)	37.5 ±5.2	39.7 ±4.0	39.2 ±1.9	39.2 ±2.2
pO_2 (mmHg)	493 ±74	533 ±48	379 ±49	362 ±58
pH	7.46 ±.09	7.44 ±.05	7.43 ±.04	7.42 ±.03

* Data expressed in $\bar{x} \pm SD$

Figure 1:

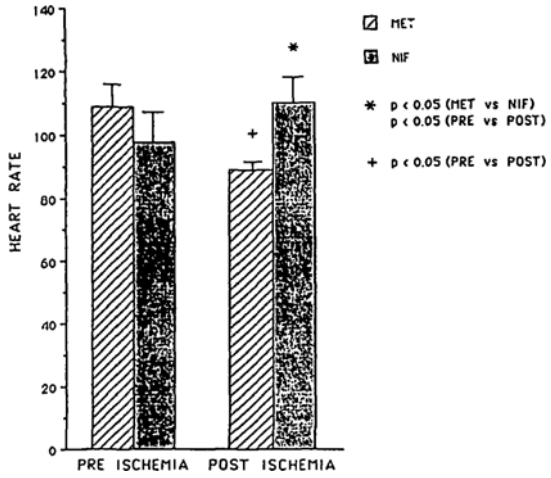


Table 2:

Coronary Blood Flow Ratio	METO (n=4) Pre	METO (n=4) Post	NIFE (n=4) Pre	NIFE (n=4) Post
SE/EPI CD	1.14 ± 0.24	0.91 ± 0.12	1.01 ± 0.16	0.44 ± 0.26*
SE/EPI CNT	1.12 ± 0.22	1.04 ± 0.18	0.98 ± 0.17	0.68 ± 0.26
CD/CNT SE	0.79 ± 0.08	0.94 ± 0.11	0.66 ± 0.15	0.27 ± 0.10*+
CD/CNT EPI	0.80 ± 0.20	1.00 ± 0.11	0.64 ± 0.10	0.40 ± 0.23+

Mean ± SD
* p<0.05 within group
+ p<0.05 between group

Discussion: In a chronic swine model with collateralized coronary vessels, nifedipine caused significant tachycardia in association with transmural and intercoronary blood flow maldistribution when compared to metoprolol, during controlled myocardial ischemia under isoflurane anaesthesia. The tachycardia and maldistribution of myocardial blood flow may contribute to the higher incidence of myocardial ischemia detected in CAD patients on calcium entry blockers compared to beta-adrenergic blockers.

References:

1. Anesthesiology 69:343-347, 1988.

This study was supported in part by the David Sheridan Research Award.

A RANDOMISED STUDY OF PROPOFOL-SUFENTANIL VS. ENFLURANE-SUFENTANIL ANAESTHESIA IN PATIENTS UNDERGOING CORONARY ARTERY REVASCULARISATION SURGERY: EFFECTS ON MYOCARDIAL METABOLISM

RI Hall MD,FRCPC, JT Murphy MD,FRCPC, EA Moffitt MD,FRCPC and the Maritime Heart Centre

Department of Anaesthesia, Victoria General Hospital and Dalhousie University, Halifax, NS, Canada B3H 2Y9. Supported by a grant from ICI Pharmaceutica, Wilmington, Delaware.

Introduction: Little information is available concerning the effect of propofol (PROP) on myocardial metabolism. This randomised study of patients with preserved ventricular function undergoing elective coronary artery revascularisation surgery (CABG) sought to compare the effects of propofol-sufentanil anaesthesia to sufentanil-enflurane anaesthesia on myocardial blood flow and metabolism (i.e. changes in myocardial lactate extraction (MLE)).

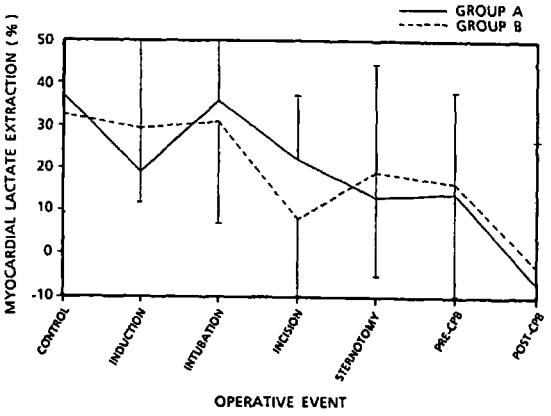
Methods: Following institutional approval and informed consent, 40 patients with preserved ventricular function undergoing elective CABG were studied. All concurrent cardiac medications were continued and a standardised premedication given. Monitors placed included a coronary sinus catheter. Patients were then randomised to one of two groups. Group A received sufentanil (SUF) 0.2 $\mu g.kg^{-1}.min^{-1}$ IV over 1 min followed by PROP 1-2 $mg.kg^{-1}$ IV over 1-3 min. A variable rate continuous infusion of PROP (50-200 $\mu g.kg^{-1}.min^{-1}$) was initiated and maintained throughout the case (50 $\mu g.kg^{-1}.min^{-1}$ during cardiopulmonary bypass (CPB)). Responses to noxious stimulation uncontrolled by PROP were treated by SUF 1 $\mu g.kg$ bolus (maximum cumulative dose 5 $\mu g.kg^{-1}$). Pancuronium maintained neuromuscular blockade. Diazepam (DIAZ) 0.15 $mg.kg^{-1}$ was administered prior to CPB and 0.05 $mg.kg^{-1}$ at skin closure. Group B received SUF 5 $\mu g.kg^{-1}$ IV over 1-3 min for induction of anaesthesia and maintenance anaesthesia was provided by enflurane (NF) (0.25-3% inspired). Responses to noxious stimulation not controlled by NF were treated by additional doses of SUF (maximum cumulative dose 7 $\mu g.kg^{-1}$). DIAZ and pancuronium were administered as for Group A. In addition to hemodynamic variables, coronary sinus blood flow (CSBF), coronary vascular resistance (CVR), myocardial oxygen consumption (MVO_2), systemic and coronary sinus blood gases and lactate levels were measured at 1) awake, sedated (AWAKE), 2) post-induction (IND), 3) post-intubation (ETT), 4) first skin incision (INC), 5) sternotomy (ST), 6) just prior to initiation of CPB (CPB) intervals. Calculated parameters included MLE. A repeated measures ANOVA or chi-square determined statistical differences ($p<0.05$) between the groups. A power analysis determined a 78% probability of detecting a difference in myocardial lactate extraction of 20% between the two groups with $\alpha=0.05$ when 20 patients per group were studied.

Results: For any of the measured or calculated myocardial metabolic parameters (Table)(Figure), including MLE or the absolute number of myocardia producing lactate at some point (n=13 in each group), no statistically significant differences between the two groups were detected at any interval prior to CPB. The greatest hemodynamic changes occurred on induction of anaesthesia.

TABLE. Changes in Myocardial Flow and Metabolism in CABG Patients Receiving Either Propofol-Sufentanil (Group A, n=20) or Sufentanil-Enflurane (Group B, n=20) Anaesthesia. (Mean±SD).

PARAMETER	AWAKE		IND		ETT	
	PROP	ENF	PROP	ENF	PROP	ENF
MLE(%)	37±18	33±23	19±38	29±17	36±19	31±24
CSBF(ml/min)	134±52	107±56	101±38	109±50	114±50	84±32
CVR(mmHg/ml/min)	0.7±0.4	1.0±0.7	0.7±0.6	0.8±0.6	0.7±0.2	1.0±0.6
MVO_2(ml/min)	13±5	13±6	10±4	13±7	11±5	10±4

FIGURE. Changes in Myocardial Lactate Extraction (MLE) in CABG Patients Receiving EIther Propofol-Sufentanil (Group A, n=20) or Sufentanil-Enflurane (Group B, n=20) Anaesthesia. (Mean±SD).



Discussion: In patients with preserved ventricular function undergoing CABG, PROP-SUF was not associated with an increased incidence or degree of myocardial ischaemia when compared to NF-SUF anaesthesia. No differences existed between the two anaesthetic techniques with respect to alteration in myocardial blood flow or coronary vascular resistance.

References:

Stephan H, Sonntag H, Schink HD, et al: Br J Anaesth 1986;58:969-975.

AMRINONE VERSUS DOBUTAMINE FOR TREATMENT OF LOW CARDIAC OUTPUT AFTER CORONARY ARTERY SURGERY

JY Dupuis, M.D., HJ Nathan, M.D., C Cattran, M.D., JE Wynands, M.D.

Department of Anaesthesia, Ottawa Civic Hospital, 1053 Carling Ave., Ottawa K1Y 4E9

Amrinone (Amr) and dobutamine (Dob) are used with comparable efficacy for treatment of congestive heart failure[1]. However the two drugs have never been compared in situation of myocardial depression following global ischemia and reperfusion of the heart. This is the first randomized study where Amr and Dob are compared as primary and sole treatment of low cardiac output (CO) following coronary artery bypass graft (CABG) surgery with cardiopulmonary bypass (CPB).

Methods: With institutional approval, sixty-five patients with poor left ventricular (LV) function (ejection fraction ≤ 40% or abnormal contraction of more than 50% of the LV in the right anterior oblique view during contrast ventriculography) gave informed consent to participate in this open prospective randomized study. Low CO following CABG surgery (including redos) was the inclusion criteria even if the blood pressure was satisfactory. Low CO was defined as cardiac index (CI) less than 2.4 l/min/M^2 in presence of pulmonary capillary wedge pressure (PCWP) of 15 to 18 mmHg, hemoglobin > 80 g/l and normal ionized calcium and electrolytes. Valvular or combined procedures (valve and CABG), significant renal or hepatic dysfunction, thrombocytopenia (<100,000 platelets/mm^3), serious dysrhythmia, prior use of inotropic therapy other than study drugs or intra-aortic balloon pump (IABP) were exclusion criteria. All usual antianginal drugs were continued until surgery. Standard premedication and anaesthesia (sufentanil and muscle relaxant supplemented with isoflurane when necessary) were used in all cases. Routine cardiac monitoring included ECG leads II and V_5, radial arterial cannula and pulmonary artery (PA) catheter allowing measurement of continuous mixed venous oxygen saturation (SvO_2) and cardiac output by thermodilution. Myocardial protection during aortic cross-clamping was with cold potassium cardioplegia, topical cooling and systemic hypothermia (30 to 32 °C).

After completion of coronary bypasses, the patients were stratified into 2 blocks for randomization according to their ability to separate from CPB: 1) those requiring test drug post separation and 2) those requiring test drug to separate from CPB. The treatment objective was to achieve CI > 2.4 l/min/M^2 and mean arterial pressure (MAP) ≥ 70 mmHg. The drug regimen was for the Amr group 0.75 mg/kg bolus followed by a maintenance infusion of 10 µg/kg/min; when the objectives were not achieved, another 0.75 mg/kg bolus and a third bolus of 0.5 mg/kg were given. For dobutamine, the initial dosage was 5 µg/kg/min increased stepwise to 15 µg/kg/min as indicated. If the treatment objectives were not achieved within 10 min of maximal therapy with the primary agent, then dopamine (dopa) was added starting at 5 µg/kg/min and increased stepwise to 15 µg/kg/min when necessary. If maximal combination therapy was inadequate, the alternate primary agent (Amr or Dob) was added. Heart rate (HR), systolic and diastolic blood pressure (SBP and DBP), MAP, mean PA pressure, central venous pressure (CVP), PCWP, CO and SvO_2 were recorded before treatment, then every 5 min for the first half hour and every 15 min for the next 2.5 h following beginning of treatment. Arterial blood gases were measured every 15 min throughout the study to document any metabolic acidosis. Treatment was considered successful only when the objectives were achieved with the primary agent alone.

Data was analyzed by ANOVA for repeated measures and Dunnett's t-test, 2-tail Fisher's exact test and multiple t-test. $P \leq .05$ was considered significant.

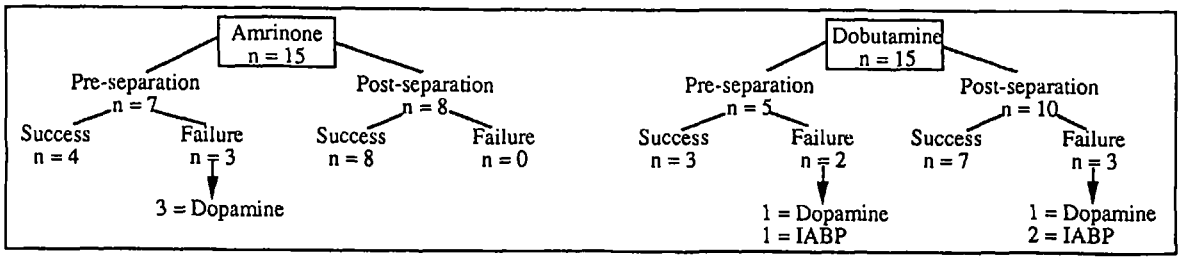
Results: Thirty patients met the study criteria and were randomized in the 2 treatment groups. The number of patients who were successfully treated with each agent is shown in the figure. No significant difference was found. Three patients in the Amr group needed dopa to separate from CPB. In the Dob group, 1 patient had dopa and one IABP to separate from CPB; one was given dopa after CPB and IABP was used in the other 2 without dopa being given due to tachycardia. Comparisons of hemodynamic values over time showed no significant difference between the groups. Although not reaching statistical significance, some trends were evident: MAP and systemic vascular resistance fell with Amr, but rose with Dob; CI and SvO_2 rose more with Amr than Dob.

Discussion: Our data suggest that as primary agent to improve cardiac output following CABG surgery, Amr and Dob have the same efficacy. The beneficial effect of Amr on the myocardial function is partly due to peripheral vasodilation, however this did not increase the need for dopamine in the group of patients treated with Amr. Forty-six percent of the enrolled patients with poor preoperative LV function met the study criteria : this high percentage reemphasizes the correlation between preoperative LV dysfunction and need of inotropic support after cardiac surgery.

References:

1) Klein NA, Siskind SJ, Frishman WH, Sonnenblick EH, LeJemtel TH. Am J Card 1981; 48: 170-5.

Figure : Successful and failed treatments in each group pre- and post-separation from CPB.



MYOCARDIAL OXYGENATION AND ISCHAEMIA IN NORMOTENSIVE PATIENTS UNDERGOING CORONARY REVASCULARIZATION

JT Murphy MD, EA Moffitt MD, RI Hall MD, AJ McIntyre MD, CE Kinley MD, JA Sullivan MD, RW Landymore MD

Department of Anaesthesia and Division of Cardiovascular Surgery, Dalhousie University and Maritime Heart Centre, Victoria General Hospital, Halifax, Nova Scotia, Canada, B3H 2Y9

Introduction: A randomized study of the major anaesthetic agents given for coronary artery bypass grafting (CABG) has shown no effect on intraoperative ischaemia or patient outcome.[1] A study on perioperative ischaemia in patients undergoing vascular surgery has suggested that the preoperative ischaemia pattern be examined in order to predict the risk of intraoperative ischaemia.[2] The objective of this study was to examine the haemodynamics, myocardial oxygenation and lactate balance, coronary sinus blood flow (CSBF), and incidence of perioperative ischaemia in 40 randomized CABG patients given enflurane (**ENF**), isoflurane (**ISO**) or sufentanil (**Suf**) by infusion, after **Suf** or fentanyl (**Fen**) for induction.

Methods: With institutional approval and informed consent, 40 normotensive males with preserved ventricular function were studied. Chronic cardiac medications were maintained. Premedication was standardized. Supplemental i.v. diazepam (mean dose 7.3 mg) was given prior to insertion of arterial (A), pulmonary artery and coronary sinus (CS) catheters. Patients randomly received one of the following anaesthetic protocols: **Group 1**: **Suf** 4 $\mu g \cdot kg^{-1}$ for induction (IND) -> **ENF** for maintenance (MAIN); **Group 2**: **Fen** 30 $\mu g \cdot kg^{-1}$ (IND) -> **ENF** (MAIN); **Group 3**: **Suf** 4 $\mu g \cdot kg^{-1}$ (IND) -> **ISO** (MAIN); **Group 4**: **Suf** 6 $\mu g \cdot kg^{-1}$ (IND) -> **Suf** 1.44 $\mu g \cdot kg^{-1} \cdot hr^{-1}$ + **ENF** (MAIN). Pancuronium (0.1 $mg \cdot kg^{-1}$) and oxygen were used in all groups. **ENF** or **ISO** was administered five minutes after injection of the opioid if systolic blood pressure had not been reduced by 25% and subsequently titrated to keep systolic blood pressure lower than control during maintenance. Following a control study in the awake patient (pre-induction), serial studies were performed post-induction and intubation, pre- and post-sternotomy, twice after cardiopulmonary bypass (CPB) and at 1 and 24 hours postoperatively. Measurements included standard haemodynamics, CSBF, blood gases (A and CS), and lactate (A and CS). Myocardial oxygen consumption and myocardial lactate production (MLP) were calculated. ECG lead V5 was recorded intraoperatively and ST segment depression measured 40 ms after the J-point. Ischaemia was defined by ST segment depression or elevation > 0.1 mv (ECG ischaemia) or MLP (MLP ischaemia). Pre- and postoperative ECGs were reviewed for the presence of any ST segment changes. Repeated measures analysis of variance (Systat ver. 4), or Fisher exact tests determined differences within and between groups ($p<0.05$).

Results: Analyses of patient demographics and operative characteristics showed no differences between groups. There were no between group differences in any variable at any study time due to the anaesthetic. Mean arterial pressure (MAP) was lowest at post-induction and was maintained lower than control at the other intraoperative study times.

Haemodynamics: **40 PATIENTS (mean ± SD)**

	PRE-INDUCTION	POST-INDUCTION
Heart Rate (bpm)	57±13	62±13
M A P (mm Hg)	88±8	67±7 **
Wedge P (mm Hg)	14±4	11±4
Coronary Perfusion Pressure (mm Hg)	49±7	40±7
Cardiac Index ($l \cdot min^{-1} \cdot m^{-2}$)	2.8±0.8	2.7±0.7

**p < 0.05

Ischaemia: There was a 48% incidence of ST segment abnormality on the preop 12-lead ECG. Ischaemia occurred at least once in 21/40 and 28/40 patients in the pre- and post-CPB periods respectively. Intraoperative myocardial ischaemia was detected in 12/40 observations (OBS) at control (abnormal preop ECG in 9/12, $p<0.05$) and 15/40 OBS at post-induction (abnormal preop ECG in 8/15). A total of 47/160 OBS satisfied criteria for ischaemia during the four pre-CPB studies (abnormal preop ECG in 30/47, $p<0.01$), while during the first three post-CPB studies 47/116 OBS (abnormal preop ECG in 22/47, $p>0.05$) were noted. The use of MLP as a marker of myocardial ischaemia increased the detection of ischaemia from 75/316 (ECG alone) to 105/316 observations. Intraoperative ECG-ischaemia correlated poorly with MLP ischaemia: 2/8 and 8/32 ($p<0.05$) ECG-ischaemia events in the control and prebypass periods were associated with MLP. Also, only 2/6 and 9/24 MLP-ischaemia events were associated with ECG-ischaemia at control and pre-CPB.

Discussion: No discernible differences in intraoperative haemodynamics or ischaemia occurred with these commonly used anaesthesia protocols. While an abnormal preop ECG was not predictive of increased incidence of intraoperative ischaemia, a normal ECG was associated with a significantly lower incidence of pre-CPB ischaemia. The poor correlation between ECG ischaemia and MLP ischaemia may reflect the regional nature of ECG V5 ischaemia compared to the likely global nature of MLP ischaemia. Nevertheless, detection of ischaemia was enhanced by adding measurement of MLP. Additional ECG leads or alternate methods of detecting myocardial ischaemia (e.g. transesophageal echocardiography) may improve the detection rate of perioperative ischaemia. These patients had decreased myocardial oxygen demand during anaesthesia. The incidences of ischaemia while awake and during pre-CPB were equal, suggesting that silent myocardial ischaemia continued during anaesthesia. Silent ischaemia is not necessarily associated with increased oxygen demand. Hence, focus on maintenance of myocardial oxygen supply in CABG patients is clearly clinically important.

References:

1.Anesthesiology 70:179-188, 1989.
2.Anesthesiology 68:681-688, 1988.

EFFECT OF DESMOPRESSIN (DDAVP) ON A HUMAN IN VITRO ATRIAL TRABECULAR PREPARATION

James A. Robblee, M.D., FRCPC, Rosalind Labow, Ph.D.

University of Ottawa Heart Institute, Department of Anaesthesia, 1053 Carling Avenue, Ottawa, Ontario, K1Y 4E9

INTRODUCTION: Desmopressin acetate (DDAVP) is a synthetic analogue of vasopressin. It is commonly administered following cardiopulmonary bypass procedures to decrease blood loss. Side effects caused by the intravenous administration of DDAVP are considered to be mild and transient. Facial flushing related to vasodilation is common. Mild hypotension and tachycardia are frequently seen. Several cases of severe hypotension associated with the use of DDAVP following cardiopulmonary bypass have now been reported. A direct effect on vascular smooth muscle has been shown to contribute to the effect.[1]

In order to further delineate the cause of hypotension following the administration of DDAVP, a study was undertaken to determine the effect of pure DDAVP and chlorobutanol, the vehicle in which it is disolved, on a human in vitro atrial trabecular preparation.

METHODS: The atrial trabecular preparation is an in vitro model using human tissue. The procedure produces a reliable, long-lasting preparation. The preparations have been used to assess the responses of a variety of drugs, potential cardiotoxins as well as being used to assess the optimal conditions for cardiac preservation.2

PHARMACOLOGICAL PROTOCOL: The protocol involved 7-8 atrial trabeculae each for:

1) Desmopressin acetate (DDAVP) 4 μg, clinical injection containing chlorobutanol 5 mg.
2) DDAVP, pure solid.
3) Chlorobutanol (1, 1, 1-tri-chloro-2-methyl-2-propranolol) - 5 mg.

A cumulative dose-response (D-R) protocol was instituted with each compound. Doses of each compound (0.2 mL of each of solutions 1,2 or 3) were added in a cumulative manner to a Krebs-Henseleit (K-H) containing bath in which the trabecula was immersed. Readings of developed force (DF) and resting force (RF) were taken 15 minutes after each dose, just prior to the addition of the next dose. The relative DF and relative RF at each dose for each trabecula were calculated as a percent of the values at L_{max} for that trabecula, so that each trabecula acted as its own control.

RESULTS: The mean values for the DF for each group of trabeculae in each treated solution were determined and plotted together for a composite graph of the D-R of the three solutions and the deterioration of the preparation by time alone (Figure 1). The 50 percent inhibition of the DF (IC^{50}) is given in table 1. The results show that the clinical preparation of DDAVP causes a more rapid decrease in DF than pure DDAVP but the decrease caused by pure DDAVP is greater than would be expected by time decay alone. The IC^{50} for clinical DDAVP occurred at 60 minutes. The concentration of DDAVP was 2.4×10^{-2} μg/kg and the concentration of chlorobutanol was 32 μg/kg. The IC^{50} for pure solid DDAVP occurs at 105 minutes. The concentration of DDAVP was 4.2×10^{-1} μg/kg. The IC^{50} for chlorobutanol occurred at 65 minutes at a concentration of 35 μg/kg. The IC^{50} over time was 150 minutes. The decrease observed in the clinical preparation is similar to the decrease observed when chlorobutanol alone is added to the preparation.

DISCUSSION: We have found that DDAVP causes direct depression of myocardial muscle tissue. Although pure DDAVP causes myocardial depression, the effect of the clinical preparation containing chlorobutanol as a preservative causes a more profound decrease in DF. The degree of myocardial depression observed with the clinical preparation of DDAVP is similar in magnitude to the degree of myocardial depression observed for chlorobutanol alone. Concentrations studied were ten times observed clinical concentrations. Rapid injection may cause concentrations of DDAVP and chlorobutanol to rise to levels capable of causing severe myocardial depression. The sporadic occurrence of hypotension in patients receiving DDAVP following cardiopulmonary bypass could be caused by use of the drug in patients with pre-existing myocardial depression and/or by rapid administration of the drug.

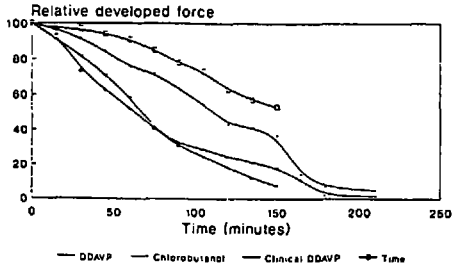
We conclude that DDAVP should be used with caution in patients following cardiopulmonary bypass.

REFERENCES:

1. Johns RA. Desmopressin is a potent vasorelevant of aorta and pulmonary artery isolated from rabbit and rat. Anaes 72:858-864, 1990.

2. Keon WJ, Taichman GC, Mainwood GW. Human atrial trabeculae: An experimental preparation for studying myocardial response to perioperative manipulations. Can J Surg. 1984;27:372-377.

DDAVP and Chlorobutanol
Dose response curves



Effect of DDAVP on Atrial Trabecular Preparation

Table 1

Preparation	Inh. Agent	IC^{50}	Time
Clinical DDAVP*	DDAVP	2.4×10^{-2}	60
	Chlorobutanol	32	60
DDAVP Solid**	DDAVP	4.2×10^{-1}	105
Chlorobutanol	Chlorobutanol	35	65
Time	-	-	150

* Pharmacological preparation containing chlorobutanol as a preservative

** Pure solid dissolved in buffer

ONSET AND TIMING OF POST-OPERATIVE ISCHEMIC EPISODES

W.S. BEATTIE, M.D., D.N. BUCKLEY, M.D.
Department of Anaesthesia, McMaster University Medical Centre, 1200 Main Street West, Hamilton, Ontario, Canada L8N 3Z5

Introduction:

The risk of post-op morbidity and mortality is increased in patients with ischemic episodes. Post-op ischemia has been associated with hemodynamic alteration (tachycardia & hypotension), however, the timing of these events is unknown. Non-operative ischemia has been shown to have a circadian rhythm. Factors such as pain, atelectasis, and sleep deprivation may change any intrinsic rhythm. The purpose of the present study was to note the frequency, timing, and parameters associated with ischemia in the first 24 hours post-op.

Method:

Patients: After informed consent, 42 patients with risk factors for coronary disease wore a 2 channel Holter Monitor with ST segment capabilities for 24 hours post-op.

All patients were having either peripheral vascular surgery or major joint replacement. The anaesthetic in all cases included tracheal intubation and ventilation with a balanced technique.

Post-operative Care: Patients were transferred to the PAR and monitored for a mean of 2.14 hr (1.0-3.5 hr) whereupon they were transferred to the ward. Post-op analgesia consisted of intravenous morphine on a PRN basis.

Detection of Ischemia: Holter tapes were analyzed by a blinded independent observer. Ischemia was defined as 1 mm or greater ST depression, 80 msec after the J point. ST depression had to be sustained for more than 60 sec. ST segment had to return to baseline for more than 1 min for subsequent episodes to be defined as distinct ischemic events.

Results:

The mean age of patients was 68.2 yrs (61-78). 12 patients had 27 episodes of ischemia. Ischemic episodes occurred at 3 time periods post-operatively: the 1st hour (n=6), at around 12 hrs (n=14), and at 23 hrs (n=7). Characteristics of these episodes are seen in Table 1. Later episodes were longer and occurred at lower heart rates than those occurring in the recovery room. There is a marked circadian variation to the later ischemia. (Figure 1) None of the ischemia was symptomatic or detected by the attending staff.

Discussion:

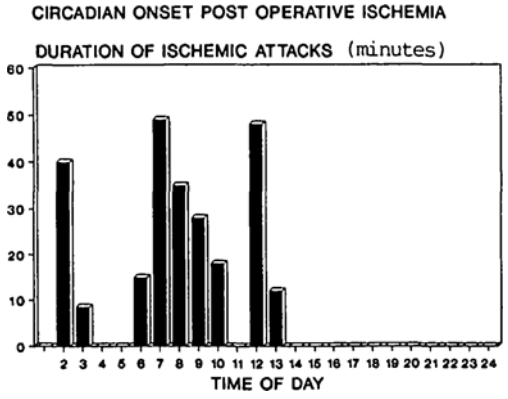
One third of the ischemic episodes occurred without tachycardia (less than 10% change in heart rate). While this study did not measure continuous BP, there was no hypo- or hypertension noted. The non-tachycardic ischemia may be associated with altered coronary resistance. The circadian onset has been previously described in non-surgical ischemia.

Table 1

CHARACTERISTICS OF POST-OP ISCHEMIA

	Time of Day Mean	(Range)	Hours Post-Op	HR-Onset	HR-Mean	Duration
Par	1109	(9-14)	1	120 (88-144)	92 (68-133)	5.3 (1-12)
WD	0645	(2-12)	16.7 (11-23)	78 (54-102)	85 (75-133)	14.9 (1-37)

Figure 1



The Effect of Combined Alfentanil and Midazolam Anaesthesia on the Normal A-V Conduction System and Accessory Pathways in Patients with Wolff-Parkinson-White Syndrome.

W.B. Dobkowski, M.D., FRCPC, J.M. Murkin, M.D., FRCPC, M.D. Sharpe, M.D., FRCPC, G. Guiraudon, M.D., FRCSC, FACC, G. Klein, M.D., FRCPC, R. Yee, M.D., FRCPC, FACC
Departments of Anaesthesia, Cardiovascular Surgery & Cardiology, University Hospital, University of Western Ontario, London, Ontario, Canada

INTRODUCTION:

A safe anaesthetic technique for patients with Wolff-Parkinson-White (WPW) or other pre-excitation syndromes has not been developed yet.[1,2] Recent reports [3,4] have shown that administration of IMAC Isoflurane and Halothane depresses conduction in normal accessory pathways (AP). Fentanyl is known to reduce heart rate via a central mechanism and Morphine has direct negative chronotropic and dromotropic actions.[1] Sufentanil is presently under investigation in our institution. The purpose of this study was to investigate the effect of combined technique, Alfentanil and Midazolam, on the electrophysiologic (EP) properties of the normal atrioventricular (A-V) conduction system and also on accessory pathways in a similar group of patients with WPW Syndrome, undergoing cryoablation of the accessory pathways.

METHODS:

Following approval from the institutional committee on human research, 8 patients (6 men & 2 women) aged 20-38 were investigated. All patients were otherwise healthy. Diagnostic electrophysiologic (EP) studies, using transvenous endocardial electrodes were performed in the EP Laboratory. EP studies protocol was as follows:

1. Right atrial refractory period determination (RARP) at cycle length 500msec (including atrial ERP, AV nodal ERP, accessory pathway ERP where relevant). Coupling intervals in steps of 20msec, (300-400), and 10msec below 300msec.
2. Right atrial refractory period (RARP) determination at cycle length 400, measurements the same as above.
3. Right ventricular refractory period (RVRP) determination at cycle length 400: (ventricular refractory period, (VRP) retrograde accessory pathway refractory period (RAPRP) and where applicable ventriculoatrial conduction system refractory period (VRP)). All recordings will be made on paper at a paper speed of 10mm per second. Analysis subsequently.
4. Shortest cycle length (SCL) with 1:1 conduction (including normal AV (SCL-AV) and accessory pathway (SCL-AP)).

On the day of surgery, patients were premedicated with Lorazepam (0.06mg/kg po). Anaesthesia was induced with Alfentanil 50μg/kg, Midazolam 0.15mg/kg and Vecuronium 20mg and was maintained with continuous infusion of Alfentanil 2μg/kg/min and intermittent doses of Midazolam (2-5mg) every 45 minutes. Positive pressure ventilation with air/O_2 was implemented to maintain normocapnea. Other monitors included arterial line, CVP catheter, Foley catheter and nasopharyngeal temperature probe. After sternotomy EP studies with above protocol, using hexapolar epicardial electrodes, placed on the (R) atrium and (R) ventricle were repeated. For statistical analysis comparison of EP studies pre-operatively and during Alfentanil-Midazolam anaesthesia was done using a paired students T-test. Results are shown as mean ± standard deviation (SD).

RESULTS:

Arterial blood gases, electrolytes (including Ca++ and Mg++) and E_tCO_2 were within normal limits. All accessory pathways were identified and successfully cryoablated. We have not found any statistically significant prolongation in normal A-V and accessory pathways conduction under Alfentanil-Midazolam anaesthesia. (see table)

DISCUSSION:

These results, obtained from a relatively small but homogenous group of patients, have shown that the combined technique with Alfentanil and Midazolam has no significant effect on the electrophysiologic properties of the normal A-V and pathological pathways conduction in patients with WPW Syndrome. It could suggest:

1. Alfentanil-Midazolam anaesthesia should not increase the incidence of arrhythmias in WPW patients undergoing cardiac and non-cardiac surgery.
2. Does not interfere with intraoperative mapping during WPW surgery.
3. Could be used as an alternative technique for patients with other pre-excitation syndromes.

REFERENCES:

1. Y.L. Atlee, Z.Y. Bosnjak, Mechanism for Cardiac Dysrhythmias During Anaesthesia, Anesthesiology 72:3347-374, 1990.
2. D. Lubarsky et al, Anaesthesia Unmasking Benign Wolff-Parkinson-White Syndrome, Anesthesia & Analgesia 68:172-174, 1988.
3. M.D. Sharpe et al, Halothane Depresses Conduction of Normal and Accessory Pathways During Surgery for Wolff-Parkinson-White Syndrome, Anesthesia & Analgesia 70:S1-S450, 1990.
4. W.B. Dobkowski et al, The Effect of Isoflurane (IMAC) on the Normal AV Conduction System and Accessory Pathways, Anesthesia & Analgesia 70:S1-S86, 1990.

TABLE

Antegrade Conduction (msec)

	# Pts	Control	Alf & Mid
RAERP	8	215±18	209±21
AVN-ERP	8	264±24	250±19
AP-ERP	8	322±52	311±46
SCL-AP	8	306±60	312±50

Retrograde Conduction (msec)

	# Pts	Control	Alf & Mid
RVERP	8	206±22	214±28
APERP	6	252±28	238±30
SCL-AP	7	304±66	288±54

mean±SD, Alf=Alfentanil, Mid=Midazolam

METABOLIC AND ENDOCRINE EFFECTS OF PROPOFOL DURING CARDIOPULMONARY BYPASS IN CHILDREN.

GJA Laycock FFARCS, IM Mitchell FRCS, NS Morton FFARCS, RW Logan FRCP(GLAS) & J Black FIMIS.
ROYAL HOSPITAL FOR SICK CHILDREN, GLASGOW SCOTLAND.

INTRODUCTION

Cardiopulmonary bypass (CPB) can be associated with multiorgan damage resulting in both immediate and long term effects [1]. In part this damage may be related to inadequate regional tissue oxygen delivery, and to the well documented "stress response" seen during and after CPB [2]. Metabolic depression additional to hypothermia can be achieved with thiopentone or isoflurane titrated to EEG suppression [3] and may result in reduced cerebral damage [4]. Also a reduction in the stress response to non cardiac surgery in children is associated with an improved postoperative outcome [5,6]. Propofol has been shown to suppress the EEG [7] and reduce whole body oxygen uptake (VO2) during hypothermic CPB (28C) in adults [8]. The aim of this study was to examine the effect of propofol given during CPB on the resultant metabolic and endocrine responses in children.

METHODS

After ethical approval and informed parental consent, 20 children undergoing elective open heart surgery were studied (excluding complex cyanotic abnormalities and age<1). Anaesthesia was standardized, based on fentanyl 50ug/kg and enflurane before CPB and midazolam 0.1mg/kg at the onset of CPB. During CPB moderate hypothermia (25-28C), non-pulsatile perfusion and pH stat management were employed. Pump flows were 2.4 l/min/m2 reducing to 1.2-1.6 l/min/m2 during stable hypothermia. The pump was primed with Ringers lactate and blood,to achieve a Hct of 25%. Methylprednisolone 10mg/kg was added to the pump prime. After randomization, half the children received propofol titrated to EEG suppression throughout CPB (for details see adjoining abstract). Blood samples for determination of haemoglobin concentration, oxygen saturation & pO2 were aspirated from the venous and arterial ports of the oxygenator during stable hypothermia and at normothermia before termination of CPB. Oxygen content and then oxygen delivery (DO2) and oxygen uptake (VO2) were calculated. Venous blood was also sampled post induction (PI), at the start of CPB (SB), the end of CPB (EB), and 3 & 24hrs post CPB for hormone measurements. Data were analysed using analysis of variance, Mann-Whitney U and Wilcoxon tests as appropriate. A significance level of 5% was used.

RESULTS

There were no significant differences in age, weight or duration of CPB between the two groups (see adjoining absract). Oxygen deliveries (DO2) were higher at both temperatures in the propofol group although these were not statistically significant. Despite this, oxygen uptakes (VO2) were lower in the propofol group, this being statistically significant at 37C. Propofol also significantly reduced the glucose and cortisol responses to CPB, but had no effect on T3 or blood lactate.

TABLE 1 [mean(SD)]

	25-28C		37C	
	CONT	PROP	CONT	PROP
DO2	157(39)	181(63)	266(52)*	287(39)*
VO2	45(22)	28(13)	101(26)*	82(13)*+

+P<0.05 (between cont. & prop. gps.)
*P<0.005(comparing within gps.from 25-28C to 37C)

Glucose — TABLE 2 [mean(SD)]

	PI	SB	EB*	3	24
C	7.4(2.4)	7.2(2.8)	9.8(2.6)	8.8(2.1)	5.9(1.3)
P	5.5(1.3)	6.6(2.1)	7.6(2.0)	7.8(1.7)	6.0(1.7)

(mmol/l) *P<0.05 (between cont. & prop. gps.)

Cortisol+

	PI	SB	EB**	3**	24
C	306(159)	2151(2148)	3246(989)	1221(671)	93(45)
P	199(102)	1200(878)	1364(588)	411(206)	227(155)

(umol/l) **P<0.001 (between cont. & prop. gps.)

T3+

	PI	SB	EB	3	24
C	2.1(0.34)	1.76(0.3)	1.70(0.34)	1.60(0.3)	0.75(0.2)
P	2.1(0.26)	1.87(0.3)	1.77(0.25)	1.56(0.2)	0.74(0.2)

(nmol/l) P-ns (between cont. & prop. gps.)

Lactate

	PI	SB	EB	3	24
C	2.3(0.9)	5.4(1.2)	4.1(1.1)	2.6(1.1)	1.4(0.4)
P	2.1(0.5)	5.4(1.6)	3.8(1.1)	1.5(0.6)	2.1(0.7)

(mmol/l) P-ns (between cont. & prop. gps.)
(+ values at SB,EB & 3 corrected for haemodilution)

DISCUSSION

Increasing anaesthetic depth [1], potentiation of the protective effects of hypothermia (particularly during rewarming), prevention of hyperglycaemia [9] and attenuation of the stress response may all be important in reducing the detrimental effects of CPB. This study indicates that propofol when given in doses sufficient to suppress the EEG during CPB, can reduce both whole body oxygen requirements (VO2) and the glucose and cortisol responses to CPB in children. The reduction in VO2 was not associated with an increase in blood lactate. Propofol may therefore be a useful agent in reducing the unwanted effects of CPB.

REFERENCES

1. Cardiopulmonary Bypass: Current Concepts and Controversies. Ed JH Tinker. WB Saunders 1989.
2. J. Thorac. Cardiovas. Surgery.. 1988;36:65-74.
3. Anesthesiology 1987;67:218-224.
4. Anesthesiology 1986;64:165-170.
5. Lancet 1987;Jan 31:243-247.
6. B.M.J. 1988;296:668-672.
7 & 8. J. Cardiothoracic anesthesia (in press).
9. Anesthesiology 1990;72:812-815.

INCIDENCE OF MYOCARDIAL DYSFUNCTION IN PATIENTS UNDERGOING EMERGENCY SURGERY

J. H. Devitt MD MSc FRCPC, R. F. McLean MD FRCPC, B. A. McLellan MD FRCPC, J. Dubbin MD FRCPC, L. E. Ehrlich MD FRCPC
From the Departments of Anaesthesia, Emergency Services, Medicine and Radiology, Sunnybrook Health Science Centre, University of Toronto, Toronto, Ontario.

Introduction: There is little data on the frequency of myocardial contusion in patients presenting for emergency surgery. Previous reports suffer from deficiencies of either not confining the study to the immediate post-injury period or using unreliable diagnostic techniques to confirm the presence of myocardial contusion[1,2]. As a level I trauma unit we undertook a prospective review to determine the frequency and effect of myocardial contusion in the peri-operative period.

Methods: All patients with blunt thoracic trauma as defined by an Abbreviated Injury Score of 2 or greater in the thoracic region including single rib fractures were identified on admission. Those undergoing emergency surgery within 24 hours of admission were studied. Demographic data collected included age, Injury Severity Score (ISS) and intra-operative mortality. The anaesthetist providing the anaesthetic was given a questionnaire to be filled out at the time of surgery. Data requested included intra-operative dysrhythmias requiring treatment, lowest recorded systolic arterial pressure and etiology of hypotension if present. Radionuclide angiography (RNA) was obtained within 72 hours of admission. Right and left ventricular ejection fractions and wall motion studies were performed. Interpretation of the RNA was accomplished by a cardiologist and nuclear physician blinded to the patients' condition. An attempt was made to obtain autopsies on all patients enrolled in the study who died. The diagnosis of myocardial contusion was suspected if the right ventricular ejection fraction (EF) was less than .4, left ventricular EF less than .5 or wall motion abnormalities were detected. It was confirmed if a contusion was seen at thoracotomy or at autopsy. Patients without any evidence of myocardial contusion were designated Group I and those with Group II. Groups I and II were then compared with respect to age, ISS, mortality, frequency of treated dysrhythmias and frequency of intra-operative hypotension, defined as a systolic arterial pressure of less than 80 mm Hg. Ages and ISS were compared statistically using a t-test while mortality, treated dysrhythmias and hypotension were compared with Chi square. $P<0.05$ was considered significant.

Results: The study was conducted over a 15 month period from January 1, 1989 to March 31, 1990. One hundred and thirteen patients required emergent surgical procedures within first 24 hours after admission fit the study criteria. Thirteen patients were not studied because of our inability to obtain RNA or autopsy data. Of the remaining 100 patients, 92 did not have evidence of myocardial contusion (Group I) while 8 patients presented to the operating room with evidence of myocardial contusion (Group II). Myocardial contusion was diagnosed in 3 patients by RNA, 3 at autopsy and 2 at thoracotomy. Five patients with suspected myocardial contusion survived the operating room.

Mean age and ISS of Group I and II patients is presented in table I. Both groups had similar ages but group II had a significantly greater severity of injury. Seven patients died during surgery for an intra-operative mortality rate of 6.2%. Cause of death was attributed to hypovolemia in 6 instances and closed head injury in the other. The intra-operative mortality in group I was 2.2% and 37.5% in group II. This difference was significant ($P<0.005$). After the patients who expired intra-operatively were excluded, the frequency of hypotension and intra-operative dysrhythmias was analyzed and presented in table II. While group II patients tended to have a greater incidence of dysrhythmias and hypotension the difference was not statistically significant.

Table I

Age and ISS mean (St Dev)

	Age	ISS
Group I	33.8 (16.8)	33.5 (12.0)
Group II	38.9 (19.0)	50.4 (17.6)
	NS	P<0.001

Table II

Frequency of Hypotension and Dysrhythmias

	Hypotension	Dysrhythmias
Group I	8.9%	5.6%
Group II	25.0%	12.5%
	NS	NS

Discussion: The incidence of myocardial contusion in patients with blunt thoracic trauma appears to be small, and smaller still in those patients who survive the operating room. Patients with a suspected myocardial contusion had a higher mortality rate and ISS indicating a greater severity of injury. The leading cause of intra-operative death was attributed to hemorrhage. This would suggest that myocardial contusion is a marker for the severity of injury rather than an independent risk factor. The frequency of hypotension and dysrhythmias was also greater in those patients with a suspected myocardial contusion. The most likely explanation is that these patients were more severely injured than those where a myocardial contusion was not suspected. Anaesthetic management then should be directed towards the other underlying injuries.

References:

1. Eisenach JS, Nugent M, Miller FA, Muchta P. Echocardiographic Evaluation of Patients with Blunt Chest Injury: Correlation with Peri-operative Hypotension. Anesthesiology 1986: 64,364-366.
2. Fabian TC, Mangiante EC, Patterson CR, Payne LW, Isaacson ML. Myocardial Contusion in Blunt Trauma: Clinical Characteristics, Means of Diagnosis and Implications for Patient Management. Journal of Trauma 1988:28,50-56

Supported by Physicians' Service Incorporated of Ontario.

COMPARISON OF CONTINUOUS WARM BLOOD VS. INTERMITTENT COLD CRYSTALLOID CARDIOPLEGIA IN PATIENTS UNDERGOING CABG.

FE Ralley FFARCS, GR Robbins FRCPC, JF Symes FRCSC.
Departments of Anaesthesia and Surgery, McGill University and Royal Victoria Hospital, Montreal, H3A 1A1

INTRODUCTION: At present, during cardiac surgery, the mainstay of myocardial protection remains hypothermic cardioplegia. Although profound hypothermia reduces myocardial oxygen consumption (MVO_2), therefore prolonging tolerance to ischemic arrest, disadvantages such as its effect on enzyme function, calcium sequestration, membrane stability, etc., may be potentially detrimental to the myocardium. Recently it has been demonstrated that the major determinant of MVO_2 is electro-mechanical work rather than hypothermia per se [1]. Normothermic hyperkalemic cardiac arrest produces nearly 90% reduction in MVO_2 compared to 95% with hypothermia [2]. Ideally if adequate reduction of MVO_2 for myocardial protection can be achieved with normothermic hyperkalemic cardiac arrest, and ischemia prevented by continuous perfusion with warm blood, these disadvantages associated with hypothermia may be avoided.

Differences in the method by which cardioplegia is administered may play a role in the incidence of postoperative ventricular dysfunction. As a major determinent of survival in patients with coronary artery disease is their level of left ventricular dysfunction, improvement in intraoperative myocardial preservation may lead to an improved post-operative course and outcome. Therefore, we compared continuous warm blood cardioplegia (CWBC) to intermittent cold crystalloid cardioplegia (ICCC) on hemodynamic parameters and need for interventive pharmacological or mechanical therapy for the first 24 hours post elective CABG.

METHODS: We retrospectively studied 100 consecutive patients who underwent elective CABG. The first 50 patients received ICCC and the following 50 patients CWBC. Surgery was performed by the same surgeon and anaesthesia and postoperative care was as routine for our institution. Cardiopulmonary bypass was performed with a Stockert Shiley Pump with Bentley 10-plus bubble oxygenator with flow rate of 2.4 L/M^2 at normothermia which was reduced by 50% at 28°C. Patients receiving ICCC were cooled to 24-28°C (nasopharyngeal) and rewarmed to > 37°C. Crystalloid cardioplegia at 4°C was given intermittently into the aortic root during aortic cross clamping (AXC) at 15-20 min intervals, depending on intra-myocardial temperature. Patients received CWBC at a mean rate of 150 ml/min at 36°C via a Shiley BCD-plus 4:1 blood cardioplegia system. Antegrade perfusion via the aortic root and saphenous veins grafts after completion of distal anastomoses were performed during AXC. Requirement for defibrillation after AXC was noted. Recordings of hemodynamic parameters, temperature, drug infusions and use of mechanical assist device were retrieved at hourly intervals for the first 12 hours, then at 14, 16, 20 and 24 hours post-operatively. The time from arrival in the Intensive Care Unit (I.C.U.) to extubation was also recorded. Mortality rate up to 30 days from surgery was compared between both groups. Statistical analysis was with Student's t-test for intergroup comparisons and Chi-squared analysis with Yates correction for proportions. A P value of < 0.05 was considered significant.

RESULTS: There were no significant differences in demographic data, number of grafts/patient, ejection fraction or bypass time between groups. All patients in ICCC gp required defibrillation after AXC compared with only four patients in the CWBC gp ($P < 0.05$). Differences in core temperature for the first 6 hours in ICU between groups are shown in Figure 1. The only significant differences in hemodynamic parameters were that the C.I. was higher in the CWBC gp compared to the ICCC gp for the first hour on arrival in ICU (2.4 ± 0.01 vs. 2.1 ± 0.01 $L/min/M^2$) and the PCWP was significantly lower from 4-20 hours in the CWBC gp (mean 12 versus 14 mmHg). On arrival in the I.C.U., four patients in ICCC gp were receiving inotropic support (mean dose dobutrex 3.8 ± 0.73 μg/kg/min) compared to no patients in CWBC gp ($P < 0.5$). At 3, 4 and 5 hours in I.C.U., there were significantly more patients receiving inotropic support in ICCC gp.

Although there were consistently fewer patients on vasodilator therapy in the CWBC gp compared to the ICCC this did not reach statistical significance. Two patients in ICCC received IABP, whereas no patient in CWBC gp did (P = NS). Time from arrival in the ICU to extubation was 795.3 ± 41.7 mins in the CWBC gp compared to 866.5 ± 38.35 min in the ICCC gp (P = NS). There was one death in each gp both from non-cardiac causes.

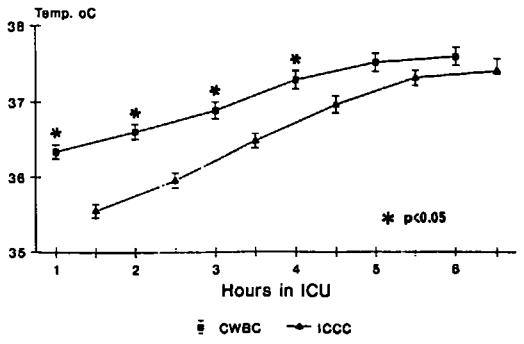
DISCUSSION: This study shows that continuous warm blood cardioplegia may produce a significant improvement in patients' immediate postoperative course, compared to intermittent cold crystalloid cardioplegia which is at present the most widely used technique for myocardial preservation during CABG. Patients in the CWBC gp arrived in the ICU on no inotropic support and maintained a mean C.I. > 2.0 L/M^2, with significantly less requirement for pharmacological intervention. Furthermore, these patients were normothermic at all times. Rewarming in the first few hours after CABG has been associated with a significant incidence of shivering which causes increases in VO_2 and myocardial work [3]. Normothermia may also explain the reduction in the use of vasodilating therapy in the CWBC gp.

No attempt was made to wean patients in the CWBC gp earlier, compared to ICCC gp. However, the mean extubation time for patients in the CWBC gp was shorter compared to the ICCC gp. As our experience with normothermic patients grows, plus the introduction of a more progressive weaning protocol this difference may become significant.

It is necessary to show conclusively that any new technique of myocardial preservation reproducibly produces improvement in left ventricular performance following cardiac surgery before recommending it for all patients. However, these preliminary findings suggest that this technique of continuous warm blood cardioplegia warrants further investigation.

REFERENCES

1. Surgery 58: 602-612, 1965.
2. J Thorac Cardiovasc Surg 73: 87-94, 1977.
3. Can J Anaesth 35: 4; 332-337, 1988.



PANCURONIUM VERSUS VECURONIUM FOR TREATMENT OF SHIVERING PATIENTS AFTER CARDIAC SURGERY

JY Dupuis, M.D., M Bourke, M.D., H Nathan, M.D., JE Wynands, M.D.

Department of Anaesthesia, Ottawa Civic Hospital, 1053 Carling Ave., Ottawa K1Y 4E9

We compared pancuronium (P) and vecuronium (V) as treatment for shivering patients after cardiac surgery, and sought to determine if their effect in reducing total body oxygen consumption (VO_2) modified the expected heart rate (HR) response associated with each muscle relaxant (MR). We also examined if residual neuromuscular blockade (RNMB) at onset of shivering and preoperative therapy with beta blockers (BB) influenced the response of those patients to shivering and its treatment.

Methods: One female and 29 male patients undergoing cardiac surgery gave informed consent to participate in this double-blind randomized prospective study. Patients with postoperative shivering, defined as intermittent or continuous movements of the chest and limb muscles, were included. Patients on inotropes, those with heart rythm other than sinus, those with uncontrolled bleeding and those with pre-existing myocardial ischemia were excluded. All usual antianginal drugs were continued until surgery. Standard premedication and narcotic anaesthesia (sufentanil-MR-benzodiazepine supplemented with isoflurane) were used in all cases. A radial artery cannula and pulmonary artery (PA) catheter allowing cardiac output (CO) measurements by thermodilution were used for invasive hemodynamic monitoring. Continuous ST segment analysis of ECG leads II and V_5 were monitored for ischemia detection during and after surgery with a Spacelab monitor (model 90303B). Tactile evaluation of neuromuscular blockade was done with train-of-four (TOF) stimulation using a portable neurostimulator (Digi Stim III). Hemoglobin (Hb), arterial (SaO_2) and mixed venous oxygen saturation (SvO_2) were measured with a Co-Oximeter.

After stabilization in the intensive care unit, the following baseline data were obtained: HR, systolic and diastolic blood pressure (SBP and DBP), mean arterial pressure (MAP), PA wedge pressure, ST segment analysis, PA blood temperature, Hb concentration, ABG, SaO_2, SvO_2, and the number of twitches after TOF stimulation. All patients who shivered within 4 h of admission to ICU were given 4 to 8 mg of i.v. morphine and 2.5 to 5 mg of diazepam at onset of shivering. If shivering persisted, the hemodynamic data collection was repeated and randomization for treatment with P or V was carried out: the patients were given .08 mg/kg of P or V. Data collection was repeated 5, 10, 15, 20, 30, 40, 60 and 120 minutes after administration of MR. Hypertension (MAP > 100 mmHg) despite adequate sedation was treated with sodium nitroprusside as necessary. VO_2 was derived from the Fick equation and values indexed to body surface area (VO_2-I). New horizontal or downsloping ST segment depression > 1 mm lasting longer than one minute were used to define an ischemic episode. Left ventricular (LV) myocardial oxygen consumption (MVO_2) in ml O_2/min/100g was estimated using the formula proposed by Rooke and Feigl[1] which takes into account changes in cardiac output and inotropic state:

$$K_1(SBP \times HR) + K_2\left[\frac{(0.8\ SBP + 0.2\ DBP) \times HR \times SV)}{BW}\right] + 1.43$$

where SV = stroke volume, K_1 = .000408 and K_2 = .000325. Data was analyzed by ANOVA for repeated measures and Dunnett's t-test, Fisher exact probability test and Student's t-test with Bonferroni correction when necessary.

Results: The results in table 1 show that P decreases VO_2-I by 32% but this is accompanied by a 14 % and 10% increase in HR and MVO_2 respectively. V decreases VO_2-I by 36% with small decrease in HR (-4%) and MVO_2 (-6%). Increased HR was associated with myocardial ischemia in 3 patients treated with P. No patient treated with V had myocardial ischemia. Five of the 30 patients had significant RNMB (1 or 2 twitches) at onset of shivering: shivering in these patients increased VO_2-I from 76 ± 15 to 170 ±53 ml O_2/min/M^2 (+124%) compared to 77 ±15 to 148 ±37 ml O_2/min/M^2 (+92%) in patients with 4 twitches (P = .27). Seven patients in the P group and 8 in the V group were treated with BB before surgery.This therapy with BB was associated with lower heart rates 96 ±16 bpm vs 109 ±15 bpm (P = 0.03), lower estimated MVO_2 (8.8 ±1.2 vs 10.7 ±10.7 ml O_2/min/100 g) [P = .003], and similar VO_2-I (149 ±42 vs 155 ±38 ml/min/M^2) at onset of shivering. However preoperative intake of BB did not alter the HR and MVO_2 response to P or V.

Discussion: Both P and V have beneficial effect by reducing VO_2 of shivering patients after cardiac surgery. This decreased VO_2 is not accompanied by a proportional decrease in HR or MVO_2 with either MR. P produces the same increase in HR as when given to nonshivering patients[2] and is associated with myocardial ischemia. Preoperative BB does not influence the HR response. V causes small decreases in HR and is associated with no myocardial ischemia. RNMB does not blunt the increase of VO_2 due to shivering. The data suggest that if treatment with MR is considered in those patients, V in a dose sufficient to abolish most muscular activity should be used.

References

1) Rooke GA, Feigl EO. Circ Res 1982; 50: 273-86.
2) Stoelting RK. Anesthesiology 1972; 36: 612-5.

TABLE 1

		P (n=15)	V (n=15)
VO2-I (ml O2/min/M2)	Baseline	81 ± 4	73 ± 16
	Shivering	148 ± 34*	156 ± 46 *
	10 min. after MR	100 ± 16 †	100 ± 17 †
HR (BPM)	Baseline	81 ± 7	78 ± 13
	Shivering	101 ± 14 †	104 ± 18 †
	10 min. after MR	115 ± 14 ¶†	100 ± 15 †
Estimated MVO2 (ml O2/min/100 g)	Baseline	7.2 ± .8	7.1 ± 1.0
	Shivering	9.9 ± 2.2††	9.6 ± 1.5††
	10 min. after MR	10.9±.9††Δ	9.1 ± 1.5††

Mean ± SD
* P < .001 as compared to baseline and after MR
† P < .05 as compared to baseline
¶ P < .01 as compared to baseline and V after MR
†† P < .05 as compared to baseline
Δ P = .02 as compared to V after MR