Abstracts

Epidural anaesthesia for Caesarean section in patients with recurrent genital herpes simplex infections

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Patients with recurrent herpes simplex virus-2 (HSV-2) often are delivered by Caesarean section to minimize exposure of the neonate to the virus. A significant number of anaesthetists do not use regional anaesthesia in these patients for fear of introducing virus into the central nervous system.[1] We would like to report our experience with lumbar epidural anaesthesia in patients with recurrent HSV-2 infections.

Methods

Following institutional approval, the charts of all patients presenting for Caesarean section, with the diagnosis of active HSV-2 infection, between January 1983 and December 1987 were studied. The sites of existing lesions and documentation of outbreaks or positive cultures within one week of delivery were recorded. The mode of anaesthesia was recorded and for those patients who received general anaesthesia (GA), the anaesthetic record was further reviewed for specific reason for the use of GA. In hospital, maternal postoperative course was reviewed for (1) the development of or exacerbation of herpetic outbreaks, (2) development of neurological complications, and (3) complications related to the anaesthetic.

Results

Sixty-seven charts were reviewed. Eleven charts were removed from further analysis because of the absence of active infection at the time of surgery or positive cultures within one week of surgery. There were 56 patients with active infections, 45 (80 per cent) of whom had lesions identified (Table). Of the 11 patients who did not have lesions identified at the time of delivery, eight had had positive cultures within the week, one patient was positive for virus within 24 hours (electron microscopy) and two patients had suffered an outbreak of herpetic lesions within the week leading up to delivery.

Fifty-three patients received epidural anaesthesia for Caesarean delivery. Three patients received GA, two patients at their own request. One patient had herpetic lesions over the proposed site of epidural insertion and the epidural was deemed to be contraindicated by the attending anaesthetist.

TABLE Site of herpetic lesions

Site	*Patients*
Genital	39
Buttocks	1
Back	1
Unspecified	4

The average postoperative stay was 6.4 days (range 3–12 days). Two patients developed postoperative wound infections. One patient who had been culture-positive prior to surgery developed an outbreak of herpetic lesions in the early postoperative period. No patient developed an anaesthetic or neurologic complication.

Discussion

In the last two decades there has been a dramatic increase in the incidence and prevalence of HSV-2 infections in the North American population, much of it occurring in the reproductive age population. In parturients with a history of recurrent HSV-2 infection, the risk of an infection on the day of delivery is 1.4 per cent.[2] Our study documents a similar increase of infection in our patient population with an approximate doubling of prevalence over the study years. Ravindran reported on 30 patients with HSV-2 infections who received epidural anaesthesia without sequelae.[3] Ramanathan reported on 32 patients with recurrent HSV-2 infections, with lesions, who received epidural anaesthesia for Caesarean section, again without sequelae.[4] We report the results of a five year retrospective analysis, documenting the use of epidural anaesthesia in 53 parturients with active HSV-2 infections without anaesthetic or neurologic complications. Our patients express a preference for regional anaesthesia for Caesarean sections. Because of the localized, low-grade infective nature of recurrent attacks and the absence of documented complications following the use of epidural anaesthesia in these patients, we feel that the use of epidural anaesthesia is safe, provided that the actual site is uninvolved.

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Prolonged suppression of gastric acid secretion in the obstetric patient

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As Mendelson suggested, various treatments have been employed to reduce the risk of aspiration of gastric contents in obstetrical patients.[1] Omeprazole is a substituted benzimidazole, which selectively blocks the proton pump of the parietal cell, the terminal step in the production of acid. Studies have shown that omeprazole reduces both the acidity and volume of gastric secretions for some 12 to 24 hours with few side effects.[2]

This study was carried out to assess the efficacy and duration of omeprazole in obstetric patients. Approval from the local University Medical Ethical Research Committee and informed written consent from patients were obtained.

Methods

Healthy women, with an uncomplicated pregnancy of more than 38 weeks' gestation, undergoing elective Caesarean section under general anaesthesia, were selected. Each patient was given 80 mg omeprazole at 20.00 hours. The following morning, immediately after the establishment of tracheal anaesthesia, the gastric contents were aspirated and again before reversal of neuromuscular block and extubation, with a new Salem Sump tube on each occasion. The volumes and pH of the gastric samples were recorded.

Maternal pulse and blood pressure were monitored at five-minute intervals. The need for incremental doses of oxytocin and VAS assessment of uterine contractility after delivery by the surgeons were noted. Infant well-being was determined by Apgar scores and seven-day follow up.

Plasma omeprazole concentrations were measured by HPLC in maternal venous and umbilical arterial and venous blood samples, collected at delivery.

Results

Twenty patients were included in the study. The mean time from omeprazole administration to induction of anaesthesia was 853 minutes (range 765–977). No side effects of omeprazole treatment were reported.

Sixteen of 20 (80 per cent) post-induction and 17 of 20 (85 per cent) pre-extubation samples had pH values ≥ 2.5: 16 of the post-induction volumes (80 per cent) and 19 of the pre-extubation volumes (95 per cent) were below 25 ml. The combination of $pH < 2.5$ and volume > 25 ml was found only once in a post-induction aspirate (Figure). There was no apparent relationship between the time from omeprazole administration to induction and intragastric pH or volume.

Omeprazole levels in all samples were low, with means of 44.2 ± 71.2, 23 ± 34.4 and 12.3 ± 26.8 nmol $\cdot L^{-1}$ in maternal, umbilical arterial and venous blood respectively. There was no correlation between maternal plasma levels and the pH of gastric aspirates: six of the 16 patients with $pH \geq 2.5$ and all patients with $pH < 2.5$ having a concentration lower than the sensitivity of the assay (20 mmol $\cdot L^{-1}$). Sixteen of the umbilical venous and arterial samples had omeprazole levels below the measurement limit. No untoward effects were noted in the infants.

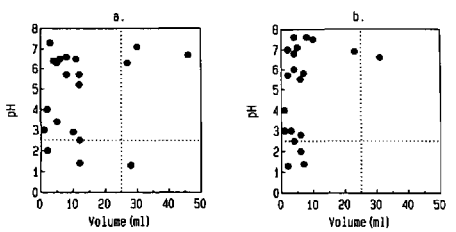

FIGURE pH and volume of a. post-intubation b. pre-extubation gastric aspirates.

Discussion

The aim of antacid treatment is to produce gastric $pH > 2.5$ total volume < 25 ml. Omeprazole given at least 12 hours prior to induction produced these conditions in 80 per cent of patients. While a failure rate of 20 per cent is unacceptable for obstetric anaesthesia, the findings give hope of a single antacid therapy for labours up to 12 hours duration. The short plasma half-life and rapid elimination is reflected in the maternal and fetal levels.

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Transplacental oxygenation during emergency Caesarean section – influence of maternal inspired oxygen concentration

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The relationship between maternal and fetal oxygen tension during general [1,2] and epidural[3] anaesthesia remains controversial. Current understanding suggests that these older studies may be seriously flawed because of failure to relieve aorto-caval compression[1] and because the possible deleterious fetal effects of prolonged I-D and U-D intervals were not considered.[2] Failure to standardize anaesthetic techniques and to exclude maternal hypocapnia have also contributed to difficulties of interpretation. The objective of this study was to compare the effects of a maternal FiO_2 of 0.5 and 1.0, supplemented by isoflurane, on fetal oxygenation and maternal haemodynamics in patients undergoing emergency Caesarean section with general anaesthesia.

Methods

Following Ethics Committee approval and informed consent 28 patients (ASA Physical Status I) undergoing general anaesthesia for emergency Caesarean section were randomly allocated to one of two treatment groups.

Group 1: 50 per cent oxygen – 50 per cent nitrous oxide + 0.75 per cent isoflurane

Group 2: 100 per cent oxygen + 1.5 per cent isoflurane.

Patients included in the study were confined to those of 36–42 weeks gestation and those undergoing Caesarean section for failure to progess in labour. Patients with diabetes, pre-eclampsia, multiple pregnancy and labours complicated by clinical or biochemical evidence of fetal distress were excluded. A standard anaesthetic technique of antacid prophylaxis uterine displacement, preoxygenation, thiopentone 3–4 mg $\cdot kg^{-1}$ administration followed by succinylcholine 1.5 mg $\cdot kg^{-1}$ was employed. Normocapnic controlled ventilation was commenced using fresh gas flows of 100 ml $\cdot kg^{-1}$. Baseline pre-induction

TABLE Data mean ± SEM

N	*Group 1* FiO_2 *0.5 + 0.75% isoflurane* *14*	*Group 2* FiO_2 *1.0 ± 1.5% isoflurane* *14*
I-D interval (sec)	627 ± 43	634 ± 44
U-D interval (sec)	87 ± 11	87 ± 12
Maternal PaO_2 (kPa)	26.43 ± 1.84	42.13 ± 4.49
$PuvO_2$ (kPa)	3.97 ± 0.21	4.6 ± 0.43
$PuaO_2$ (kPa)	2.25 ± 0.26	2.67 ± 0.14
Apgar scores		
1 minute		
<7	5	4
≥7	9	10
5 minutes		
<7	1	0
≥7	13	14

arterial pressure and heart rate were recorded using an automated non-invasive monitoring device and was repeated 1, 3, 5, 7 and 9 minutes following anaesthetic induction. Maternal arterial blood samples were taken from a radial artery cannula at the time of uterine incision. Heparinized blood samples were obtained from the umbilical artery and vein of a loop of clamped cord at delivery before the infants' first breath. Apgar scores at one and five minutes after birth were recorded by a neonatologist. Twenty-four hours after surgery the patients were questioned about awareness and dreaming. Ordinal data was analysed using the Chi-squared or Fisher exact test. Interval data was analysed using Mann-Whitney U-tests and Kendall correlation coefficient for correlation between the variables. $P < 0.05$ was considered significant.

Results

The patients in the two groups were similar with respect to age, weight, parity and indications for Caesarean section. I-D and U-D intervals, blood loss and haemodynamic changes were similar in the two groups. Maternal PaO_2 42.13 ± 4.49 kPa in Group 2 (FiO_2 1.0 + 1.5 per cent isoflurane) was significantly greater than maternal PaO_2 26.41 ± 1.84 kPa in Group 1 (FiO_2 0.5 + 0.75 per cent isoflurane) while $PuvO_2$ 4.60 ± 0.43, 3.97 ± 0.2, and $PuaO_2$ 2.67 ± 0.14, 2.25 ± 0.26 were measured in groups two and one respectively. A positve correlation was noted between increased maternal oxygen tensions and $PuaO_2$. The two groups were similar with respect to number of neonates with Apgar scores ≥ and <7 at one and five minutes. Awareness was not reported (Table).

Discussion

Fetal oxygenation has been variously reported to correlate with maternal PaO_2 in response to increasing FiO_2,[3] to remain unchanged when FiO_2 increased from 0.5 to 1.0[2] or to decrease when maternal PaO_2 exceeded 40 kPa.[1] Transplacental oxygenation is critically dependent on partial pressure gradients. However, maternal hyperoxia may provoke vasoconstriction in the feto-placental circulation and may limit fetal benefit. Although increased maternal PaO_2 using an FiO_2 1.0 was not associated with significant improvements in fetal oxygenation, acid–base balance or neonatal outcome in this study, further investigation of the technique in a larger series of parturients with fetal distress may be justified.

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A comparative study of patient controlled epidural fentanyl and single dose epidural morphine for post-Caesarean section analgesia

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Epidural opiates have been used successfully to provide postoperative analgesia. Epidural morphine given as a single bolus has a prolonged duration of action but is associated with a significant incidence of nausea and pruritus and may cause delayed respiratory depression.[1] Fentanyl, because of higher lipophilicity, may offer advantages when used in the epidural space because it has been shown not to cause delayed respiratory depression.[2] Fentanyl's shorter duration of action requires repeated dosing to achieve clinically useful postoperative analgesia.[3] The purpose of this study is to compare, in a prospective, randomized, double-blinded fashion, the efficacy and safety of patient controlled administration of epidural fentanyl compared with single-dose epidural morphine for post-Caesarean section analgesia.

Methods

Following approval from the Screening Committee for Research Involving Human Subjects and informed consent, ASA physical status I or II patients undergoing elective Caesarean section were selected. Epidural catheterization was performed in a standard manner and the patients received epidural anaesthesia using 1.73 per cent carbonated lidocaine with 1:400,000 epinephrine. Intraoperative supplemental analgesia was provided with IV fentanyl or additional epidural lidocaine. The patients were then randomly assigned into one of two groups. Patients in group A received 100 μg epidural fentanyl, diluted to 6 ml total volume, 20 minutes after delivery of the infant. Postoperatively, the epidural catheter was left in place for 24 hours and on arrival in the PAR, the patients were provided with a Deltec™ (Pharmacia (Canada)) ambulatory epidural patient controlled analgesia (PCA) system. When additional analgesia was needed, the patients were instructed to self-administer 50 μg epidural fentanyl (100 $\mu g \cdot ml^{-1}$), wait five minutes, and then self-

administer a second dose of 50 μg of fentanyl. The PCA system was programmed to provide a maximum of two doses per hour with a lockout period of five minutes between doses. Group B patients received 3 mg epidural morphine, diluted to a total volume of 6 ml, 20 minutes after delivery of the infant. These patients also had the epidural catheter left *in situ* and were given the same instructions as group A patients. The PCA system was filled with saline but otherwise programmed in the same manner as for group A patients. While the patients were in the PAR supplemental analgesia was provided with 12.5 to 25 μg IV fentanyl if required. Once discharged to the postpartum unit, supplemental analgesia consisting of Tylenol #3 one to two tablets every four hours, or IM meperidine 50–100 mg every 3–4 hours was provided. Nausea was treated with IM metaclopramide 10 mg and significant pruritus was treated with IM naloxone 0.2 mg. HR and RR were recorded hourly for the first 12 hours and 15 minutes after each PCA demand. The patients were assessed at 2, 4, 8 and 24 hours measuring the degree of pain, satisfaction with pain relief, nausea and pruritus using a 10 cm linear visual analogue scale. Ventilatory response to the inhalation of five per cent CO_2 was recorded prior to epidural insertion and four and eight hours postoperatively. Data were analyzed using the Mann Whitney U test and Student's t test and repeated measures analysis of variance.

Results

To date, data collection and analysis has been completed in 19 patients, nine in group A and ten in group B. Comparison of the two groups revealed no difference with regard to age, weight, height, gravidity, parity, dose of lidocaine or the duration of the operative procedure. The degree of postoperative pain and satisfaction with pain relief were similar in both groups. The mean (±) 24 hour total dose of fentanyl required in the group A patients was 780 ± 190 μg (hourly dose of 33±8 μg). There was no difference in the amount of supplemental analgesia required by the two groups. The degree of nausea and pruritus experienced in the two groups are depicted in Figures 1 and 2 respectively. Group A patients had significantly less nausea only at the eight-hour assessment and experienced significantly less pruritus at the 4, 8, and 24 hour assessments. The ventilatory response to the inhalation of five per cent CO_2 was not significantly different between the two groups, and there was no significant respiratory depression in either group.

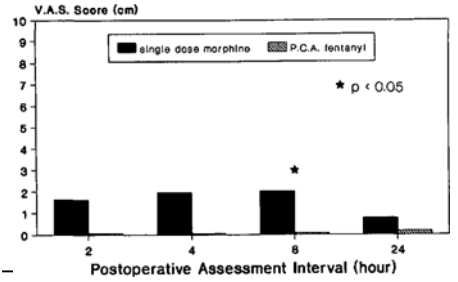

FIGURE 1 Postoperative nausea (mean).

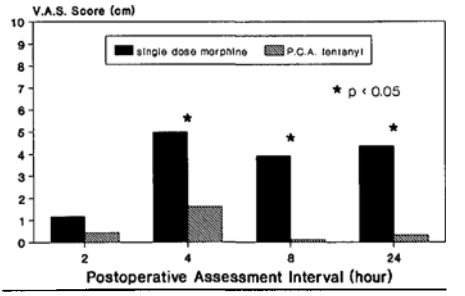

FIGURE 2 Postoperative pruritus (mean).

Discussion

Patient controlled administration of epidural fentanyl can provide comparable analgesia when compared with single dose 3 mg epidural morphine. Patients receiving epidural fentanyl experienced less pruritus and nausea when compared with those receiving morphine. This may be due to the differences in the physical properties of the two agents. The use of small incremental doses titrated by the patient may also minimize its rostral spread and so reduce systemic side effects.

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Use of atracurium or d-tubocurarine in Caesarian section: is there a difference for the neonate?

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On the basis of pharmacokinetic properties, atracurium would appear to be a good muscle relaxant for Caesarian sections. With its high molecular weight (1243 g), high degree of ionization (at physiological pH), high protein binding (82 per cent) and low lipid solubility, it is likely that placental transfer would be minimal.[1] Furthermore, even if placental transfer occurred, its rapid metabolism would ensure fast elimination from the neonatal circulation. This study was undertaken to compare the neonatal effects and placental transfer of atracurium and d-tubocurarine.

Methods

The protocol for this double-blinded study was institutionally approved, and written consent was obtained from each patient. We studied 46 patients undergoing elective repeat Caesarian section who were randomly assigned to either atracurium (25 patients) or d-tubocurarine (21 patients). No premedication was given. Following preoxygenation and a precurarisation dose of either atracurium or d-tubocurarine (0.05 $mg \cdot kg^{-1}$), anaesthesia was induced with thiopentone 4 $mg \cdot kg^{-1}$ and succinylcholine 1.5 $mg \cdot kg^{-1}$, and maintained with nitrous oxide 50 per cent, halothane 0.5 per cent and either atracurium or d-tubocurarine 0.3 $mg \cdot kg^{-1}$. The time intervals between different events (precurarisation, induction, skin incision, curarisation, hysterotomy and birth) were noted. The neonates were evaluated using the Apgar test at one, five and ten minutes and the "neurological and adaptive capacity scoring" (NACS) test at 15 minutes, 2 and 24 hours after birth. Muscle relaxant blood levels were taken at birth from maternal blood and umbilical venous blood. Statistical analysis was done with ANOVA and the F test or with the Mann-Whitney test.

Results

There was no statistically significant difference between the two maternal groups for age, parity and time intervals in the Caesarian section events. Neonatal groups were also statistically similar for birth weight, sex, Apgar at one, five and ten minutes and NACS at 2 and 24 hours. However, there was a significant difference with the NACS test at 15 minutes ($P < 0.02$). Further analysis revealed that this difference came from the "active tone" part of the test ($P < 0.05$). The mean atracurium blood level at birth was 0.50 $\mu g \cdot ml^{-1}$ (0.285–0.724) for the mother and 0.041 $\mu g \cdot ml^{-1}$ (0.022–0.057) in the umbilical cord venous blood. The mean laudanosine blood level at birth was 0.286 $\mu g \cdot ml^{-1}$ (0.134–0.514) for the mother and 0.0359 $\mu g \cdot ml^{-1}$ (0.012–0.552) in the umbilical cord venous blood.

Discussion

Our study shows that neonates born after the use of atracurium for the Caesarian section scored significantly less on the NACS test at 15 minutes than neonates in the d-tubocurarine group. Only 55 per cent of neonates in the atracurium group compared with 83 per cent of those in the d-tubocurarine group had a score of ≥35 (considered normal by Amiel-Tison[2]). The NACS test has five parts to it and the "active tone" part was found to be the one statistically different between the two groups. That would strongly suggest a certain degree of partial curarisation in the atracurium group, lasting for a short while after birth. However, this partial curarisation did not appear to be clinically significant as their Apgar scores were similar to the d-tubocurarine group and none experienced respiratory distress. Umbilical venous concentrations of atracurium were around eight per cent the maternal concentrations which is similar to what Flynn *et al.* obtained (seven per cent).[1] A study in 1976 using d-tubocurarine showed that umbilical venous concentrations of d-tubocurarine were 12 per cent the maternal concentrations.[3] Laudanosine, a metabolite of atracurium, could theoretically cause haemodynamic instability and convulsions. This has been shown to occur in experimental animals in concentrations much higher than the ones obtained in our study (6 $\mu g \cdot ml^{-1}$ for haemodynamic instability and 17 $\mu g \cdot ml^{-1}$ for convulsions).[4] In conclusion, although atracurium shows less placental transfer than d-tubocurarine, it appears to be associated with a minimal degree of partial curarisation in the neonate after Caesarian section. This did not affect clinically normal neonates, but one should be cautious with neonates who had previous fetal distress.

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Midline vs. paramedian approach to the epidural space in pregnant women

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Epidural puncture and placement of an epidural catheter can be achieved via two routes: the midline or the paramedian approach. Proponents of the paramedian route claim a reduced chance of inadvertent dural puncture and greater ease of catheter placement. This suggestion may be supported by recent anatomical studies confirming the existence of a midline dural fold.[1,2] During pregnancy, however, the likelihood of trauma to engorged epidural vessels may be greater if the epidural needle and catheter enter the epidural space laterally. We could find no previous studies in parturient women and therefore have compared the efficacy of these approaches to provide epidural analgesia for obstetrical delivery.

Methods

Following institutional approval with informed consent, 81 consecutive parturients were prospectively randomized to receive epidural anaesthesia via either the midline or the paramedian approach. All the blocks were performed by the same anaesthetist. The incidence of complications and untoward side-effects in each group was compared using t test, chi-square test and Fisher's exact test where appropriate.

Results

Both groups were comparable with regard to patient height, weight, indication for epidural anaesthesia, interspace of epidural puncture and number of attempts. No patient was excluded. Complications resulting from the attempted blocks were rare events in both groups (see Table). However, the rate of complications of the midline group was over twice that of the paramedian group (36.8/100 pts. vs 16.3/100 pts.). The propor-

TABLE

	Midline	*Paramedian*
Number of patients	37	44
Complications		
Dural tap	0	0
Blood in needle	0	0
Blood in catheter	2	1
Failure to advance		
Catheter	6	2
Paraesthesia	4	0
Inadequate block	—	1
Failed block	1	1
Unsuccessful attempts	2	2

tion of women having at least one complication was not significantly different (29 per cent midline vs 16 per cent paramedian, P = 0.27). If we restrict the analysis to what we defined *a priori* as significant complication, paraesthesia and failed block, then the difference between the two approaches conventional statistical significance (13 vs 2 per cent, P = 0.075, Fisher's exact test).

Discussion

Because serious complications of epidural anaesthesia such as inadvertent dural puncture, total spinal and systemic administration of local anaesthetic occur infrequently it is unlikely that a trial of sufficient power to detect or rule out clinically important risk reductions by either technique can be conducted. However, the results of our study indicate that the paramedian approach to the epidural space may be superior in yielding less unwanted side effects. Further studies should be conducted to evaluate the possible advantages of the paramedian approach to epidural cannulation.

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The origin of the differences between invasive and noninvasive blood pressure measurements

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The relationship between invasive and non-invasive blood pressure (NIBP) measurements has been studied extensively. The invasive measurement has been considered as the gold standard. Any difference between the two techniques is then considered to be an error of the non-invasive technique. However, the origin of the difference may lie in the arterial monitoring system rather than in inherent differences between the two measurement techniques. A study was done in 21 patients comparing invasive and NIBP (Dinamap 1846) measurements in patients with prominent inotropic waves (Type A) and patients without such prominence (Type B). (See Figure). There were statistically significantly more patients with Type A patterns where the systolic difference exceeded 11 mmHg than in patients with Type B contours (see Table I). The largest differences between the invasive and non-invasive techniques were 35 mgHg for Type A and 26 mmHg for Type B. To elucidate the differences between invasive and NIBP measurements, two further series of experiments were done: firstly, the damped natural frequency of the arterial catheter manometer system was measured and secondly the frequency content of the peak systolic pressure was measured by Fourier analysis of the arterial pulse wave signal. The damped natural frequency of the catheter manometer system was measured by sine wave oscillation in a specially produced chamber with a DNF exceeding 100 Hz. The point of maximum oscillation (DNF) was determined by computerized graphical fitting of the sine wave envelope and the DF by the magnitude of the oscillation. The results are shown in Table II. The main cause of the low DNF was shown by the

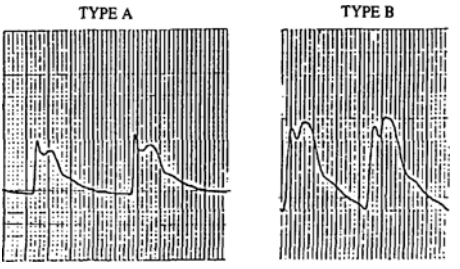

FIGURE Arterial pressure waveforms: Type A shows a prominent early pressure pulse and Type B shows a pressure pulse lower than peak systolic pressure.

TABLE I The number of patients where the difference between invasive systolic BP and systolic NIBP exceeded 11 mmHg

Difference	*Type A*	*Type B*
Greater than 11 mmHg	10	1
Less than 11 mmHg	3	7

P 0.5 Fisher exact probability.

TABLE II The damped natural frequency (DNF) and damping factor (DF) of arterial catheter-manometer systems including the arterial cannula

Cannula size	*Tubing length (mm)*	*DNF (Hz)*	*DF*
20 g	1,200	14.2	0.24
20 g	900	15.6	0.20
20 g	300	24.9	0.19
24 g	300	20.0	0.30

high DNF of the 24 g arterial cannula with a short connecting tubing of 30 cm. The last part of the investigation was to record arterial pressure wave forms on a FM tape recorder for Fourier and power density spectra analysis at a later stage. The analysis showed the peak inotropic pressure pulse component as recorded by the catheter manometer system to have a frequency content exceeding 30 Hz. Digital filtering at 30 Hz markedly attenuated the prominent pressure peak but did not remove the peak entirely. The catheter manometer system has a DNF well below 30 Hz and will therefore not transmit these high frequency components from the vascular system to the recording system. The main origin of the inotropic pressure pulse is conluded to be reflections within the catheter-manometer system. The inotropic pressure pulse is still useful as it indicates a steep rise in the arterial pressure waveform (i.e., a high inotropism or dp/dt).

Conclusion

The origin of differences between invasive and non-invasive BP measurements in Type A pressure contours can be partially but not totally explained by an underdamped catheter-manometer system with a low DNF. The origin of differences in Type B pressure wave contours is still unclear.

A clinical comparison of three different designs of right-sided double-lumen endobronchial tubes

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For certain thoracic surgical procedures one-lung ventilation (OLV) is best achieved with a right-sided double-lumen bronchial tube (right-DLT). The margin of safety in positioning these tubes is small since they can obstruct the right upper lobe bronchial orifice[1] and it can be difficult to achieve satisfactory one-lung isolation due to the unusual shapes of the bronchial (distal) cuffs. The purpose of this study was to compare the adequacy of OLV using the three different designs of disposable right-DLT which are currently available.

Method

Thirty patients having elective pulmonary resections via left thoracotomy were studied. The patients were randomly assigned to be intubated with either a Mallinckrodt or Rusch or Sheridan disposable right-DLT (see Figure). After induction of general anaesthesia in the supine position the patients were intubated with an appropriate size right-DLT. The right-DLT was positioned initially with fibreoptic endoscopy and the side ventilation slot of the bronchial lumen aligned with the orifice of the right upper lobe bronchus.

The lungs were ventilated with a tidal volume of 10 $ml \cdot kg^{-1}$ during both two- and one-lung ventilation. Following intubation, patients were placed in the right lateral decubitus position. After the left hemi-thorax was opened, a repeat endoscopy was performed and the bronchial tube was repositioned as needed. The bronchial cuff was then inflated with air until either satisfactory one-lung isolation was achieved or until the manometer-measured cuff pressure reached 44 cm H_2O. The adequacy of one-lung isolation was monitored by observing for the cessation of gas flow, measured by a Wright's spirometer, from the proximal tracheal lumen of the right-DLT during ventilation via the bronchial lumen. OLV was defined as inadequate if the ventilation-slot of the bronchial lumen could not be positioned adequately either on the first or second endoscopy or if it was impossible to achieve isolation of the ventilated (right) lung from the non-ventilated (left) lung with less then 44 cm H_2O pressure in the bronchial cuff. The adequacy of OLV with each design right-DLT was compared using a Chi-square test.

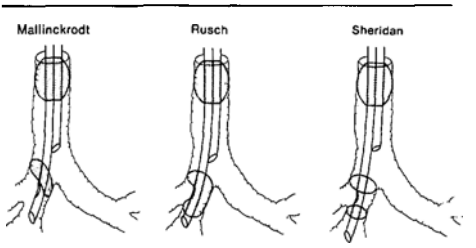

FIGURE The three designs of right-sided double-lumen endobronchial tube studied.

Results

The differences in the designs of the three right-DLT's are shown in the Figure.

The Sheridan design uses two bronchial cuffs in series. Overall, 47 per cent (14/30) right-DLT's provided adequate OLV. In four patients (two Rusch, two Sheridan) initial visualization of the right upper lobe bronchus was impossible and the tube was replaced with a left-sided double-lumen tube. In another four patients (two Mallinckrodt, two Rusch) OLV was inadequate by definition of this study. However, OLV was possible in these four patients with either bronchial cuff pressures between 44–50 cm H_2O or incomplete obstruction of the right upper lobe. The results for all 30 patients are shown in the Table. There was a significant difference in the proportion of adequate OLV between the three designs of tube (Chi-square = 7.5 with 2 D.F., P = 0.02). The Sheridan provided adequate OLV in a significantly higher proportion of patients than the other two designs (Chi-square = 4.8 with 1 D.F., P = 0.03).

TABLE Adequacy of one-lung ventilation by 3 different designs of right double-lumen tube

Design	*Adequate*	*Inadequate*	*Total*
Mallinckrodt	4	6	10
Rusch	2	8	10
Sheridan	8	2	10
Total	14	16	30

Discussion

The Sheridan design of right-sided double-lumen bronchial tube permitted adequate OLV in a significantly larger proportion of cases than the other two designs. The upper limit of acceptable pressure in the bronchial cuff was set at 44 cm H_2O (32 mmHg) since pressures above this may decrease mucosal capillary perfusion.[2] The Sheridan tube is longer from the bronchial-lumen ventilation slot to the distal bronchial-lumen tip. This length may exceed the length of the right bronchus intermedius in some patients and interfere with initial positioning. In spite of improved designs and endoscopic positioning, there is still a high incidence of inadequate OLV when right-sided double-lumen tubes are used.

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Simplified ST segment analysis of intraoperative oesophageal electrocardiograms

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The oesophageal electrocardiogram (EsECG) may reflect myocardial ischaemia that may not be evident on the body surface electrocardiogram[1,2] (SECG). One of the reasons why EsECG has not gained wide intraoperative usage is that the shapes and the relative sizes of the P, Q, R, S and T waves in the EsECG can be quite different from the shapes and the relative sizes of these waves in the SECG. In addition, the waves change with the electrode position relative to the heart. The interpretation of EsECG measurements for the diagnosis of ischaemia is also not well established.

Some digital electrocardiographs can simultaneously record multiple channels of EsECG and SECG. The onset and offset of a wave can be determined on the SECG and then can be used for the EsECG also. This technique was used for automated wave recognition and measurement of intraoperative EsECG in real-time. The ST segment deviations in EsECG and SECG were studied.

Methods

After approval from the Institutional Review Board, informed consent was obtained from patients undergoing aortocoronary bypass surgery. Leads I, II, III, aVR, aVL, aVF, V_4 and V_5 were used to acquire SECG. Immediately after induction of anaesthesia, Portex Cardio-Esophascope® #18 French oesophageal stethoscope with electrodes 7 cm and 20 cm from the distal end was placed to acquire EsECG leads EsV_2 and EsV_1 respectively. Twenty patients with adequate signals in both EsV_1 and EsV_2 were included in the study. Attempt was made to obtain an equiphasic P wave in one of the oesophageal leads. This lead was at the level of the atrio-ventricular junction and was thought to reflect the intra-cardiac electrocardiogram. The oesophageal lead wires were connected to Hewlett-Packard #14392A electrocautery protection filter whose output was connected to leads V_1 and V_2 on the Marquette MAC-12® digital electrocardiograph which also acquired the SECG. Those patients were identified who on placement of the oesophageal stethoscope had greater than 100 μV ST deviation in at least one SECG or EsECG lead.

TABLE ST deviation values

	ST deviations (μV)				
No	*II*	V_4	V_5	EsV_1	EsV_2
1	87	122	112	−137	−88
2	−49	390	144	19	29
3	43	24	4	−100	−140
4	126	−132	−157	−88	−50

Results

On the placement of the oesophageal stethoscope, four patients had greater than 100 μV ST segment deviation in at least one of the leads II, V_4, V_5, EsV_1 and EsV_2. The ST deviations in these leads are listed in the Table. In spite of the noise reduction techniques employed by the digital electrocardiograph, there was substantially greater amount of noise in EsECG.

Discussion

Two of the ST episodes were evident in SECG but not in EsECG. One episode was evident in EsECG but not in SECG. The fourth episode was evident in SECG as well as EsECG. This indicates that EsECG and SECG supplant each other. Ideally both types of leads should be used for the detection of ischaemia. EsECG even when recorded at the atrioventricular junction level does not identify all the ST episodes that may be present in the surface ECG.

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Anaesthetic machines and related patient monitors – a provincial hospital survey

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In 1980 the province of Manitoba Anaesthetic Machine Program was completed to accommodate Canadian Standards Associa-

tion Standard Z168.3 – M1980, "Continuous Flow Inhalational Anaesthetic Apparatus (Anaesthetic Machines) for Medical Use." Further standards have since been published.[1-3] A formal survey of all anaesthetizing locations in the province was re-initiated in the spring of 1988.

Methods

The survey was conducted by a provincially appointed and funded committee which included both urban and rural representation. All hospitals in province of Manitoba participated. The survey consisted of a mail survey followed by an on-site technical inspection of each anaesthetic machine. The questionnaire sought information as to: number of anaesthetic machines present, machine type and age, frequency of use, maintenance arrangements and frequency, as well as ancillary monitors provided at each site. The on-site technical inspection included DISS wall and machine inlet medical gas hoses (CSA colour coded), gauges, yokes, oxygen fail safe, oxygen flush mechanism, common gas outlet, back bar lock-out mechanism, flow meters, vaporizers, ventilators, absorbers, breathing circuits and waste anaesthetic gas scavenging systems. Patient monitors on site were noted (ECG, NIBP, SaO_2, $ETCO_2$, temp.) but their frequency of use could not be verified. Preventative maintenance arrangements, preoperative check lists and the availability of equipment operating manuals were verified. Each health care facility involved was provided with a detailed written report of the survey.

Results

Sixty-six hospitals (8 urban 58 rural) were surveyed with a total of 203 anaesthetic machines (111 urban, 92 rural). The number of active machines (used at least once in the past year) was 167. Fifty-nine per cent of the anaesthetic machines surveyed had been manufactured between 1970–80, while 7 per cent were prior to 1970 and 34 per cent after 1980. Vaporizers surveyed on the 167 active machines included halothane (n = 165), enflurane (n = 73), isoflurane (n = 91) and methoxyflurane (n = 5). A back bar lock-out device was present on 26 per cent (43/167) of machines surveyed. One hundred and thirty-four anaesthetic patient ventilators were identified. A waste anaesthetic gas scavenging system was identified on 86 per cent (145/167) of the machines surveyed; however, only 36 per cent were CSA approved devices. Thirty-one health care facilities provided for paediatric anaesthetic services of which 55 per cent were scavenged. Fourteen anaesthetic machines in active service received no preventative maintenance. The Table summarizes the monitoring devices available with each active anaesthetic machine.

TABLE

	n	%
Anaesthetic machine monitors / alarms		
Oxygen monitor (FiO_2)	10/167	66
Vent. low-pressure alarm	116/134*	87
Separate H/L pressure monitor	55/134*	41
Spirometer	70/167	42
Oxygen pressure fail safe†	167/167	100 (98)
Patient monitors		
Electrocardiogram	123/167	74
Automated non invasive BP	121/167	72
Temperature	75/167	45
Pulse oximetry	44/167	26
Capnography	10/167	6

*Machines equipped with ventilator.
†Present on all machines. However 4/167 had significant operational faults as to make them ineffective.

Discussion

The Canadian Anaesthetists Society, the Canadian Standards Association as well as numerous similar regulatory agencies in the USA continue to strive for higher standards of anaesthetic equipment and appropriate monitoring devices. This survey would suggest that these guidelines are not well followed. Serious equipment deficiencies were identified in both urban and rural Manitoba which can now be addressed.

References

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Blood contamination of drug syringes used in anaesthesia

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It is common practice by anaesthetists in many operating rooms to refill and reuse syringes used to inject drugs into patients' intravenous tubing.[1] Previous studies have investigated bacterial contamination of syringes either by mishandling[2] or by multiple refilling.[1] However, contamination between patients may carry the risk of transmitting other organisms such as those causing hepatitis and AIDS. The purpose of this study was to examine the contents of syringes used for multiple injections into intravenous tubing for the presence of red blood cells as a marker for inadvertent syringe contamination.

Methods

Forty specimens were obtained, spanning six test situations. In each study case a 10 ml syringe fitted with a 21-gauge needle was filled with fresh normal saline. Over the course of one hour during general anaesthesia four injections of 2 ml each were made into the flashball of an intravenous line that had been established at the onset of the case and through which Ringer's lactate solution was being infused. Each injection was made with the tubing above the site of injection obstructed to ensure forward flow, and with constant pressure on the plunger of the syringe during insertion and withdrawal. After the four injections were made the needle was removed and the remaining 2 ml

TABLE Results

Group	*N*	*Contaminated*
I	8	0
II	8	1
III	6	1
IV	4	1
V	6	5
VI	6	0

in the syringe were injected directly through a 5 micron millipore filtre, which was then fixed with 95 per cent alcohol and stained with Pap stain on a slide. The filtre was removed from the slide with chloroform and the sample inspected by microscope for the presence or absence of red blood cells. The slides were prepared by cytology lab technologists and examined by technologists and/or a pathologist all experienced in this technique, who were blinded as to the sample groups.

Injections were made into tubing under the following experimental conditions:

I "Clean" tubing with no sign of discolouration.

II "Clean" tubing where an automatic blood pressure cuff was periodically used on the same arm as the intravenous catheter.

III "Clean" tubing which had previously contained a back-flow of blood but had been flushed clear.

IV Blood-tinged fluid.

Positive controls (Group V) were made by diluting a blood-contaminated specimen until the solution was clear compared with normal saline when viewed against a white sheet. Negative controls (Group VI) consisted of normal saline (Table).

Results

Two samples from Group IV were discarded because they showed visible discolouration when viewed against a white sheet.

Discussion

It is evident that blood contamination of syringes may occur without being visually apparent and without obvious back-flow of blood into the intravenous tubing or of solution into the syringe. When a blood pressure cuff is present on the intravenous arm or if the tubing has been previously contaminated, blood that is not visible to the eye may be trapped in injection ports, and not clear despite continuous flushing through the tubing. Blood inadvertently aspirated into a syringe in this manner could be injected into subsequent patients if the syringe is reused. The 83 per cent sensitivity of the test method may mean that the number of contaminated samples was underestimated. Whether or not the size of the inoculum of infectious organisms transmitted in this manner would be sufficient to cause disease is not known.

References

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Comparison of liquid crystal skin temperature probe and axillary thermistor probe in measuring core temperature trends during anaesthesia in paediatric patients

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Liquid crystal temperature (LCT) is a non-invasive alternative to an axillary thermistor (AT) probe to measure temperature during anaesthesia, where a more invasive temperature probe (oesophageal) cannot be placed. The accuracy of both LCT and AT in detecting core temperature has been disputed. This study compares the accuracy of Liquid Crystal Temperature (LCT) skin strips and axillary thermistor (AT) probes in detecting core temperature changes in anaesthetized children.

Methods

Ninety-five children undergoing operative procedures requiring tracheal intubation were studied. LCT strips were placed on the forehead; an AT probe was taped to the skin over the axillary artery and an oesophageal temperature probe/stethoscope (ET) was placed in the oesophagus. Temperature was recorded every five minutes for the duration of the surgical procedure. Correlation of axillary and LCT with oesophageal temperature using linear regression analysis and analysis of mean difference was carried out.

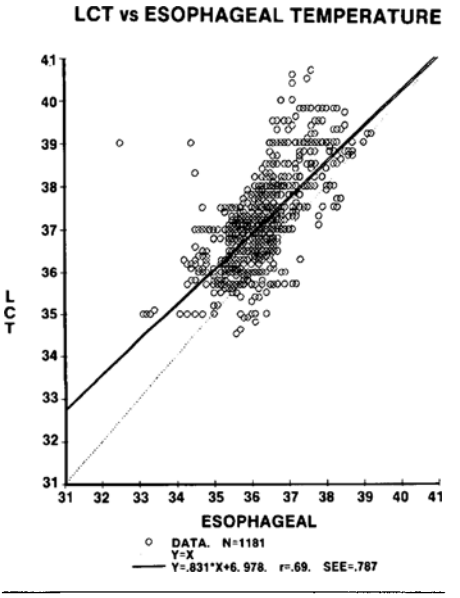

FIGURE 1

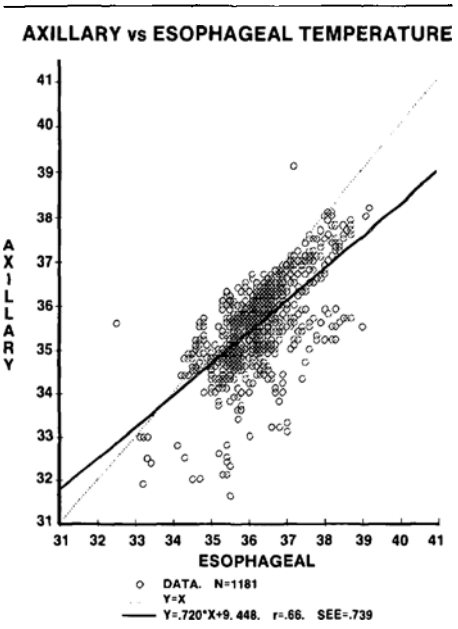

FIGURE 2

Results

The mean (± SEM) age of the patients 64.7 ± 6.9 months, mean weight 23.3 kg ± 2.3, patient preop temperature 36.4 ± 0.09, anaesthetic time 129.7 ± 10.6 minutes, surgery time 98.1 ± 9.3 minutes. Figures 1 and 2 show an R^2 correlation coefficient of 0.69 for LCT and R^2 value of 0.66 for AT versus oesophageal temperature. The mean difference between LCT-oesophageal was 0.843 ± 0.801 $P < 0.0001$ and axillary – oesophageal was – 0.674 ± 0.781 $P < 0.0001$.

Discussion

The high incidence and severe consequences of both hypothermia and hyperthermia have aroused widespread concern and stimulated enthusiasm for both monitoring body temperature and increased attempts to conserve it. The oesophageal temperature is the best representative of true core temperature. However, this form of monitoring is only practical in intubated patients. Alternative temperature monitoring sites are axilla or forehead. We have demonstrated that LCT and axillary probes are not an accurate replacement for oesophageal temperature probe, but that LCT strip is as accurate as an axillary probe in measuring body temperature. If LCT calibration was readjusted downward by 0.8° C by the manufacturer, it should prove to be more accurate.

Intrathechal morphine in cardiac surgical procedures

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Pain after heart surgery can be severe and can delay weaning from mechanical ventilation. Since long-lasting analgesia and improved pulmonary function tests have been demonstrated with epidural or intrathecal morphine (MS) use, in upper abdominal and thoracic surgery,[1,2] we undertook a study of intrathecal MS in patients undergoing coronary artery bypass grafting and/or valve replacement. We examined postoperative analgesia, the incidence of postoperative hypertension, and extubation times over the first 24 postoperative hours.

Methods

Thirty-two consecutive patients were premedicated with morphine, scopolamine and midazolam. Those requiring haemodynamic support preoperatively were excluded. The patients were divided into study (n = 12), and control (n = 20) groups based on their coagulation profile. Even though peridural haematoma is very rare,[3] only those with a normal coagulogram received spinal MS, while those with elevated PT/PTT or decreased platelets did not undergo lumbar puncture. The groups were not significantly different with respect to age, height, weight, procedure, sufentanil dosage or surgical, bypass or cross clamp times. One mg MS mixed with 1 ml spinal fluid was administered to the study patients, before induction of anaesthesia, and using a 25 g needle. Previous studies had used higher doses but encountered frequent side effects.[4] Anaesthesia consisted of a low-dose narcotic technique (sufentanil 7 $\mu \cdot kg^{-1}$, mean, 4.0 $\mu \cdot kg^{-1}$) with supplementary isoflurane, thiopentone and/or midazolam. Relaxation was achieved with vecuronium. Postoperative analgesia was provided at the bedside nurse's discretion with morphine or butorphanol and sedation with midazolam.

Results

Ten/twelve study patients did not require parenteral analgesia on postop day one vs 6/20 control patients ($P < 0.01$). Analgesia for those study patients that did complain on day one (n = 2) lasted 16.8 hrs, versus 8.5 hrs for controls (n = 14). Nausea was more frequent among the study group (42 vs 15 per cent) but other side effects including pruritus were unusual, and did not differ between groups. PCO_2 was statistically higher in the study population but this was not clinically important, and the lowest respiratory rates were similar. There was no difference in the incidence of hypertension nor in the extubation time, using standard ICU extubation criteria.

Conclusion

Spinal morphine provided excellent, safe, postoperative analgesia but in this study failed to provide any secondary benefit, i.e., decreased hypertension or earlier extubation, in the first 24 hours.

References

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Non-invasive monitoring to guide respiratory management post cardiac surgery

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Good correlation has been demonstrated between end-tidal CO_2 ($P_{ET}CO_2$) and $PaCO_2$[1] and between pulse oximetry and arterial oxygen saturation (SaO_2)[2] during anaesthesia, but not during rewarming from hypothermia. This study was performed to determine if capnography and pulse oximetry are reliable when used for respiratory management after cardiac surgery.

Method

After Ethics Committee approval 20 patients were studied following uncomplicated coronary artery bypass grafting (CABG). A central mass spectrometer sampling tube (SARA) and Hewlett Packard (HP) capnometer sensor were placed in the patient airway, and an Ohmeda pulse oximeter was attached to a digit. Temperature was recorded from the PA catheter. Temperature corrected arterial blood gas (ABG) samples were taken 30 min after arrival in the ICU, hourly until the temperature peaked, then four-hourly. At the time of each ABG determination $P_{ET}CO_2$ from SARA and capnometer, and SaO_2 from the pulse oximeter were recorded. The temperature, haemodynamic and ventilatory variables were also recorded. After analysis of results from these 20 patients, 24 patients undergoing CABG were managed using the noninvasive monitors. An ABG 30 min after arrival in the ICU and the simultaneous $P_{ET}CO_2$ (SARA or HP) and SaO_2 from the pulse oximeter were recorded by the nurse. Based on the 30 min $P_{ET}CO_2$-$PaCO_2$ gradient the ventilator was adjusted to maintain an assumed $PaCO_2$ of 40 mmHg and SaO_2 of > 95 per cent. Further ABGs were drawn four hours after arrival and then four-hourly. The results were not shown to the nurse or physician giving care. Non-invasive variables were recorded hourly for eight hours then four-hourly until extubation. Correlations between direct and non-invasive measurements of CO_2 and SaO_2, and of temperature and haemodynamic variables with the gradient between $PaCO_2$ and $PetCO_2$, were analyzed with linear regression or ANOVA where appropriate.

Results

Invasive and non-invasive variables in the first 20 patients at each temperature band are shown (Table). Temperature had no significant effect on the gradients; SARA values were 2–3 mmHg lower than HP. Haemodynamic variables did not affect gradients for either $P_{ET}CO_2$ or SaO_2. In 23 episodes of hypercarbia ($PaCO_2$ > 45 mmHg) SARA failed to predict high $PaCO_2$ in two cases, HP in one, and both in two cases (i.e., five failures). In all but one instance failure was due to an increase in gradient of ≤ 5 mmHg. Pulse oximetry failed to detect SaO_2 < 95 per cent in two instances with no obvious cause.

TABLE Comparison between invasive and non-invasive monitoring at each temperature range: mean ± SEM

	$PaCO_2$-SARA CO_2 (mmHg)	*$PaCO_2$-HP CO_2 (mmHg)*	*SaO_2-pulse O_2sat (%)*
< 35° C	8.75 ± 0.98	6.50 ± 0.78	1.10 ± 0.58
35-36° C	11.25 ± 1.20	8.63 ± 1.25	1.13 ± 0.41
36-37° C	9.13 ± 1.08	6.25 ± 1.01	1.25 ± 0.44
> 37° C	8.94 ± 1.16	5.42 ± 1.37	0.89 ± 0.36

In the 24 patients managed with non-invasive monitoring there were 14 episodes of hypercarbia; ten were detected by capnography. In the other four episodes the gradient between $P_{ET}CO_2$ and $PaCO_2$ had increased by 3–5 mmHg. Three episodes of hypoxaemia (O_2sat < 95 per cent) occurred; two were not detected by oximetry. Non-invasive monitor failures occurred in all temperature ranges.

Discussion

The small transient increases in $PaCO_2$–$P_{ET}CO_2$ gradients (9/44 patients) and incidence of failure of the pulse oximeter to detect SaO_2 < 95 per cent (4/44 patients) indicate these monitors cannot entirely replace ABGs after cardiac surgery. Despite this, in the majority of patients continuous accurate information on the adequacy of ventilation and oxygenation was provided. Possible causes of isolated noninvasive "errors" include operator error (e.g., nurse/physician failing to record true end-tidal or to verify oximeter signal), or transient changes in dead space ($P_{ET}CO_2$). Laboratory error in ABG determinations may also occur.

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Effects of halothane on hypoxic pulmonary vasoconstriction

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We wished to characterize more exactly the effects of halothane on hypoxic pulmonary vasoconstriction (HPV). Using a stop flow technique, pulmonary vascular resistance (PVR) can be divided into inflow (Rin), middle (Rm), and outflow (Rout) resistance.[1] The hypoxic pressor response is localized to the middle resistor. We reasoned that halothane could specifically antagonize HPV by also acting on the middle resistor. Alternatively, halothane could act as a nonspecific vasodilator and selectively decrease all subdivisions of vascular resistance.

Methods

The study was approved by the Animal Care Committee. The

TABLE

	Normoxia$_1$ control	*Hypoxia control*	*Normoxia halothane*	*Hypoxia halothane*	*Normoxia$_2$ control*
%Rtot	100	125*	81†	85	95
		±25	±9	±7	±9
%Rin	100	112	101	106	95
		±26	±24	±25	±6
%Rmid	100	417*	63	81	98
		±175	±41†	±37	±3
%Rout	100	68	76	81	92
		±18	±15	±13	±22

*Denotes difference ($P < 0.01$) from normoxia$_1$, normoxia$_2$, thypoxia-halothane.

†Denotes difference ($P < 0.05$) from normoxia$_1$ normoxia$_2$.

left lower lobe of six mongrel dogs were surgically prepared by cannulating the pulmonary artery, vein and left lower lobe bronchus. The isolated lobe was left *in situ* and connected to an extracorporeal circuit primed with autologous blood. The lobe was gravity perfused in Zone 3 by appropriately setting heights of the inflow (Pin) and outflow (Pout) reservoirs. With an instantaneous occlusion of inflow or outflow, pressure changes rapidly (ΔP) followed by a slow change. Rin and Rout can be calculated from the ΔP of inflow or outflow occlusion respectively divided by lobar flow ($\dot{Q}_L$). Total resistance (Rtot) is calculated from Pin − Pout/$\dot{Q}_L$. Rm is calculated from Rtot − (Rin + Rout). Each lobe was sequentially ventilated with five gas mixtures; normoxia$_1$ (35 per cent O_2)-control, hypoxia (three per cent O_2)-control, normoxia (35 per cent O_2)-halothane (0.6 MAC), hypoxia (three per cent O_2)-halothane (0.6 MAC), and normoxia$_2$ (35 per cent O_2)-control. The distribution of resistances, venous blood gases, inspired gas, temperature and haematocrit were measured during each period of ventilation. ANOVA and paired t test with correction factor for multiple comparisons were used for statistics.

Results

There were no statistical differences between conditions for inspired gas CO_2, pulmonary vein CO_2, pH, haematocrit, temperature, inflow pressure, outflow pressure or total vascular compliance. The pulmonary vein O_2 and inspired O_2 were similar in the two normoxic conditions, and were also similar in the two hypoxic conditions. Inspired halothane concentration was similar in normoxia-halothane and hypoxia-halothane. The Table illustrates the percent change in total PVR and its subdivisions for each period of ventilation after normalizing flow in each dog for the initial normoxia$_1$ conditions. Hypoxia increased total PVR compared to normoxia$_1$ and normoxia$_2$ controls. Halothane inhibited this hypoxic pressor response when comparing hypoxia-halothane with hypoxia-control. Halothane also decreased PVR when comparing normoxia-halothane to normoxia$_1$ and normoxia$_2$ controls. The changes in PVR were due to changes in the middle resistor as both Rin and Rout were not statistically different in any period.

Discussion

Halothane acts to decrease pulmonary vascular resistance by dilating the middle resistor and is thus a selective inhibitor of hypoxic pulmonary vasoconstriction rather than a nonspecific vasodilator.

Supported by a grant from the Saskatchewan Heart Foundation and Saskatchewan Lung Association.

Reference

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Effects of halothane on hypoxic pulmonary vascular flow

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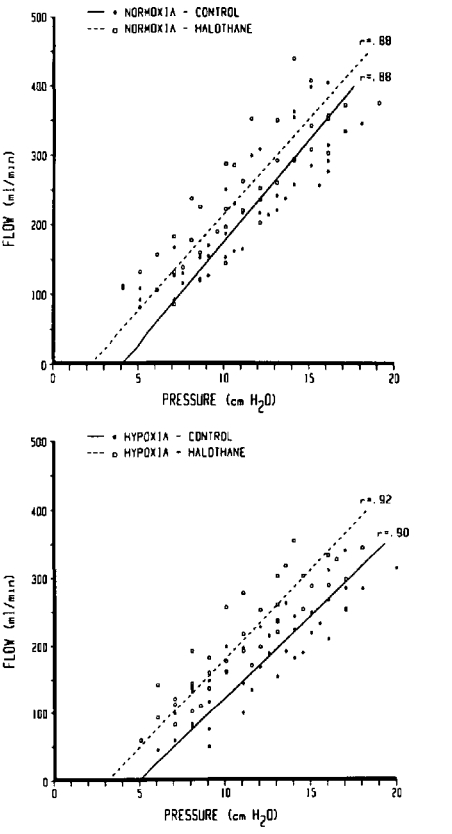
The pulmonary vasculature is composed of a flow-dependent resistance and a flow-independent resistance.[1] The flow-dependent resistance is reflected by the slope of the pressure-flow plot. The flow-independent resistance is reflected by the zero flow pressure intercept of the pressure-flow plot. We evaluated the effects of halothane on the canine pulmonary vasculature using this model to characterize its actions better both in normoxic and hypoxic conditions.

Methods

Through a left thoracotomy we cannulated the left lower lobar artery, vein, and bronchus in six dogs. The *in situ* left lower lobe was connected to an extracorporeal circuit and was perfusedwith autologous blood. The lobe was maintained in zone two conditions by carefully setting the heights of the inflow and outflow reservoir in relation to the lobe. We decreased inflow pressure in steps of 2 to 3 cm H_2O and measured lobar flows at each driving pressure. The lobe was initially ventilated with 35 per cent O_2 (normoxia-control). We then sequentially ventilated the lobe with three per cent O_2 (hypoxia-control), 35 per cent O_2 with halothane 0.6 MAC (normoxia-halothane) and finally three per cent O_2 with halothane 0.6 MAC (hypoxia-halothane). In each condition the gas mixture included seven per cent CO_2. During each condition we also measured inspired gases, lobar venous blood gases, temperature and lobar haematocrits. Results were analyzed by analysis of variance (ANOVA) and t tests with a correction for multiple comparisons. The pressure-flow plots were analyzed by linear regressions with the slopes and the zero flow intercepts derived from the resultant linear equation.

Results

Values of inspired and lobar venous CO_2, pH, haematocrit, inflow pressure and temperature were similar among the four conditions. The values of venous O_2 and inspired O_2 were similar between the two normoxic conditions and between the two hypoxic conditions. The Figure illustrates the pressure-flow relationship during each condition. The four lines showed a significant correlation ($R > 0.88$) ($P < 0.01$) with the slopes of the lines similar between each condition. The extrapolated



FIGURE

pressure intercepts were 4.0, 5.0, 2.2, and 3.1 cm H_2O for normoxia-control, hypoxia-control, normoxia-halothane and hypoxia-halothane conditions respectively. These intercepts were different between groups ($P < 0.05$).

Discussion

The slope of the pressure-flow relationship was not affected by either halothane or hypoxia. This implies that halothane and hypoxia do not affect the calibre of the vasculature. Instead hypoxia increases and halothane decreases the flow-independent pressure intercept. The pressure intercept is likely related to the tone in alveolar vessels[1] and this further implies that halothane acts primarily to decrease tone in these small vessels. This changes the concept that halothane is a general vasodilator and instead suggests that it acts preferentially at the alveolar vessel level.

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Haemodynamic and prostanoid response to fat microembolism after cemented arthroplasty

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Fat microembolism due to cemented arthroplasty (CA) has been demonstrated to increase pulmonary vascular resistance (PVR), pulmonary artery pressure (PAP), pulmonary shunt fraction ($\dot{Q}_S/\dot{Q}_T$) and decrease arterial O_2 tension (PaO_2). However, in a dog model of CA quantitative morphometry to determine the number of fat emboli suggests that the percentage of pulmonary vasculature occluded by fat is insufficient to account for these physiological changes. We hypothesize that after acute lung injury from fat microembolism the products of arachidonic acid metabolism are released and contribute to the physiological changes. Therefore, in a dog model of CA we measured 6-keto prostaglandin F1α (6PGF) (a stable metabolite of prostacyclin) and thromboxane B_2 (TxB_2) (a stable metabolite of thromboxane A_2) using a radioimmunoassay technique.

Methods

Seven mongrel dogs were anaesthetized with pentobarbitone (30 $mg \cdot kg^{-1}$), the trachea intubated and the lungs in each animal ventilated to an arterial $PaCO_2$ of 35–40 mmHg. Arterial (BP), pulmonary artery (PA), right atrial (RA), and left atrial (LA) pressures were monitored continuously. Cardiac output ($\dot{Q}$), 6PGF and TxB_2 levels were measured before and after reaming, and at 1, 5, 15, 30 and 60 minutes after cement and prostheses insertion. $\dot{Q}_S/\dot{Q}_T$ and physiological deadspace/tidal volume (V_D/V_T) were calculated at each measurement period. In the last three dogs, five arterial samples were drawn during the first 60 seconds after CA for 6PGF and TxB_2 assay.

Both femora were exposed and reamed. Howmedica Simplex P bone cement was then injected into each femur and contoured metal prostheses were hammered into place. When the 60-minute measurement was completed, the animal was killed by injecting KCl into the LA cannula. The lungs were excised, fixed in inflation, and quantitative morphometry performed to determine the number of fat emboli.

Results

There were no significant changes in BP, LAP, RAP, or V_D/V_T. Significant increases in PAP, PVR and $\dot{Q}_S/\dot{Q}_T$ after cement and prostheses insertion were noted (Table). There was a significant decrease in PaO_2 (Table). There was a significant increase in 6PGF, at one minute after cement insertion, with the arterial sample ($1.14\ ng \cdot ml^{-1}$) being significantly higher than the mixed venous ($0.80\ ng \cdot ml^{-1}$) sample. There was a marked (3–4-fold) increase in TxB_2 30–40 seconds after CA which remained significantly elevated at the one minute measurement.

TABLE

	Pre-reaming baseline	*Post-reaming baseline*
MAP mmHg	159 ± 10	151 ± 7
PAP mmHg	16.6 ± 7.3	13.3 ± 3.2
CO l/min	3.7 ± 0.9	3.4 ± 1
PVR cm·dyne^{-1} sec^{-5}	197 ± 52	243 ± 72
PaO_2 mmHg	104 ± 7	105 ± 6
QS/QT %	25.1 ± 2.5	20.3 ± 1.8
6PGF (a) ng·ml^{-1}	0.24 ± 0.06	0.29 ± 0.13
6PGF (v) ng·ml^{-1}	0.25 ± 0.09	0.33 ± 0.14
TxB_2 (a) ng·ml^{-1}	0.73 ± 0.24	0.87 ± 0.55
TxB_2 (v) ng·ml^{-1}	0.73 ± 0.25	0.86 ± 0.37

40

	Post-cemented arthroplasty		
	1 min	*5 min*	*15 min*
MAP mmHg	133 ± 25	143 ± 19	145 ± 14
PAP mmHg	31.5 ± 13*	30 ± 10.5*	25.9 ± 5.1*
CO l/min	—	3.0 ± 0.7	3.1 ± 3.1
PVR cm·dyne^{-1} sec^{-5}	—	738 ± 305*	628 ± 221*
PaO_2 mmHg	96 ± 4*	88 ± 5*	88 ± 7*
QS/QT %	—	26.3 ± 4.2*	26.3 ± 4.5*
6PGF (a) ng·ml^{-1}	1.14 ± 0.42*	0.72 ± 0.33*	0.36 ± 0.11
6PGF (v) ng·ml^{-1}	0.80 ± 0.19*	0.64 ± 0.21*	0.46 ± 0.19
TxB_2 (a) ng·ml^{-1}	1.22 ± 0.65*	1.04 ± 0.41	0.98 ± 0.40
TxB_2 (v) ng·ml^{-1}	1.16 ± 0.62*	0.89 ± 0.32	1.01 ± 0.40

Data presented as mean ± 1 SD.
*Denotes a significant change from baseline ($P < 0.05$) using two-way analysis of variance and Dunnett's multiple range test.

Discussion

The increases in PAP, PVR and $\dot{Q}_S/\dot{Q}_T$, immediately after CA were associated with an increase in 6PGF and TxB_2 levels. However, the reaming process is not responsible for these changes. Although pulmonary hypertension persisted for the 60-minute period after CA the TxB_2 response was transient. Our findings suggest that fat microembolism after CA is associated with the production of arachidonic acid metabolites. Whether this prostanoid response is the cause of the pulmonary haemodynamic changes after fat microembolism or only a marker for endothelial and cellular injury is not known. However, the significantly higher 6PGF level in the arterial blood at one minute compared with the mixed venous sample verifies that the lung is the source of prostaglandin production.

Diffusion hypoxia, does it exist? A study in ASA I patients

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Hypoxia is a frequent and major complication of general anaesthesia. The contribution of post nitrous oxide hypoxia (diffusion hypoxia) to the overall hypoxia has yet to be determined. This study was set up to try to determine that contribution.

Methods

Twelve ASA physical status I patients aged 16–65 years agreed to take part in the study. All were undergoing minor procedures involving general anaesthesia. All patients were seen and informed consent obtained, premedication of papaveretum and hyoscine was prescribed, dosage adjusted for weight. In the anaesthetic room, the patient was connected to a Kontron pulse oximeter, pulse and BP recorded, and an intravenous cannula inserted into one hand. Anaesthesia was induced with thiopentone, then maintained with oxygen 33 per cent in air and halothane. A vaporiser setting of three per cent, approximately four times the minimal alveolar concentration (MAC) in air was used. Spontaneous respiration via a mask and a Mapleson A circuit was maintained for ten minutes. Regular pulse, BP, end–tidal carbon dioxide ($ETCO_2$), and oxygen saturation were recorded. The patient was then disconnected from the anaesthetic circuit and allowed to breathe air for up to ten minutes or until the first sign of lightening of anaesthesia occurred. Anaesthesia was then re-established with oxygen 33 per cent in nitrous oxide (N_2O) 66 per cent, and halothane with a vaporiser setting of two per cent, approximately four MAC in N_2O. The patient was then taken into the operating theatre and the procedure performed on this anaesthetic mixture. At the end of the procedure, the circuit was disconnected and the patient allowed to breathe air. Throughout the entire procedure, regular recordings of pulse, BP, $ETCO_2$ and oxygen saturation levels were recorded. The trial was abandoned and oxygen administered if saturation dropped below 85 per cent oxygen at any stage.

Results

Statistical analysis of data employing Students t test was performed. Oxygen saturation changes at two, five and ten minutes and maximum saturation changes were analysed, and revealed no significant difference between the two groups. (Significance assessed as a "β" value of 0.05). There was no difference to the mean time of maximum saturation change, in both groups this was four minutes. $ETCO_2$ at the completion of ten minutes air/oxygen/halothane and at the end of the period of

TABLE Oxygen saturation change with time % change

Patient no.	*At 2 min*		*At 5 min*		*At 10 min*		*Maximum change*	
	Air	*N_2O†*	*Air*	*N_2O*	*Air*	*N_2O*	*Air*	*N_2O*
1	5	7	2	7	–	–	5	7
2	2	5	2	3	–	–	2	5
3	2	2	3	2	–	–	3	2
4	2	2	3	6	–	–	3	6
5	3	4	2	4	5	3	5	4
6	2	4	4	2	2	3	4	6
7	2	4	3	3	4	3	5	4
8	3	2	2	2	2	4	3	4
9	3	4	5	2	5	4	6	5
10	3	3	2	5	3	4	4	5
11	7	5	2	2	2	1	7	5
12	2	4	2	3	2	1	8	6

*Air = air/O_2/halothane technique
†N_2O = N_2O/O_2/halothane technique

N_2O/oxygen/halothane was performed using Student's t test and no significant difference was found between the two groups. (Table).

TABLE

			PGE1		
	Baseline	*PGF2a*	*Low*	*Inter*	*High*
CI	4.5±1.2	3.3±0.5*	3.1±0.3	3.2±0.5	3.5±0.5
SVR	24±7	32±6*	32±8	31±10	27±8a
PVR	2.3±0.5	5.8±1.2*	5.6±1.5	5±1.2	4.4±1.3a
CCP	9±3	15±3*	14±3	13±3	12±3a
Slope	1.5±1.2	2.8±0.5*	2.8±0.6	2.5±0.6	2.5±0.6

Values are mean ± SD. $P < 0.05$ by paired t test * vs baseline; a vs PGF2a.

Discussion

The Fink principle to describe diffusion hypoxia was first described in 1955, but with the introduction of the pulse oximeter the assessment of second to second changes in oxygen saturation has become possible, using simple, accurate and non-invasive techniques. Fink originated the theory after an *in vitro* experiment, and followed that up with a study on eight patients who were allowed to breathe room air immediately after completion of anaesthesia including a mixture of N_2O and oxygen. His results showed reductions in oxygen saturation of varying degrees and duration in the presence of supposedly adequate spontaneous ventilation, although the extent to which respiratory depression was responsible for any hypoxia was not accurately determined. By measuring E_TCO_2 and obtaining no significant difference at the end of the anaesthetic periods, respiratory depression should have been excluded as a cause of hypoxia in this study.

Conclusion

Diffusion hypoxia does not appear to be a significant problem following minor surgery in healthy adults who received anaesthesia involving spontaneous respiration and little cardiovascular and respiratory disturbance. Routine administration of oxygen in the absence of other problems may not be necessary in these patients. It does not follow that the same is true of other groups of patients having more major procedures.

Prostaglandin E1 efficacy in canine model of pulmonary hypertension

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An acute increase in pulmonary vascular resistance (PVR) following repair of congenital heart lesions may seriously compromise a successful surgical outcome. Active vasoconstriction is partly responsible for these episodes of pulmonary hypertension and results from the highly reactive nature of these patients' pulmonary vasculature. In this critical situation inotropic agents may fail to increase cardiac output and vasodilators such as tolazoline and phentolamine have been used.[1] However, the fear that they may induce systemic hypotension limits their use. Prostaglandin E1 (PGE1) has been tried in various types of pulmonary hypertension but there exist great discrepancies in doses used and effects on PVR. We therefore evaluated incremental dose-response of PGE1 on pulmonary vascular dynamics in a model of vasoconstrictive pulmonary hypertension.

Methods

In eight dogs the pulmonary artery pressure (PAP)/flow relationship was assessed. Using an adjustable arteriovenous fistula, PAP/CI lines were generated by altering CI. The slope of these lines represents vascular conductance in the pulmonary vessels set up as parallel units, leading to capillaries submitted to a critical closing pressure (CCP), the mean of which is the intercept of the PAP/CI line at zero flow. The intercept thus represents the effective vascular outflow pressure which is usually higher than the assumed value (left atrial pressure). An aortic electromagnetic flow-probe was used to derive CI values.

Results

By infusing prostaglandin F2 alpha (PGF2a) into the main pulmonary artery, we caused vasoconstriction (see table): PVR increased almost threefold due to a 90 per cent increase in PAP/CI line slope and 60 per cent increase in CCP. PAP increased from 16 ± 5 to 24 ± 4 mmHg. CI decreased by 25 per cent. Mean arterial pressure (MAP) was unchanged and systemic vascular resistance (SVR) increased by 33 per cent. After stabilization three dose ranges of PGE1 were tested by 15-minute infusion in a peripheral vein: low (0.04 to 0.08 $\mu g \cdot kg^{-1} \cdot min^{-1}$, intermediate (0.12 to 0.2 $\mu g \cdot kg^{-1} \cdot min^{-1}$ and high (0.24 to 0.32 $\mu g \cdot kg^{-1} \cdot min^{-1}$. Results are presented in the Table. PVR was substantially decreased only by high-dose PGE1 (−24 per cent). This was mainly due to a decrease in CCP (−23 per cent). PAP decreased from 24 ± 4 to 20 ± 5 mmHg. Mean CI remained constant throughout PGE1 administration. At the highest dose CI was: increased in three dogs, unchanged in three and decreased in two. At high-dose PGE1, MAP decreased from 109 ± 21 to 96 ± 18 mmHg. SVR was decreased by 14 per cent. Mean left and right atrial pressures remained unchanged. Arterial gases measured in five dogs were unchanged by PGF2a hypertension but PO_2 decreased from 162 ± 74 to 94 ± 45 mmHg and PCO_2 increased from 38 ± 4 to 51 ± 8 mmHg following PGE1 administration.

Prostaglandin E1 decreased PVR substantially only at the highest dose studied by decreasing pulmonary vascular outflow pressure. Although encouraging because it decreased PVR relatively more than SVR (24 vs 14 per cent) it failed to increase CI in five out of eight dogs and had unfavourable effects on arterial blood gases. Since hypoxaemia is a great stimulus of pulmonary vasoconstriction, this effect should be further studied in models of vasoconstrictive pulmonary hypertension before PGE1 use is advocated following repair of congenital heart disease.

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Analgesic and respiratory effects of continuous lumbar epidural fentanyl in post-thoracotomy patients

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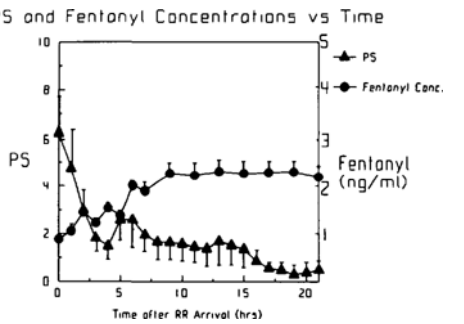
Epidural fentanyl infusions using lumbar catheters have recently been shown effective for post-thoracotomy pain.[1] Claims of the technique's safety in these patients have been made without intensively studying respiratory effects and serum concentrations. This study investigated the respiratory and analgesic effects, as well as systemic drug uptake in post-thoracotomy patients receiving continuous lumbar epidural fentanyl infusions.

Methods

After obtaining institutional approval and informed consent six ASA physical status I–III patients undergoing thoracotomy were prospectively studied. The night prior to surgery during sleep, control respiratory patterns were determined using respiratory inductance plethysmography (RIP), and arterial blood gases (ABG) taken at two-hour intervals. RIP measurements of respiratory rate (FREQ), slow respiratory rate (SRR = respiratory rate less than 10 min^{-1} persisting for 5 min), and apnoea (AP = tidal volume < 100 ml for more than 15 sec) were measured continuously and recorded at 5 min intervals. Immediately prior to surgery an epidural catheter was inserted at the L_{2-3} or L_{3-4} interspace and its position was verified with 8 ml of two per cent CO_2 lidocaine. No premedication was given, and the patients were anaesthetized with N_2O/isoflurane/vecuronium or pancuronium. One hour after induction, a bolus of 1.5 $\mu g \cdot kg^{-1}$ of epidural fentanyl was given, and an infusion of 1.0 $\mu g \cdot kg^{-1} \cdot hr^{-1}$ was started. This was continued into the postoperative period for 24 hrs. If the patient requested more analgesia, a further bolus of 0.5 $\mu g \cdot kg^{-1}$ was given and the infusion was increased by 0.25 $\mu g \cdot kg^{-1} \cdot hr^{-1}$. This process was repeated if necessary, at intervals of not less than 30 min. Fentanyl was supplied in a concentration of 10 $\mu g \cdot ml^{-1}$ for the infusion and 5 $\mu g \cdot ml^{-1}$ for bolus dosing. RIP monitoring was resumed in the recovery room (RR). Upon arrival in the RR, and following infusion rate changes, assessment of pain, using a visual analogue score (PS; 10 = severe pain, 0 = no pain), and vital signs were both made at 15 min intervals for one hour and then hourly. Also, following infusion rate changes, ABG and serum fentanyl concentration samples were collected at 15 min intervals for one hour, hourly for 4 hrs, and then at 2-hr intervals. Fentanyl concentrations were determined by radioimmunoassay. Data were analyzed using paired sample t tests.

Results

The average infusion rate was 1.30 ± 0.07 $\mu g \cdot kg^{-1} \cdot hr^{-1}$. As a percentage of the total time, 19 per cent was spent using an infusion rate of 1.00 $\mu g \cdot kg^{-1} \cdot hr^{-1}$, 37 per cent 1.25, 32 per cent 1.50, and 13 per cent 1.75 $\mu g \cdot kg^{-1} \cdot hr^{-1}$ respectively. The mean PS was 1.79 ± 0.30, and the mean serum fentanyl concentration was 1.83 ± 0.13 ng $\cdot ml^{-1}$. The Figure shows mean PS, and mean serum fentanyl concentrations as a function of time after RR arrival. The Table compares preoperative and postoperative respiratory variables. One patient had 262 and 80 APs pre- and postoperatively. Excluding this patient, the mean



FIGURE

TABLE Values are means ± SEM

	FREQ	*PCO_2*	*pH*	*AP‡*
Preoperative	14.7 ± 1.4	37.3 ± 1.2	7.42 ± 0.01	65 ± 37
Postoperative	17.4 ± 0.7*	43.6 ± 1.5*	7.36 ± 0.01†	31 ± 12

	AP·hr^{-1}‡	*SRR*	*SRR·hr^{-1}*
Preoperative	7.4 ± 3.9	11.0 ± 7.3	1.24 ± 0.78
Postoperative	1.7 ± 0.6	27.7 ± 3.3	1.33 ± 0.63

*P < 0.05, †P < 0.01; ‡see Results.

AP·hr^{-1} becomes 3.3 ± 1.4 preoperatively and 1.2 ± 0.5 postoperatively (NS).

Discussion

This study confirms that lumbar epidural fentanyl infusions are effective for post-thoracotomy pain relief. Although arterial PCO_2 and pH were significantly different from preoperative values they are similar to those in patients receiving systemic narcotics,[2] and there were no significant changes in the incidence of apnoea and SRR, while FREQ significantly increased. The serum fentanyl concentrations were however within reported analgesic ranges,[3] and this calls into question the mechanism of action of this technique.

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The effect of spontaneous versus machanical ventilation on the onset and depth of diaphragmatic relaxation with succinycholine in the dog

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Diaphragmatic blood flow is higher during spontaneous than mechanical ventilation. As a result, the type of ventilation may effect neuromuscular relaxant onset time and intensity of twitch depression by promoting drug delivery to the diaphragm.[1] The purpose of this study was to determine if spontaneous ventilation prior to muscle relaxant administration is accompanied by a more rapid and pronounced relaxation of the diaphragm.

Methods

This study was approved by the UTHSCSA committee on animal care. Seven mongrel dogs anaesthetized with halothane were studied. Each dog was alternately mechanically ventilated and/or allowed to ventilate spontaneously. Diaphragmatic blood flow was estimated using a doppler flow probe around the left phrenic artery.[2] Diaphragmatic force of contraction was measured using transdiaphragmatic pressure (Pdi) following bilateral phrenic nerve train-of-four stimulation. Time of onset was measured from the end of injection of succinylcholine to the time a specific percentage of first twitch depression was attained. Phrenic artery blood flow, Pdi and onset times were examined when the animal was spontaneously or mechanically ventilated prior to muscle relaxant administration. Each animal was allowed to recover fully and was started on the alternate mode of ventilation. Results are expressed as mean ± SEM with comparisons made using a paired Student's t test. A P value <0.05 was considered statistically significant.

Results

At constant temperature, blood pressure and acid–base balance phrenic artery blood flow increased from 2.55 ± 0.34 with mechanical ventilation to 5.70 ± 0.75 $ml \cdot min^{-1}$ with spontaneous ventilation (both $P < 0.001$). Maximal twitch depression increased 241 ± 36 per cent ($P < 0.001$). Also, onset times to 50 per cent twitch depression and maximal twitch depression decreased from 92.4 ± 15 to 26 ± 3.4 seconds and from 156 ± 9 to 96 ± 9 seconds, respectively (both $P < 0.001$).

Discussion

This study showed that maximal diaphragmatic twitch depression from succinylcholine was increased two-fold and onset time reduced by 38 per cent when drug administration was preceded by spontaneous ventilation compared with mechanical ventilation. Furthermore, spontaneous ventilation was also associated with a two-fold increase in phrenic artery blood flow which could explain the greater twitch height depression and faster onset by a specific increase in drug delivery to the diaphragm. Onset time to maximal twitch depression was not reduced proportionately to the increase in blood flow because maximal twitch depression was greater in the spontaneously ventilating dog. Had the amount of succinylcholine administered been sufficient to completely abolish diaphragmatic twitch during controlled ventilation (as is probably the custom in clinical practice) then onset time to maximal twitch depression should have been reduced further.

Administration during spontaneous ventilation of a muscle relaxant will increase its effect and rapidity of action on the diaphragm without increasing the dose. Since diaphragmatic contraction is important in the act of vomiting, rapid paralysis of this relatively insensitive muscle may be of great importance, especially during rapid sequence induction. This animal study suggests that increasing diaphragmatic activity by spontaneous ventilation, and possibly more by spontaneous hyperventilation, prior to induction may significantly accelerate diaphragmatic muscle paralysis without increasing the dosage of muscle relaxant.

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Respiratory compliance during repair of atrial septal defect in young children

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Early extubation of the trachea after cardiopulmonary bypass procedures in children has been proposed in order to avoid the complications of postoperative ventilation.[1] However, in children with intra-cardiac left to right shunts, respiratory compliance is decreased[2] and if this continues postoperatively, spontaneously breathing patients may have increased work of breathing and gas exchange abnormalities. In this study we have measured compliance in young children during and after repair of a secundum-type atrial septal defect (ASD).

Methods

With approval from the Human Ethics Committee, informed written consent was obtained from the parents of 22 children, aged one to six years. Ten children presented for repair of ASD and the remaining 12 children were ASA physical status I and scheduled to undergo non-cardiac procedures. During sedation with oral chloral hydrate 50 $mg \cdot kg^{-1}$, total respiratory compliance was measured with the single breath test.[3] Anaesthesia was then induced with halothane and intubation was facilitated with succinylcholine or pancuronium. Compliance was measured with an inflation technique. Anaesthesia was maintained with halothane or isoflurane and fentanyl. After the procedure, compliance was again measured with the inflation technique prior to extubation of the trachea.

For the single breath test, a pneumotachograph was attached to the anaesthesia mask for measuring flow and its integral, volume. The pressure in the mouth (Pm) was measured via non-compliant tubing placed under the mask. During quiet breathing at end–inspiration the pneumotachograph was occlud-

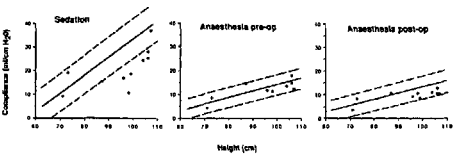

FIGURE Perioperative compliance vs height for ten patients with ASD (◆). The regression line for perioperative compliance vs height for 12 ASA I children is shown with the hatched lines representing ±2SEE.

ed briefly until Pm reached a plateau. Compliance was the volume of the passive expiration following the end-inspiratory occlusion, divided by plateau Pm. In the inflation technique, a volume of anaesthetic gas equal to the patients' tidal volume was delivered into the tracheal tube with a graduated syringe and the airway was occluded for 3 s in order to measure airway pressure at equilibrium. The delivered volume, corrected to BTPS, divided by the equilibrium pressure was the compliance. The regression of compliance vs height for the non-cardiac children was considered the normal regression line (Figure). The compliance vs height for the ASD children was compared with this normal regression line ±2 standard errors of the estimate (SEE).

Results

In six of the ten patients in the ASD group during sedation, respiratory compliance was below 2 SEE of the normal regression line. However, following induction of anaesthesia and intubation of the trachea, compliance in all patients from the ASD group was within ±2 SEE of the non-cardiac regression line. Following surgery and before extubation, compliance was within ±2 SEE of the non-cardiac regression line in nine out of ten patients, and at −2 SEE in the one remaining patient. With the exception of one ASD patient, who had a marked decrease in compliance, all patients were extubated at the end of the procedure.

Conclusion

In spite of decreased respiratory compliance preoperatively in six out of ten patients in the ASD group, intraoperative compliance did not differ significantly from compliance in the ASA physical status I children. Decreased preoperative compliance in patients with ASD does not contra-indicate early postoperative extubation.

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Respiratory function changes – Comparison between transabdominal and retroperitoneal approaches for abdominal aortic reconstruction

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The retroperitoneal approach to abdominal aortic reconstruction offers distinct technical advantages for large, inflammatory or suprarenal aneurysms and where extensive bowel adhesions are present.[1] Recent retrospective studies have highlighted significantly less atelectasis and pneumonia with the retroperitoneal compared with the transabdominal approach for elective abdominal aortic aneurysm resection. Reduced intraoperative blood and fluid requirements and early return of bowel function have also been reported.[2-3]

The objective of this study was to compare lung volume and gas exchange changes following elective abdominal aortic aneurysm resection using the retroperitoneal and transabdominal approaches.

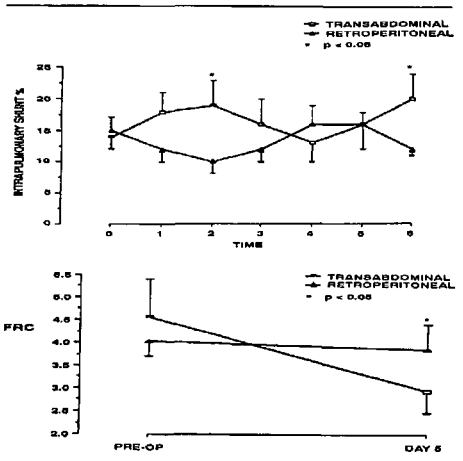
Methods

Following Ethics Committee approval and informed consent, 20 patients presenting for elective abdominal aortic aneurysm resection were prospectively allocated to midline transabdominal (T-A), (n = 9) or left loin retroperitoneal (R-P), (n = 11) groups. Preoperative cardiac status was assessed by physical examination, electrocardiogram and resting left ventricular ejection fraction determination with radionuclide ventriculography. Preoperative respiratory function was assessed by physical examination, chest roentgenogram, FEV_1, FVC, FRC, A-aDO_2 gradient and intrapulmonary shunt with an FiO_2 of 0.4.

A standardised anaesthetic technique was used for all patients studied. Radial and pulmonary artery catheters were inserted under local anaesthesia and following sedation with fentanyl 3–6 $\mu g \cdot kg^{-1}$. Fentanyl 50 $\mu g \cdot kg^{-1}$ was administered to induce anaesthesia and vecuronium 0.1 $mg \cdot kg^{-1}$ was administered to facilitate tracheal intubation. Controlled normocapnic ventilation was commenced with oxygen; isoflurane 0.25–0.5 per cent and fentanyl infusion 30 $\mu g \cdot kg^{-1} \cdot h^{-1}$. Pulmonary occlusion pressure was maintained between 10 and 15 mmHg and hypertension >25 per cent of baseline was controlled by nitroglycerin infusion. A-aDO_2 gradient and intrapulmonary shunt measurements were repeated 3 mins pre-aortic cross clamp, 3 mins pre- and post-aortic unclamping, 1, 4, and 24 hours following surgery. FEV_1 and FVC measurements were repeated on days three and five and FRC on day five. Data were analysed by paired Student's t test and MANOVA. $P<0.5$ was considered significant.

Results

The two groups were comparable with regards to age and preoperative cardio-respiratory status. There were no significant differences in measured and derived haemodynamic changes between the groups before and after induction, aortic cross-clamping and unclamping. Intrapulmonary shunting and $AaDO_2$ gradients were significantly lower in the retroperitoneal group during the cross-clamp period and 24 hours following surgery. Postoperative reductions in FVC were similar in the two groups



FIGURE

while FRC was significantly reduced in the transabdominal group (Figure).

Discussion

The retroperitoneal approach for elective abdominal aortic aneurysm resection was associated with significantly better perioperative oxygenation and preservation of lung volumes compared with the transabdominal approach. The retroperitoneal approach may better preserve diaphragmatic contractility. The right lateral decubitus position required for the retroperitoneal approach was not associated with significant haemodynamic changes following aortic cross-clamping and release. Retroperitoneal may be the preferred approach for abdominal aortic aneurysm surgery, especially in patients with impaired respiratory function.

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A comparison of haemodynamic changes during lighted stylet or direct laryngoscopy for endotracheal intubation

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Tracheal intubation frequently results in elevation of heart rate and blood pressure. Pressure on the laryngeal tissues during direct laryngoscopy, as well as insertion of the tracheal tube, contributes to this effect. The purpose of the study was to determine whether intubation using the lighted stylet (light wand),[1,2] which does not involve the use of a laryngoscope, might result in fewer haemodynamic changes when compared with direct laryngoscopy for tracheal intubation.

Methods

After approval by our Human Investigation Committee, forty ASA physical status I patients were randomly assigned to one of two groups: (1) tracheal intubation with a curved laryngoscope blade (no. 3 or 4 Macintosh) or (2) tracheal intubation with the lighted stylet (Tube-stat™, Concept Corporation, Clearwater, FL). All intubations were performed by the principal author (BAK). Monitoring included noninvasive blood pressure, continuous EKG and peripheral nerve stimulator for all patients. Patients were not premedicated. The patients were preoxygenated with 100 per cent O_2 for five minutes after receiving a-tubocurarine 0.04 $mg \cdot kg^{-1}$ and fentanyl 1 $\mu g \cdot kg^{-1}$ IV. Three sets of heart rate and blood pressure measurements were collected over this five-minute period. The mean preinduction heart rate and blood pressure were determined and this weighted measurement was used as a baseline for comparison with post-intubation heart rate and blood pressure measurements. Induction of anaesthesia was accomplished with sodium thiopentone 5 $mg \cdot kg^{-1}$ IV bolus and succinylcholine, 2.0 $mg \cdot kg^{-1}$ was administered to facilitate tracheal intubation. Laryngoscopy began after the abolition of the twitch response. The time required for laryngoscopy and intubation was recorded. Heart rate and blood pressure were measured every minute from the start of intubation for five minutes.

Intubation times and differences in mean blood pressure and heart rate between groups were compared using Student's t test or repeated measures analysis of variance (ANOVA) and the Student Neuman Keuls test where appropriate. Statistical differences were considered significant at $P < 0.05$.

Results

There was no statistical difference in intubation time, preinduction and post-intubation heart rate and mean blood pressure between groups (Table I, Figures 1 and 2).

Discussion

Based on this study, we could find no evidence that intubation using the lighted stylet produced fewer haemodynamic changes than direct laryngoscopy for endotracheal intubation. This confirms a recent paper by Knight *et al.*[3] Because laryngoscopy, intubation and cuff inflation almost occur simultaneously, it is difficult to determine whether the rise in blood pressure and heart rate are related to laryngoscopy or nonspecific glottic and tracheal stimulation from endotracheal tube placement and cuff inflation. Therefore, we looked at the duration of laryngoscopy and the maximal response in heart rate and blood pressure after intubation. Where laryngoscopy was prolonged (> 15 seconds), patients in the lighted stylet group tended to display smaller post-intubation increases in mean blood pressure and heart rate compared with patients in the direct laryngoscopy group (Table II). Statistical significance may not have been achieved due to a

Table I Duration of laryngoscopy (seconds)

Group	*Mean*	*SD*
Direct (n = 20)	20.45	8.02
Stylet (n = 20)	25.80	13.54

No difference using Student's t test.

Table II Duration of laryngoscopy versus maximum percent increase in mean arterial pressure and heart rate post-intubation

Group	*Duration (seconds)*	*n*	*% Increase MBP post-intubation (mean ± SD)*	*%Increase HR post-intubation (mean ± SD)*
Direct	0–15	8	3.20 ± 16.42	16.83 ± 20.93
Stylet	0–15	4	6.58 ± 7.06	2.42 ± 5.14
Direct	16–30	12	27.19 ± 22.61	26.83 ± 14.79
Stylet	16–30	16	9.84 ± 22.84	14.52 ± 17.47

No difference using Student's t test.

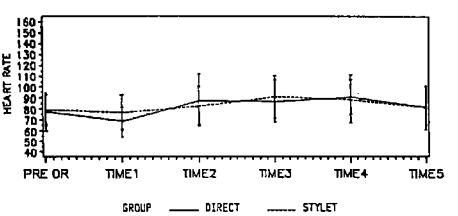

FIGURE 1 Heart rate responses to each technique of intubation at times designated.

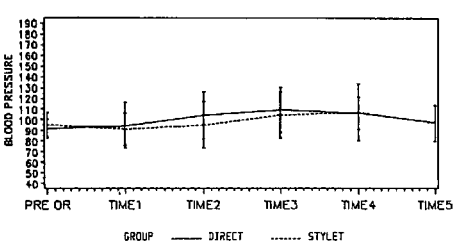

FIGURE 2 Mean arterial blood pressure responses to each technique of intubation at times designated.

relatively small number of patients in this study. On the basis of this study, we recommend that the lighted stylet should be selected for anatomical rather than haemodynamic considerations.

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Effects of halothane and isoflurane on the vasomotricity of human coronary artery rings

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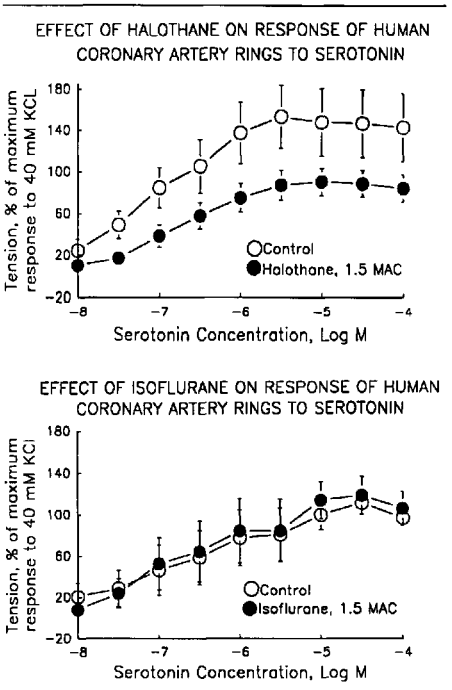
Through the release of two potent vasodilators, prostacyclin and EDRF (endothelium derived relaxing factor), the endothelium is a major determinant of vascular tone in a normal coronary artery.[1] Arteriosclerosis alters endothelial cell function and structure, thereby making the diseased vessel more susceptible to circulating vasoconstrictors and prone to spasm. Halothane and isoflurane are systemic vasodilators. We wanted to elucidate their effects on the vasomotricity of human coronary arteries *in vitro*.

Methods

Human hearts are obtained from donors and recipients of organ transplant procedures. The coronary arteries are dissected, cleaned, cut into 4 mm rings and hung on a pair of stirrups. Each ring is then immersed in Krebs-Ringer (control solution) with 95 per cent O_2/5 per cent CO_2 and maintained at 37° C. The upper stirrup is linked to a force transducer which relays the signal to a recorder for observation and analysis of the changes in vessel tension. Once the rings have been stretched to their optimal passive tension we submit them to KCl 40 mM to produce a standard reference vasoconstriction. Next, bradykinin 10^{-6} M is added to determine the presence of endothelium. After rinsing thoroughly with control solution, halothane or isoflurane 1.5 MAC is added to the gas mixture in half the chambers. Once a steady state is achieved, we proceed with the response to increasing concentrations of PGF_2-alpha, serotonin, histamine and phenylephrin from 10^{-8} to 10^{-4} M in treated and control rings. At the end of the experiment, solution samples from the treated chambers are kept in hexane for determination of anaesthetic concentration in the liquid phase. All rings are transferred into formaldehyde for histological studies. Statistical analysis was performed using the Student paired t test. $P < 0.05$ was considered significant.

Results

All four mediators used (PGF_2-alpha, serotonin, histamine and phenylephrine) induced a dose-dependent increase in vasomotor tone of human coronary artery rings *in vitro*. Halothane treated vessels (n = 8) showed a significant decrease in their constrictor response to PGF_2-alpha, serotonin and histamine. Whereas, isoflurane did not modify the dose-response curves of human coronary rings (n = 6) exposed to the same vasoactive agents.



FIGURE

The histological studies revealed a significant degree of arteriosclerosis in all vessels. The least altered arteries showed intimal thickening (Figure).

Conclusion

Although both halothane and isoflurane are known vasodilators, their action on human coronary rings *in vitro* differs. Previous studies in the dog have shown that halothane has a direct action on vascular smooth muscle fibres[2] while isoflurane produces vasodilation only in the presence of an intact endothelium. Based on the histological studies, we think that most, if not all, vessels studied had arteriosclerotic modifications and functional alterations of the endothelium which prevented any effect of isoflurane. We would suggest that halothane has a beneficial vasodilatory effect on the coronary arteries of patients suffering from coronary artery disease.

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The effect of continuous interpleural analgesia on pain and pulmonary function after cholecystectomy

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Open clinical trials would suggest that interpleural catheter (IPC) analgesia offers unique advantages over systemic narcotics in providing safe and effective postoperative analgesia as well as improved pulmonary function for patients recovering from upper abdominal surgery.[1,2] To date, however, continuous IPC analgesia has not been evaluated in a double-blind controlled fashion. There has also not been any data presented in the literature to document *free* bupivacaine levels achieved by continuous IPC bupivacaine infusions despite the fact that these correlate best with toxicity.[3,4] This is a preliminary report of an on-going prospective double-blind randomized study which compares continuous IPC bupivacaine infusion with parenteral narcotics with respect to pain, ease of ambulation and pulmonary function following subcostal cholecystectomy.

Methods

Institutional approval was obtained. After obtaining informed consent, eleven ASA physical status I and II patients scheduled for elective subcostal cholecystectomy were randomly assigned by pharmacy to one of two groups. All patients received an IPC. One group (Group B) was to receive IPC bupivacaine whilst the other group (Group S) was to receive saline. Preoperative studies included: bedside FVC, FEV 1.0 and PEFR, and CXR (PA and lateral). Both groups underwent general anaesthesia for their surgery receiving 1–2 $\mu g \cdot kg^{-1}$ of fentanyl at intubation and no further narcotic. Following closure of the incision, prior to emergence, with the patient breathing spontaneously, an IPC was inserted into the ipsilateral pleural space between the sixth and seventh ribs just anterior to the lateral border of latissimus dorsi. After insertion of the catheter, a 0.3 $ml \cdot kg^{-1}$ incremental bolus of either 0.5 per cent bupivacaine with 1:200,000 epinephrine or 0.9 per cent saline was given in blinded fashion. The patients were then awakened and recovered in the PAR in a routine manner. Once the patients were returned to the ward a 0.15 $ml \cdot kg^{-1} \cdot hr^{-1}$ IPC infusion of either 0.25 per cent bupivacaine or 0.9 per cent saline was established and maintained by use of a volumetric infusion pump. The IPC infusion was continued until the morning of the third postoperative day. All patients were allowed parenteral meperidine on demand for analgesia according to a standardized schedule (PAR: Meperidine 0.05–0.3 $mg \cdot kg^{-1}$ IV PRN / WARD: Meperidine 0.5–2.0 $mg \cdot kg^{-1}$ IM Q3h PRN).

The following clinical measures were obtained: VAS pain scores were obtained in the PAR and on the ward the evening of surgery (POO), and then twice daily thereafter. On each occasion patients were asked to rate their pain at rest and pain at its worst over the previous few hours. Narcotic usage over the three-day recovery period was recorded. Daily bedside spirometry was performed (patients sitting on the side of the bed with feet dangling). Daily nursing assessments of ease of ambulation were recorded on specially constructed 100 mm VAS score sheets. A portable CXR was performed on the first postoperative

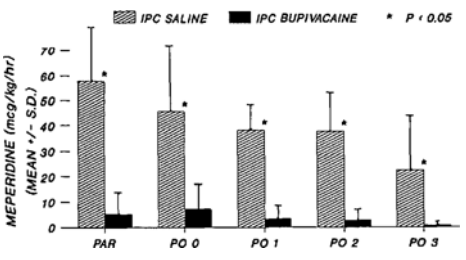

FIGURE 1 Meperidine use

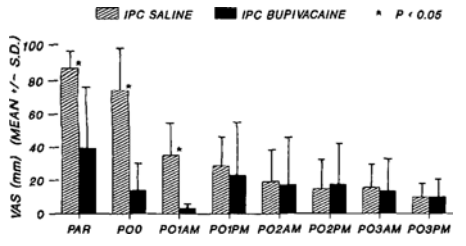

FIGURE 2 VAS "resting" pain scores

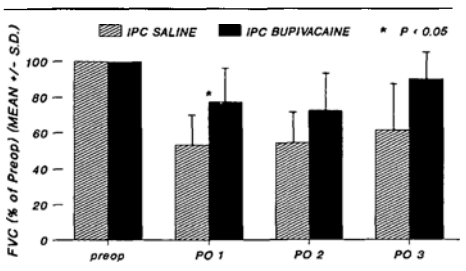

FIGURE 3 FVC measurements

morning. Formal PA and later CXR's were obtained on postop day three. Venous blood samples for plasma bupivacaine levels (free and total) and alpha$_1$-acid glycoprotein (AAG) levels were obtained in the PAR and each morning for three days. All complications encountered were recorded. Data were subjected to unpaired two tailed t test. A P value <0.05 was considered to be significant.

Results

There were no significant demographic differences between the two groups (S: n = 6; B: n = 5). The results of resting pain scores, meperidine use and pulmonary function testing (represented by FVC) are summarized in Figures 1–3. VAS scores for "worst pain" were significantly lower ($P < 0.05$) in group B from arrival in the PAR to the evening of Postop 1. VAS scores for ambulation were found to be generally better in group B but this was only statistically significant during the evening of the day of surgery (PO0). Three patients were noted to have visible air over the apex of the lung on PAR CXR, which was estimated to represent <10 per cent pneumothorax. In all three patients this resolved spontaneously without any treatment or clinical sequellae. No other complications were noted. Bupivacaine and AAG assays are pending.

Discussion

This report presents preliminary data based on small numbers. However, compared with standard parenteral narcotic analgesia, it would appear that IPC analgesia provides better pain relief and probably maintains better pulmonary function in patients recovering from subcostal cholecystectomy. It would be expected that this should correlate with a reduced incidence of pulmonary complications and reduce the duration of hospital stay. More complete assessment of the clinical significance and safety of IPC analgesia should be possible when this study is completed.

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Cerebrovascular effects of 1.0 MAC isoflurane and 0.53 MAC halothane: End tidal concentrations that result in the same mean arterial pressure

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We studied the regional cerebral blood flow (rCBF) effects of isoflurane and halothane at respective end-tidal concentrations which resulted in similar mean arterial pressures (MAP). Two groups of New Zealand white rabbits (n = 8; each group) were studied with five regional blood flow determinations in each animal. Blood flow was determined by injecting microspheres labelled with either ^{46}Sc, ^{85}SR, ^{95}Nb, ^{113}Sn or ^{141}Ce during the following conditions; injection 1: after stable 2.05 per cent end-tidal isoflurane (1.0 MAC) Group I; or after stable 0.74 ± 0.04 per cent end-tidal halothane (0.53 MAC) Group II. Injections 2–5: after MAP was increased to 20, 40, 60, and 80 per cent respectively above baseline MAP by phenylephrine infusion. Baseline MAP for Group I was 64.3 ± 3.1 mmHg (mean ± SEM) and 67.2 ± 2.0 mmHg in Group II (NS between

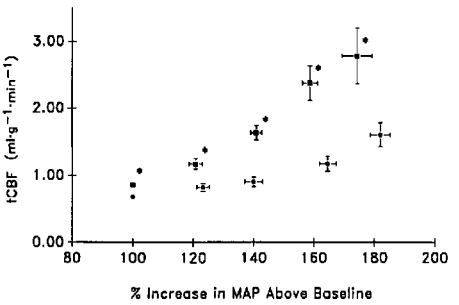

FIGURE tCBF vs percentage increase in MAP above baseline. Group I: 1.0 MAC isoflurane solid circles; Group II: 0.53 MAC halothane solid squares. Mean ± SEM n = 8 for each group except for final measurement in Group II, n = 6. *P < 0.05 between groups.

TABLE Regional cerebral blood flow: 1.0 MAC isoflurane vs 0.53 MAC halothane

Regions		*Baseline*	*Flow 2*	*Flow 3*
Frontal	(I)	0.69 ± .04	0.82 ± .09	0.90 ± .10†
	(H)	1.03 ± .07*	1.46 ± .12†*	2.08 ± .15†*
Parietal	(I)	0.62 ± .03	0.79 ± .07	0.90 ± .07†
	(H)	0.91 ± .08*	1.21 ± .09*	1.71 ± .11†*
Occipital	(I)	0.70 ± .04	0.90 ± .08	1.01 ± .10†
	(H)	0.97 ± .07*	1.34 ± .13†*	1.93 ± .18†*
Cerebellum	(I)	1.01 ± .09	1.07 ± .07	1.08 ± .08
	(H)	0.87 ± .06	0.97 ± .07	1.22 ± .11
Brain stem	(I)	0.62 ± .04	0.69 ± .05	0.77 ± .06
	(H)	0.67 ± .05	0.76 ± .08	1.09 ± .10†*

Regions		*Flow 4*	*Flow 5*
Frontal	(I)	1.28 ± .16†	1.75 ± .23†
	(H)	3.11 ± .32†*	3.75 ± .60†*
Parietal	(I)	1.16 ± .12†	1.63 ± .20†
	(H)	2.58 ± .24†*	3.02 ± .40†*
Occipital	(I)	1.37 ± .15†	1.80 ± .21†
	(H)	2.97 ± .38†*	3.45 ± .59†*
Cerebellum	(I)	1.22 ± .09	1.49 ± 17†
	(H)	1.82 ± .24†*	2.14 ± .40†*
Brain Stem	(I)	1.01 ± .10†	1.44 ± .17†
	(H)	1.60 ± .20†*	1.90 ± .25†*

*P ≤ 0.05 between groups. †P ≤ 0.05 within groups. Mean ± SEM. n = 8 for each group. rCBF = ml·g^{-1}·min^{-1}. (I) = isoflurane. (H) = halothane.

groups). The increases in MAP were the same between groups for the first three injections (20–60 per cent above baseline) but was significantly lower for the final injection in Group II (74.5 ± 5.0 per cent vs 82.2 ± 3.2 per cent; P = 0.039). Normocapnia was maintained throughout ($PaCO_2$ 36.8–38.0 mmHg). At all injection periods, total CBF (tCBF) was significantly higher with 0.53 MAC halothane than for 1.0 MAC isoflurane (Figure). A significant group-time interaction indicated cerebrovascular autoregulation was better maintained with 1.0 MAC isoflurane (P = 0.0004). Regional CBF comparisons (frontal, parietal, occipital cortex, cerebellum and brain stem all revealed significant group–time interactions; P < 0.01 for all regions) indicating that regional cerebrovascular autoregulation was better maintained with 1.0 MAC isoflurane (Table). With 1.0 MAC isoflurane, autoregulation was especially well maintained for posterior fossa structures (cerebellum and brain stem) as compared to supratentorial structures. Intracranial pressure (ICP) was significantly higher in Group II for injection 5 (6.7 ± 1.1 vs 5.0 ± 0.7 mmHg; group–time interaction; P = 0.014).

These results indicate cerebrovascular autoregulation was better maintained with 1.0 MAC isoflurane compared with 0.53 MAC halothane (end–tidal concentrations that resulted in the same baseline MAP). If these findings are applicable to the clinical setting, at haemodynamically comparable end–tidal concentrations, isoflurane is the volatile agent of choice for neuroanaesthesia particularly for surgery on the posterior fossa.

The influence of cardiopulmonary bypass on cerebral autoregulation and CO_2 responsiveness in the early postoperative period

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Central nervous system (CNS) dysfunction following cardiopulmonary bypass (CPB) has been reported to occur in many patients in the early postoperative period, with new neurological signs demonstrable in approximately two-thirds of these.[1,2] Also, cerebral blood flow (CBF) has been shown to be reduced following CPB with the greatest reductions occurring early. In a prospective study, Smith *et al.*[2] demonstrated a significant increase in CNS dysfunction at 24 h after CPB, but no significant difference in CBF, or in the incidence of CNS dysfunction, at eight days or eight weeks compared with controls. This may indicate a window of vulnerability in the early post-CPB period. CBF autoregulation and CO_2 responsiveness have not previously been investigated in man during this early post-CPB period.

Methods

Following institutional approval and written informed consent, 11 patients undergoing elective cardiac surgery, anaesthetized with a narcotic-relaxant technique (sufentanil 7–22 μg·kg^{-1} or fentanyl 20–44 μg·kg^{-1}), underwent nonpulsatile CPB at flow rates of 2.0–2.5 L·m^{-2}·min^{-1} using a membrane oxygenator and arterial line filteration. Hypothermia (26–28° C) was induced during CPB in ten patients, one patient remaining normothermic. Mean arterial pressure (MAP) was maintained at greater than 50 mmHg and alpha-stat pH management was employed. Patients with uncontrolled hypertension, CNS dysfunction or conditions associated with autonomic dysfunction were excluded from the study. Postoperative exclusions included ongoing myocardial ischaemia or haemodynamic instability requiring ionotropes or vasodilators. CBF was determined from the average ^{133}Xe clearance measured by ten scintillation detectors, five located over each cerebral hemisphere. All CBF

TABLE

	(A) CO_2 response		
	Base 1	*$PaCO_2$*	*Base 2*
n (patients)	6	6	6
CBF ($ml \cdot 100\,g^{-1} \cdot min^{-1}$)	26 ± 7	42 ± 14*	27 ± 7
$PaCO_2$ (mmHg)	38 ± 4	52 ± 3*	39 ± 4
MAP (mmHg)	84 ± 12	81 ± 6	87 ± 10
RT (°C)†	36 ± 0.6	36 ± 0.7	36 ± 0.6
Hb ($g \cdot dL^{-1}$)	10 ± 2	10 ± 2	9.9 ± 2

	(B) Autoregulation			
	Base 1	*MAP 110*	*MAP 70*	*Base 2*
n (patients)	8	8	8	8
CBF ($ml \cdot 100\,g^{-1} \cdot min^{-1}$)	26 ± 7	27 ± 6	26 ± 5	27 ±7
$PaCO_2$ (mmHg)	40 ± 5	39 ± 4	39 ± 4	39 ± 4
MAP (mmHg)	88 ± 13	110*	70*	87 ± 10
RT (°C)†	36 ± 1.0	36 ± 1.0	37 ± 1.0	37 ± 1.0
Hb ($g \cdot dL^{-1}$)	10.3 ± 2	10.3 ± 3	10.2 ± 3	10 ± 3

*$P < 0.05$ vs base 1. †All values $P < 0.05$ vs base 1.

determinations took place in the intensive care unit 3–8 hrs after CPB. The study was divided into two parts, each patient being randomly assigned to the order of testing: (A) CO_2 *response* – baseline 1, increased $PaCO_2$, baseline 2; (B) *autoregulation* – baseline 1, MAP 110 mmHg, MAP 70 mmHg, baseline 2. $PaCO_2$, rectal temperature, MAP and haemoglobin were determined during each CBF measurement. Phenylephrine and trimethaphan infusions were used to vary MAP. ANOVA and Dunnett's test with alpha of 0.05 and beta of 0.20 were used as measures of significance (Table).

Results

All patients underwent CPB averaging 99 ± 27 min without incident. Three patients were excluded, one due to hypertension requiring vasodilator therapy, two because of equipment failure. Because of time constraints complete data for part (A) was obtained in only six patients. Intact cerebral autoregulation over MAP 70–110 mmHg and cerebral CO_2 responsiveness was demonstrated. CBF increased $1.23\ ml \cdot 100g^{-1} \cdot min^{-1} \cdot mmHg^{-1}$ $PaCO_2$.

Conclusion

The low CBF in these patients presumably reflects residual anaesthesia in the early post-CPB period. Cerebrovascular reactivity to CO_2 is preserved and cerebral autoregulation is well maintained within the usual range of MAP confirming clinical practice. These results were obtained after CPB using alpha-stat pH management, but may differ if pH-stat is employed.

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Compatability of lactated Ringer's Solution with packed red blood cells

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Lactated Ringer's solution (LR) is commonly used for fluid maintenance and replacement during anaesthesia and resuscitation. Since it has been shown that under certain conditions LR can induce clotting in citrated whole blood,[1] many practitioners prefer to use non-calcium-containing crystalloid to dilute packed red blood cells. However, it is often not practical in emergency situations to concern oneself with replacing and flushing LR from intravenous equipment prior to using blood. Moreover, LR has been used with blood by many clinicians without clotting or adverse effects noted.

In current practice citrate-anticoagulated packed red blood cells (PRBC) are administered far more often than whole blood in most clinical situations. In the present study we have determined the presence or absence of clotting in PRBC reconstituted with different proportions of LR and normal saline (NS). We have also determined the effect of RL on calcium levels in stored PRBC.

Methods

Forty samples of eight-day-old banked PRBC preserved with citrate-phosphate-dextrose-adenine (CPDA-1) were mixed in 10 ml syringes with either LR or NS to achieve proportions ranging from 30 to 90 per cent crystalloid by volume. Twenty of these samples were incubated at 20° C and twenty at 37° C. One half of each group was analyzed after 30 minutes and the remainder after 60 minutes. Each mixture was then injected at a speed of 2 $ml \cdot min^{-1}$ through two filtre holders connected in series, containing a 170 micron and 20 micron filtre respectively. The filtres were then inspected for the presence of clotted blood by examiners blinded as to the composition of the samples.

In a separate experiment using 28-day-old stored PRBC, samples (n = 12) were prepared by mixing PRBC with LR or NS in concentrations of from 30 to 90 per cent crystalloid by volume. The samples were analyzed for total and ionized calcium concentration.

Results

1 All mixtures containing 70, 80 or 90 per cent by volume of LR and incubated at 37° C for 30 min or 60 min contained clots.
2 All mixtures containing 70, 80, or 90 per cent LR at 20° C clotted after 60 min but none clotted after 30 min.
3 No clotting occurred in any mixture containing 30, 50, or 60 per cent LR or in any mixture containing NS.
4 Total calcium was equal in all mixtures containing LR (1.27–1.30 mM).
5 The NS controls contained much lower levels of total calcium than the LR group (0.23–0.68 mM) and decreased with greater dilutions.
6 Ionized calcium levels increased with increasing dilutions of LR (0.14–0.77 mM), most markedly with 70 per cent or more LR. There was no detectable ionized calcium in any NS mixture.

Discussion

The practice of mixing blood products with LR is avoided by

many clinicians and discouraged in the literature.[2] This is due to the theoretical antagonism by the calcium contained in LR of the anticoagulant effect of citrate added to banked blood. It has been shown that CPDA-added stored blood contains about ten times the molar amount of citrate necessary to chelate the calcium contained in it. It would therefore follow that the calcium added to the blood when diluting with LR would be chelated to the excess citrate until a threshold is reached and the available citrate is saturated. At this point, excess calcium would be available to activate the coagulation cascade. Our results show that the ionized calcium content of the LR mixtures increased with increasing proportions of LR to PRBC, particularly with greater than 70 per cent LR, and that only mixtures containing 70 per cent or more by volume of LR showed signs of clotting. This would confirm that a certain level of ionized calcium is required for coagulation to occur. In clinical practice a unit of 230 ml PRBC is usually diluted with 100 to 200 ml, or 30 to 46 per cent by volume, of crystalloid in order to achieve a viscosity compatible with high flow rates. This study demonstrated that clotting does not occur when stored packed red cells are diluted with clinically used volumes of lactated Ringer's solution. If 70 per cent or more LR is used, delayed clotting may occur.

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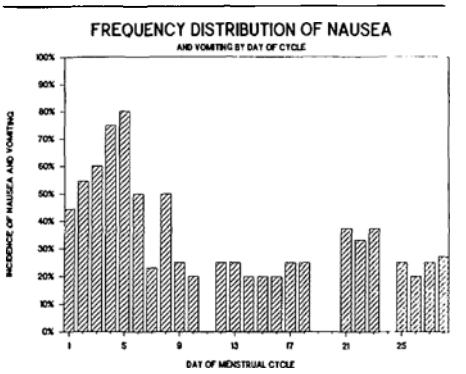

FIGURE

TABLE Percent incidence of nausea and vomiting

	No preop antiemetic	*Preop droperidol*	*Total*
Menses	51.7	33.3	46.4
Rest	22.4	9.4	17.9
	$\chi^2 = 12.97$	$\chi^2 = 5.13$	$\chi^2 = 20.39$
	RR = 3.69	RR = 4.80	RR = 3.98
	$P = 3 \times 10^{-4}$	P = 0.02	$P = 6 \times 10^{-6}$

Increased incidence of postoperative nausea and vomiting in menstruating women

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Postoperative nausea and vomiting is common in women of child-bearing age; the incidence after D & C is 12 per cent,[1] laparoscopic tubal ligation 35 per cent[2] and laparoscopic ovum retrieval 54 per cent.[1] The menstrual cycle may also alter the incidence of nausea and vomiting.[2] We evaluated the incidence of nausea and vomiting after laparoscopy performed at different times in the menstrual cycle.

Methods

All patients, 350, coming for laparoscopic surgery in our institution from July 1st, 1987 to July 1st, 1988 were studied. Patient age, weight, type of anaesthetic, duration of anaesthesia, type of and specific dosage of preanaesthetic antiemetic medication, date of the last menstrual period (LMP), evidence of nausea and vomiting, and duration of hospital stay were recorded. Exclusion criteria were: date of LMP not available, receiving oral contraceptives, post partum, pregnant at the time of surgery. Statistics were descriptive and by χ^2 where appropriate. Significance was accepted at the 95 per cent level ($P<0.05$).

Results

One hundred and fifteen patients were excluded. Of 235 patients remaining in the study, 158 had no antiemetic (Group A) and 77 received droperidol (7.5 to 12.5 $\mu g \cdot kg^{-1}$) (Group B). The incidence of nausea and vomiting for Group A was 33.5 per cent and for Group B was 16.9 per cent with an overall incidence of 28.1 per cent. We found a much higher incidence of nausea and vomiting early in the menstrual cycle. The Figure shows the frequency distribution of nausea and vomiting by day of cycle. The incidence of nausea and vomiting peaks at day five with an incidence of 80 per cent (8/10) and falls to about a 25 per cent (2/8) level at day nine. On the basis of this finding, we examined the patients by phase of the menstrual cycle, days one to eight as pre-ovulatory, days 9–16 as ovulatory and 17 to the end of cycle as post-ovulatory. Statistical analysis confirmed the null hypothesis that the ovulatory and post-ovulatory periods were not different and these were pooled for a comparison of pre-ovulatory (menses) and the rest (day nine to end of cycle). The Table shows the results of the χ^2 analysis comparing the differences in the cycle and the effect of droperidol. The incidence of nausea and vomiting was four times greater in the pre-ovulatory (menses) group than in the post-ovulatory group. Preoperative droperidol did not significantly reduce the incidence of nausea and vomiting in the pre-ovulatory or post-ovulatory state. However, comparison of 77 patients receiving droperidol with 158 patients not receiving droperidol over the total cycle showed a significant improvement with droperidol ($\chi^2 = 6.31$, RR 2.48, $P < 0.01$).

Discussion

The results of this study show that laparoscopic surgery performed around the time of the menses results in a four-fold increase in the relative risk of nausea and vomiting. The prophylactic use of droperidol does not significantly reduce the risk of nausea and vomiting at any given period in the cycle. We conclude that nausea and vomiting are mainly seen during the menses and that factors other than surgical procedure account for this finding. Such factors as hormonal levels or changing endocrine balance would seem to warrant further investigation.

Studies are also needed to assess whether these results are applicable to other types of surgery.

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Isoflurane-induced hypotension in orthognathic surgery

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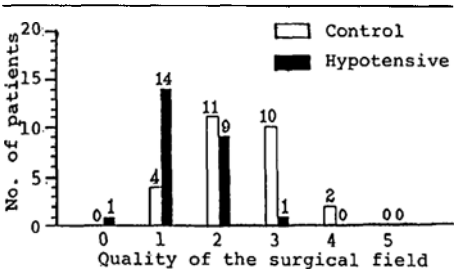
Deliberate hypotension has three proposed benefits: a decrease in surgical blood loss with a concomitant reduction in transfusions; an improved surgical field and a reduction in operative time. However, it has not been demonstrated to be effective in orthognathic surgery.[1] Besides, there is no report on the effect of deliberate hypotension on postoperative oedema. We studied the efficiency of hypotension induced with isoflurane with regard to the three points stated above and its effect on postoperative oedema in orthognathic surgery.

Methods

Fifty-two healthy (ASA physical status I) consenting patients undergoing a LeFort I maxillary osteotomy combined with a mandibular osteotomy were randomly assigned either to the hypotensive group (Group I) or to the control group (Group II). All patients were prepared in the same manner including intravenous methylprednisolone which is a standard regimen used in our institution to decrease postoperative oedema.[2] Anaesthesia was induced with fentanyl 5 $\mu g \cdot kg^{-1}$, thiopentone 5–7 $mg \cdot kg^{-1}$ and atracurium 0.5 $mg \cdot kg^{-1}$. After nasotracheal intubation, ventilation was controlled ($PaCO_2$ 35–40 mm Hg). Anaesthesia was maintained with 60 per cent N_2O, 40 per cent O_2, a low concentration of isoflurane and supplementary doses of fentanyl up to a maximum dose of 20 $\mu g \cdot kg^{-1}$. At mucosal incision, hypotension was induced by increasing inspired concentration of isoflurane to lower mean arterial pressure (MAP) to 55–65 mmHg (Group I) while MAP was maintained at 75–85 mmHg in Group II. Propranolol 1.0 mg IV was given if the heart rate increased over 100 beats $\cdot min^{-1}$. Basic fluid requirements were met with lactated Ringer's solution (LR) 6 $ml \cdot kg^{-1} \cdot hr^{-1}$. Blood losses up to 20 per cent of estimated blood volume (EBV) were replaced with 3 ml of LR for each ml of blood loss. Over 20 per cent EBV, packed red cells were given. All data were collected in a double-blind manner. Surgical field during maxillary osteotomy was evaluated using an ordinal scale.[1] At the end of surgery, blood losses were precisely measured. Postoperative oedema was evaluated subjectively on a linear analogue scale, and objectively by preoperative and postoperative measurements of the distance between skin marks placed preoperatively over mandibular angles.



FIGURE

Results

There was no significant difference between groups with respect to age, sex, weight and preoperative blood pressure. Blood losses were significantly lower in Group I than in Group II, 454.0 ± 211.3 vs 755.3 ± 334.6 ml ($P < 0.001$), as was the number of patients who had to be transfused, 12 per cent vs 44.4 per cent ($P < 0.02$). The surgical field was rated significantly better in Group I than in Group II (Figure) ($P < 0.001$) but duration of surgery was not different, 274.8 ± 58.5 vs 298.4 ± 65.8 minutes respectively. Postoperative oedema was not different between groups either with subjective or objective evaluation.

Discussion

Our data indicate that isoflurane-induced hypotension is an effective technique to decrease surgical blood loss. This decrease is associated with an important reduction in the number of patients who have to be transfused (blood loss > 20 per cent EBV). Considering the risks related to transfusions, this becomes clinically important. Surgical field is improved by hypotensive anaesthesia, allowing a better dissection and less tissue trauma. However, it did not result in a reduction in operative time as reported for other procedures. Finally, we could not demonstrate any effect of deliberate hypotension on postoperative oedema. This might result from the blunting effect of methylprednisolone.[2]

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A comparison of postoperative analgesia for ambulatory knee surgery by intra-articular injection or femoral nerve block with 0.25% bupivacaine

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Surgery on an outpatient basis has gained popularity in recent years. One of the objectives of anaesthesia for outpatient surgery is to accomplish a prompt recovery and early ambulation. However, postoperative pain may necessitate the use of narcotics which prolong the recovery time.[1] Peripheral nerve blocks for postoperative analgesia have the merit of avoiding the unwanted effects of narcotic analgesia. The efficacy of femoral nerve block for pain relief following knee surgery was investigated recently and found to be superior to placebo in early pain management.[2] Likewise, femoral and sciatic nerve blocks were found to provide satisfactory analgesia for evaluation of acute knee injuries.[3] These investigations suggest that peripheral nerve blocks or intra-articular injections with local anaesthetics may provide optimal postoperative analgesia. Therefore, the efficacy of postoperative analgesia following intra-articular injections or femoral nerve block with 0.25 per cent bupivacaine has been investigated in patients undergoing arthroscopic knee surgery, in a randomized double-blind fashion.

Methods

Following informed consent, 60 patients (ASA physical status I and II), requiring arthroscopic knee surgery were enrolled in the study. Patients with previous history of neuropathy, bleeding disorder, local infection, and allergy to local anaesthetic were excluded. Patients were similar in age, height and body weight distribution. A standard anaesthetic protocol was followed in all cases and neither a premedication nor any narcotic supplement was used. At completion of the surgery, all patients received both an intra-articular injection and a femoral nerve block (after localization with peripheral nerve stimulator) with 20 ml of randomly allocated clear solution in a blind fashion as shown in Table I.

Postopertive pain perception was assessed by an independent observer in a blind fashion by use of a Visual Analogue Scale (VAS) and a Verbal Rating Scale (VRS) preoperatively and at 0.25, 0.5, 1.0 and 2.0 hours after return of consciousness and also before discharge from the hospital. The motor function and additional narcotic analgesic requirements were also recorded. Pain assessment data were analyzed for significance by analysis of variance (ANOVA).

Results and Discussion

The results of the pain assessment using VAS at different time intervals are shown in the Table II. There was no statistically significant difference in pain perception among the three groups of patients. Likewise, motor function and additional analgesic requirements were no different in the three groups. These data suggest that neither femoral nerve block nor intra-articular injections provide adequate postoperative analgesia following arthroscopic knee surgery. Since the local anaesthetic had been appropriately placed for femoral nerve block and intra-articular injection, it is conceivable that either there is a different mechanism of pain, or femoral nerve blockade is not the best means of analgesia in this group of patients.

TABLE I Groups (n = 20)

	Femoral nerve block	*Intra-articular injection*
A	Bupivacaine 0.25%	Saline
B	Saline	Bupivacaine 0.25%
C	Saline	Saline

TABLE II VAS pain assessment

Times (hrs)	*Group A*	*Group B*	*Group C*	*Significance*
Preop (0.0)	10.35	6.65	9.10	NS
Postop (0.25)	42.75	32.95	47.50	NS
Postop (0.5)	37.65	32.20	45.50	NS
Postop (1.0)	32.95	32.30	38.55	NS
Postop (2.0)	22.65	25.00	35.00	NS
Discharge	15.35	18.60	27.75	NS

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The effect of esmolol on the sympathetic response during rigid bronchoscopy

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Rigid bronchoscopy causes an intense sympathetic response with potentially harmful results. Current methods used to obtund this response are associated with undesirable effects in terms of duration of action, respiratory and myocardial depression, and lack of cardiac selectivity. Esmolol, a new beta-blocker with cardiac selectivity and a short duration of action ($t_{\frac{1}{2}}$ – 9 min) is a potentially ideal agent for this procedure. This double-blind, randomized, controlled study investigated the safety and effectiveness of esmolol as a bolus injection in patients undergoing rigid bronchoscopy.

Method

With institutional approval and informed consent, 22 ASA physical status I–III patients scheduled for rigid bronchoscopy were randomized to one of three study drug regimens (Table I). All patients received the preinduction dose. Further doses were given (Table I) by the following criteria: at 10 min postinduction

TABLE I

	Group I	*Group II*	*Group III*
Preinduction dose	0	100 mg	200 mg
10 min postinduction	0	100 mg	100 mg
12 (±) min postinduction	0	0	100 mg

TABLE II

	Placebo	*Esmolol 100 mg*	*Esmolol 200 mg*
Preinduction HR	71.6±9.3	78.8±17.8	73.0±21.5
Change HR			
2 min	13.6±6.0*	3.4±14.8	8.5±29.9
3 min	26.9±19.7*	2.8±15.7	0.3±39.5
5 min	19.7±17.6	10.4±13.3	11.8±29.5
Preinduction SBP	158±36	159±18	157±27
Change SBP			
2 min	4.8±33.6	13.6±31.9	−9.6±48.8
3 min	54.8±28.8*	28.8±21.3*	16.2±30.1
5 min	34.9±11.5*	30.2±17.8*	31.2±21.3*
Preinduction RPP	11300±3050	12500±3320	11200±2750
Change RPP			
2 min	2680±3210	1660±4300	1320±8310
3 min	10360±7320*	2770±3720†	3530±9100
5 min	6870±4490*	4310±2970*	4900±6110
Arrhythmias	3 vent bigeminy 1 vent ectopy	2 vent bigeminy	1 vent bigeminy
STP ($mg \cdot kg^{-1} \cdot min^{-1}$)	1.25±0.44	1.13±0.39	0.97±0.58

Values are means ± SD, *$P < 0.01$, †$P < 0.05$.

for heart rate (HR) > 95 (if systolic blood pressure (SBP) > 110) and/or SBP > 140 (if HR > 70); and any time beyond 12 min if SBP or HR > 20 per cent preinduction value. Exclusion criteria included: CAD, beta- or calcium-blocker therapy, heart block, asthma or active wheezing, significant hepatic or renal failure, or pregnancy. Oral diazepam 0.1 $mg \cdot kg^{-1}$ was given 90 minutes preoperatively. Blood pressure (BP) was monitored invasively (radial arterial catheter). Pulse oximetery, continuous ECG (lead II) and 12-lead ECG were applied. The induction sequence was as follows: defasciculation with vecuronium bromide (VCB) 1 mg IV, preoxygenation for 3 min, thiopentone (STP) 5 $mg \cdot kg^{-1}$ IV, succinylcholine 1.5 $mg \cdot kg^{-1}$ IV, and then the preinduction dose of study drug given IV over 30 seconds. Manual ventilation with 100 per cent O_2 for 90 seconds preceded rigid bronchoscopy. Ventilation was performed with a Venturi Jet Ventilator in the side-port of the rigid bronchoscope. Additional doses of STP (50–75 mg) were given to maintain anaesthesia and to control further changes in HR and BP. VCB 0.05 $mg \cdot kg^{-1}$ was given 2 min postinduction for muscle relaxation. Onset of injection of the study drug preinduction dose was time 0. HR and BP were recorded every min and a 12-lead ECG every 2 min. Measurements continued for the duration of rigid bronchoscopy and ended with removal of the bronchoscope and a change in anaesthetic technique. Statistical analysis was performed using paired t tests to compare postinduction data with preinduction data.

Results

All three groups were similar with respect to sex, age, weight, procedure duration, and ASA status. Six patients received placebo, ten received 100 mg esmolol, and six received 200 mg esmolol. Table II compares the groups in terms of cardiovascular variables and amount of STP given. There were no episodes of bronchospasm. Three patients given esmolol (one in group II, and two in group III NS) developed hypotension (SBP < 90) which responded quickly to volume replacement or small doses of ephedrine.

Discussion

This study shows that esmolol 100mg minimizes the increase in HR, and that esmolol 200 mg minimizes the increase in HR, SBP, and rate pressure product (RPP) when compared with placebo in patients undergoing rigid bronchoscopy with no major side effects. There was a trend to a lesser incidence of ventricular arrhythmias and a decrease in the amount of STP required with increasing dose of esmolol.

Clinical assessment of the muscular response to tetanic nerve stimulation

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In the absence of monitoring using electromyography (EMG) or mechanomyography (MMG), the clinical assessment of the muscular response to tetanic nerve stimulation has for many years had the reputation of being the most sensitive test to detect residual curarization.[1,2] In the present study, we assessed the value of the clinical evaluation of the response to tetanic nerve stimulation (50 Hz) as a means of detecting residual curarization.

Methods

With approval of the Hospital Ethics Committee, 44 adult patients, ASA physical status I and III without conditions affecting neuromuscular function, gave written consent to participate in the study. All patients had similar anaesthesia: premedication with diazepam or lorazepam; induction with thiopentone 3 to 5 $mg \cdot kg^{-1}$ and fentanyl or sufentanil as required; tracheal intubation with vecuronium 0.06 to 0.08 $mg \cdot kg^{-1}$; maintenance with isoflurane one per cent in a mixture of oxygen 40 per cent and nitrous oxide 60 per cent; fentanyl or sufentanil, and supplements of vecuronium were added if necessary.

Following the induction of anaesthesia, both ulnar nerves were simultaneously stimulated at the wrist, using a Grass stimulator S 8800, which gave supramaximal train-of-four (TOF) stimulation every 12 seconds, with the mechanical response of both adductor pollicis muscles being measured by a force transducer (Grass FT-10) and recorded on a polygraph. Only the patients who had the same TOF ratio on both sides were included in the study. During the recovery phase of the neuromuscular block, simultaneous bilateral tetanic stimulation of 50 Hz were given at different levels of relaxation, as described in the next paragraph. The minimal interval between repeated

TABLE Tactile evaluation of the response to tetanic stimulation compared with mechanically measured response (MMG)

Level of myorelaxation measured by TOF ratio	*Tetanic fade confirmed by MMG*	*Clinically detected tetanic fade*
0.10	32/32	31/32 (97%)
0.20–0.30	32/32	25/32 (78%)
0.40–0.50	26/32	10/26 (38%)
0.60–0.70	18/32	4/18 (22%)

tetanic stimulations on the same patient was ten minutes. During the tetanic stimulations, one of the patient's hands was freed in order to allow one of the observers to perform a tactile evaluation of the muscle response of the adductor pollicis. The observers had to say if the muscular contraction was sustained or not. Their evaluations were compared with the MMG responses of the adductor pollicis on the other side.

Four residents in their second year of training and four certified anaesthetists, all familiar with the use of nerve stimulators, formed the group of observers. Each carried out sixteen evaluations which were randomly distributed in four series of four, according to the TOF values, so that four measures were done at TOF of 0.10, four at TOF of 0.20–0.30, four at TOF 0.40–0.50, and four at TOF of 0.60–0.70. The observers were not aware of that distribution, and they did not know the chosen levels of myorelaxation which were studied. A total of 128 tetanic responses were assessed. The tetanic response ratio was measured by MMG as the ratio of the amplitude of the response at the end of five seconds and the initial maximal height of the response.

The chi-square test was applied for statistical comparisons. $P < 0.05$ was considered significant.

Results

The Table shows the number of patients in which tetanic fade was found by MMG and the number of patients in which tetanic fade was detected by tactile evaluation.

No relation was found between TOF ratio and tetanic response ratio. Fade was clinically perceived in all cases where the tetanic response ratio was 0.30 or less.

Discussion and conclusion

We found no significant difference between our results and those previously reported for the clinical evaluation of the response to train-of-four nerve stimulation.[3] We conclude that tetanic fade is not a very sensitive test to detect residual curarization for two reasons: (1) the tetanic evaluation of tetanic fade by clinicians is often erroneous; (2) the MMG response to tetanic stimulation starts to be sustained when TOF ratio is as low as 0.50.

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Prediction of difficult tracheal intubation

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Visualization of the glottis by direct laryngoscopy is impaired by anatomical characteristics that hinder the alignment of the oral, pharyngeal and laryngeal axes. Currently, no single anatomical factor best determines the potential difficulty of direct laryngoscopy. Visibility of the hypopharynx,[1] mentum to thyroid notch distance,[2] and mouth opening[3] have been studied individually but may be unreliable predictors of difficult intubation. This study was designed to incorporate all of these factors in order to identify accurately patients with potentially difficult airways.

Methods

Twenty adult (ASA physical status I or II) patients who required general tracheal anaesthesia were studied after approval from our Human Investigation Committee. Anaesthesia was induced with sodium thiopentone and a muscle relaxant was administered to facilitate tracheal intubation. Laryngoscopy was performed by one of 14 experienced anaesthetists in our institution. Exposure of the glottis was described on a scale of one to four;[1] grade 1: glottis fully exposed, grade 2: glottis partially exposed, grade 3: glottis could not be exposed, corniculate cartilages only could be visualized, grade 4: glottis including corniculate cartilages could not be exposed. Difficult orotracheal intubation was defined as less than optimum glottic exposure (grades 3 and 4).

Ten patients graded 1 or 2, and ten patients graded 3 or 4 were examined postoperatively by the principal author, after obtaining informed consent. All 20 patients had full dentition and were not known to have cervical spine, temperomandibular joint disease, or upper airway pathology. All patients underwent airway assessment based on four clinical parameters: visibility of the hypopharynx, thyromental distance (distance between the end of the chin to thyroid notch), neck circumference, and distance between the central incisors with the mouth maximally open.[3] Visibility of the hypopharynx was divided into three classes based on pharyngeal exposure: tonsillar pillars, soft palate, and uvula visualized (Class 1), visualization of the uvula and partial visualization of the tonsillar pillars (Class 2), no visualization of pillars, uvula not seen or partially seen (Class 3).[1] Results were analysed using the Student's t test where appropriate. Statistical differences were considered significant at $P < 0.05$.

Results

A significant correlation exists between the ability to visualize pharyngeal structures and the ease of laryngoscopy (Table I). Thyromental and central incisor distances were significantly smaller ($P < 0.01$) in patients where tracheal intubation was considered difficult (Table II). Neck circumference was unrelated to ease of glottic exposure.

Discussion

We found that visualization of the hypopharynx was a reliable predictor of ease of glottic exposure at laryngoscopy. This finding is consistent with that of Mallampati *et al.*[1] Our finding

TABLE I Relationship between visualization of hypopharynx and glottic exposure

	Laryngoscopy grade			
Visualization of hypopharynx	*1*	*2*	*3*	*4*
Class 1 N = 9	7	2	0	0
Class 2 N = 1	0	1	0	0
Class 3 N = 10	0	0	3	7

TABLE II Relationship between clinical measures (mean ± SD) and ease of tracheal intubation

	Tracheal intubation	
Clinical parameter	*Easy (grades 1 and 2)*	*Difficult (grades 3 and 4)*
Thyromental distance range	8.0±1.26* (6.5–10.0)	5.0±0.86 (3.8–6.5)
Distance between central incisors range	4.5±0.36* (4.0–5.0)	3.5±0.59 (3.0–4.7)
Neck circumference	36.0±1.52	37.0±3.62

*Significantly different ($P < 0.05$) using Student's t test.

that thyromental distances of less than 6.5 cm are related to poor glottic exposure is consistent with the literature.[2] Although the distance between the central incisors was significantly shorter in patients considered to be difficult intubations, there was considerable overlap between the two groups (Table II range), making this measurement a less reliable predictor of difficult intubations. Because of this, we took the sum of central incisor distance and thyromental distance for each patient and compared this value between the groups. This distance ranged between 7.2–9.5 cm in patients considered difficult intubations and 10.7–15.0 cm in those considered easy intubations. All patients considered as difficult intubations had a combined distance of less than 9.5 cm. All of these patients were also assigned to class 3 visualization of the hypopharynx. Perhaps visualization of the hypopharynx indirectly reflects the combined thyromental and central incisor distances. Because visualization of the glottis requires alignment of the oral, pharyngeal and laryngeal axes, no single factor alone can be expected to predict ease of tracheal intubation.

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Changes in catecholamine metabolism in the rostral ventrolateral medulla following halothane and nitroprusside induced hypotension: an in vivo electrochemical study

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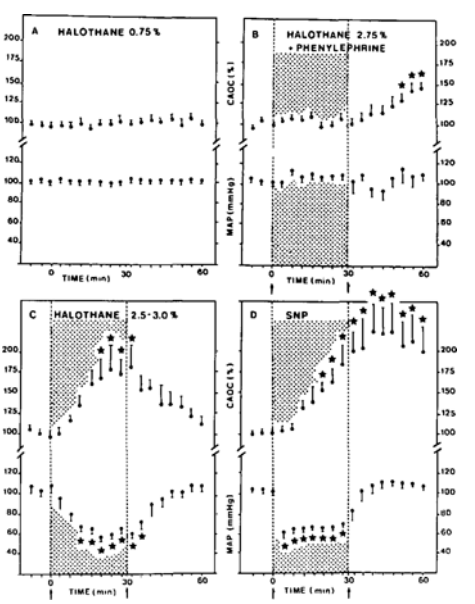
Induced hypotension produces changes in central catecholamine turnover. The rostral ventrolateral medulla (RVLM) contains adrenergic C_1 neurons which project to the intermediolateral cell column of the spinal cord. The precise function of these C_1 neurons remains unsettled. Direct proof of a dynamic and bio/histochemically specific involvement of these C_1 neurons during circulatory challenge is lacking. *In vivo* voltammetry allows on line biochemical and specific monitoring of catecholamine metabolism in central structures.[1] The objective was to observe with *in vivo* voltammetry changes in RVLM C_1 adrenergic catecholamine metabolism following induced hypotension with halothane or nitroprusside (SNP).

Methods

Rats anaesthetized (halothane, metocurine) and ventilated were stereotaxically implanted with carbon microelectrodes in the C_1 area of the RVLM. Using differential normal pulse voltammetry, the catechol oxidation current (CA · OC, per cent baseline) was used as a measure of RVLM catecolaminergic neural activity. Groups of rats (n = 5) were given (A) halothane 0.75 per cent for 60 min. (B) halothane 2.75 per cent plus plenylephrine



FIGURE

infusion to maintain mean arterial pressure (MAP) for 30 min, then halothane 0.75 per cent for 30 min. (C) halothane (2.5–3.0 per cent) for 30 min (MAP 60 ± 5 mmHg) then halothane 0.75 per cent for 30 min. (D) SNP infusion for 30 min (MAP 60 ± 5 mmHg), then halothane 0.75 per cent for 30 min. Significance was assessed at the $P < 0.05$ level, repeated measures ANOVA.

Results

Halothane 0.75 per cent produced no significant change in CA · OC or MAP (Figure A), while halothane (2.5 –3.0 per cent) produced a significant decrease in MAP and a symmetrical significant increase in CA · OC (Figure C). This increase peaked at 30 min (180 ± 28 per cent) and reached 110 ± 9 per cent baseline at 60 min. The halothane and phenylephrine combination produced no significant change in CA · OC or MAP during the 30 min exposure (Figure B). SNP produced a significant increase in CA · OC (peak 48 min, 224 ± 35 per cent) which remain elevated (198 ± 32 per cent) at 60 min (Figure D).

Discussion

These data show the existence of an inverse relationship between the level of arterial pressure and the level of activity of adrenergic perikarya of the RVLM. The CA · OC recorded in the RVLM appears primarily related to the oxidation of a metabolite of dopamine, 3,4-dihydroxyphenylacetic acid. The results are compatible with the hypothesis that RVLM adrenergic neurons act to maintain arterial pressure through their peripheral sympathetic and vasopressinergic targets. SNP induced a prolonged significant increase in RVLM catecholamine metabolism which may relate to rebound hypertension following use of this drug. On the other hand, the CA · OC in the halothane group returned toward baseline values which mirrors the clinical picture of lack of rebound hypertension following inhalational agents.

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Sodium channel blockers in focal cerebral ischaemia

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Previous studies have shown that lidocaine is beneficial in focal cerebral ischaemia because it blocks sodium channels or improves collateral blood flow.[1,2] The aim of this study was to evaluate two other sodium channel blockers (SCB), Flecainide (F) and Mexiletine (M), which have a greater and longer affinity for neural membranes. Both are used as antiarrythmics. F is an analogue of procainamide with a local anaesthetic potency five times that of procaine. M is a local anaesthetic that has been used as an anticonvulsant.

Methods

Thirty-six adult cats were randomly divided into three equal groups – control (C), F, M. They were anaesthetized with halothane in O_2/air (FiO_2 0.6) and their lungs ventilated to keep $EtCO_2$ at 30–35 mmHg. Normothermia and normal blood pressure was maintained throughout. Regional cerebral blood flow (rCBF) was measured with radiolabelled microspheres injected through a left atrial catheter. Somatosensory evoked potentials (SEP) were recorded in response to contralateral medium nerve stimulation.

The animals were subjected to six hours of permanent middle cerebral artery occlusion. Drug therapy was initiated 30 minutes before occlusion. They received either F (5 $mg \cdot kg^{-1}$ bolus followed by 0.5 $mg \cdot kg^{-1} \cdot hr^{-1}$, M (10 $mg \cdot kg^{-1}$ bolus followed by 0.2 $mg \cdot kg^{-1} \cdot min^{-1}$ for 30 minutes then 0.1 $mg \cdot kg^{-1} \cdot min^{-1}$) or C (an infusion of a similar volume of saline). rCBF was measured prior to occlusion, 30 and 360 minutes post-occlusion. The brain was carefully removed and a five-millimeter-thick section through the optic chiasm was incubated in triphenyl tetrazolium chloride to delineate the infract area. Cerebral oedema was assessed by regional wet-dry weight determinations.

TABLE

	Control	*Flecainide*	*Mexiletine*
Infarct size (%)	20.5 ± 8	38.8 ± 20	40.1 ± 20
% H_2O-infarct	82.0 ± 2	84.6 ± 3	83.5 ± 5
CBF_i-360 min	11.9 ± 9	2.8 ± 3	4.0 ± 5

Results

There were no differences among the groups in physiological parameters. There was no statistically significant difference in infarct size among the three groups. In all three groups, the water content was greater in the infarcted hemisphere than the contralateral ($P < 0.01$). However, there were no differences among the three groups. rCBF in the infarct area ($rCBF_i$) was significantly reduced ($P < 0.01$) by occlusion in all three groups. At 360 minutes, $rCBF_i$ was lower ($P < 0.01$) in the F and M groups than C. In no region, including the contralateral hemisphere, did rCBF increase. However, contralateral CBF was reduced by M but not F or C. The extent and duration of the loss of the major cortical component of the SEP was similar in all three groups (Table).

Conclusion

The reason for the reduction in CBF is unclear. It was not due to shunting as CBF was not increased in other areas. Other possible reasons for F and M failing to reduce infarct size are inadequate or excessive dose. The doses used were at the high end of the clinical dose range and would be associated with CNS features of overdose. Despite this there may still have been inadequate CNS penetration. If seizures had occurred they would have been clinically manifest and associated with an increased CBF. These two SCBs are ineffective in focal cerebral ischaemia. These results suggest that the beneficial effects of lidocaine may reflect its neurovascular effects rather than a sodium channel blocking effect.

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Paraben preservatives but not succinylcholine are cerebral vasodilators

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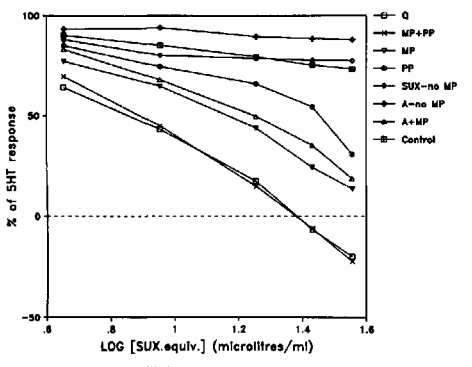
Succinylcholine(Sux) has been shown to increase intracranial pressure (ICP) independent of coadministered barbiturate.[1] Others, however, have suggested that increased ICP may be related to intubation during light anaesthesia.[2] Here we add another consideration to this controversy and describe a marked vasodilator effect of only Sux preparations containing the preservatives methylparaben (MP) or MP and propylparaben (PP).

Method

The brains of adult mongrel dogs (n = 12) anaesthetised with pentobarbital were obtained. Guinea-pigs (GP n = 6) were decapitated taking care to avoid subarachnoid haemorrhage. The basilar artery, free from arachnoid, was cut into rings 4mm (dog) or 1 mm (GP) long avoiding damage to the endothelium. The rings were mounted in organ baths of Krebs buffer at 37° C aerated with 95 per cent O_2–5 per cent CO_2. Following equilibration (60 min), vessel diameter was increased to permit optimal responses and a steady baseline was obtained under tension (2 Gdog, 60 mgGP). After first precontracting the arteries with either a receptor mediated agonist (5HT) or a voltage mediated stimulus (KCl), clinically relevant doses of each test drug were added in increasing concentrations. The concentration was expressed as Sux-equivalents which was the volume of a 20 mg · ml^{-1} Sux preparation which was added to each ml of waterbath. Drugs used were: pure Sux (Sux-noMP), Anectine® (no parabens) (A-noMP), Quelicin® (Q) (20 mgSux, 1.8 mgMP, 0.2 mgPP · ml^{-1}), MP + PP (MP 1.8 mg · ml^{-1}, PP 0.2 mg · ml^{-1}), MP alone (1.8 mg · ml^{-1}, PP alone (0.2 mg · ml^{-1}), multidose Anectine® (20 mgSUX, 1.0 mg · ml^{-1}, MP) and a control with no added drug.



FIGURE

Results

Q, MP+PP relaxed rings below baseline; Sux-noMP, A-noMP and control maintained tone; PP and MP were intermediate in effect (Figure). Studies on GP basilar arteries precontracted with 5HT yielded qualitatively and quantitatively similar findings.

KCl-precontracted (0.06 M) GP arteries were relaxed in a dose-dependent manner by the same amounts which relaxed 5 HT-contracted preps. However, dog arteries (n = 2) were more resistant to relaxation.

Removal of the endothelium (n = 2) by gentle mechanical rubbing was without effect on the responses to MP+PP, Q, MP or PP. Thus the observed vasodilation with the parabens would appear not to be dependent upon the release of EDRF (endothelium-dependent-relaxing-factor).

Conclusion

We have shown in two animal species that clinically used concentrations of MP and PP produce dose-related and additive effects and they and not SUX are responsible for the vasodilation. Future studies should give recognition to the fact that parabens are not just preservatives but have potent pharmacological actions. This is emphasized by our previous demonstration that parabens in steroid preparations have similar effects on pulmonary smooth muscle.[3]

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Auditory steady-state evoked response (ASSR) during general anaesthesia

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There is no satisfactory method to assess the fluctuations of the level of consciousness during general anaesthesia.[1] The purpose of this study was to determine whether the auditory steady-state response (ASSR) could be used to monitor anesthesia. The ASSR is a sustained, sinusoidal evoked potential which appears when the rate of stimulation is sufficiently rapid to produce overlap of the responses to individual stimuli. Its amplitude varies with the level of arousal[2] and is decreased during isoflurane anaesthesia.[3]

Methods

Ten elective adult surgical patients were tested during anaesthesia with thiopentone, vecuronium, fentanyl (2–4 μg · kg^{-1}) and isoflurane (0.5–1.5 per cent end–tidal) in air/oxygen or nitrous oxide (60 per cent)/oxygen. Recordings were carried out before induction (control), during induction, surgery and emergence, and in the recovery room 15–120 min later. Stimuli consisted of 500 Hz tones (15 ms duration, 80 dB peSPL) presented binaurally via insert earphones at a rate of 40 · sec^{-1}. The EEG was recorded from Fz, Cz and Pz (reference: right mastoid) with

TABLE ASSR amplitude (Cz) (uV) (sd)

		Periods	
Method	*Control*	*Early induction*	*Late induction*
Time	0.42 (0.20)	0.46 (0.16)	0.32 (0.18)
Frequency	0.39 (0.12)	0.39 (0.10)	0.19 (0.10)

	Periods		
Method	*Surgery*	*Emergence*	*Recovery*
Time	0.06 (0.02)	0.30 (0.20)	0.29 (0.10)
Frequency	0.03 (0.01)	0.14 (0.08)	0.24 (0.06)

a band pass of 0.3–100 Hz. An epoch of 1.5 sec (1024) points was used. Trials contaminated by eye movements were rejected. The amplitude of the ASSR was measured on the Cz channel. Two methods were used. With the time-domain method, the waveforms were digitally filtered (38–42 Hz) and the root-mean-square[2] amplitude was recorded. With the frequency-domain method, the waveforms were analyzed using the Fast Fourier Transform (FFT) from which the amplitude at 40 Hz was obtained (Table).

Results

With time-domain measurements pair-wise comparisons revealed that surgery showed significantly ($P < 0.01$) lower amplitudes than all other periods. With frequency-domain measurements similar comparisons revealed that surgery differs significantly from control, early induction and recovery ($P < 0.01$) but *not* from late induction and emergence.

Discussion

Both measurement methods show that the amplitude of the ASSR is clearly attenuated during surgical anaesthesia and that it returns to 60 per cent of control value during recovery. This suggests that the ASSR correlates well with the level of consciousness. The discrepancy between the two methods during the late induction and emergence periods might result from contamination of the recordings by muscle activity. The muscle activity would be more evident on the 38 to 42 Hz band-pass of the time-domain method than on the single frequency band-pass of the FFT. The results suggest that the state of the patient during the immediate post-operative period is somewhere between anaesthesia and full consciousness.

Acknowledgements

Supported by the MRC and FRSQ.

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Cranial duplex sonography: Effect of PCO_2 on the velocity of blood in the cerebral vasculature of anaesthetized children

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Studies in adults have demonstrated that the PCO_2 directly affects the calibre of the resistance vessels in the cerebral vasculature and therefore cerebral blood flow.[1] Although this effect is thought to hold true for children, it has not been documented. Therefore, we determined the effect of PCO_2 on cerebral blood flow velocity in healthy anaesthetized children.

Methods

With approval from the institution Ethics Committee, 13 healthy children, ASA physical status I or II scheduled for elective urological surgery were studied. All children were fasting and unmedicated. Anaesthesia was induced with thiopentone and vecuronium. After the trachea was intubated, anaesthesia was maintained with 70 per cent N_2O/O_2, fentanyl 2 $\mu g \cdot kg^{-1}$, narcotic, vecuronium and 0.8–1.0 per cent end–tidal isoflurane. All patients had a caudal block performed at the beginning of surgery. Ventilation was adjusted to achieve an end–tidal PCO_2 of 20 mmHg. Fresh gas flow was maintained constant throughout the study to avoid any variation in intrathoracic pressure. Normothermia was maintained. The PCO_2 was then equilibrated between 20 and 80 mmHg with an exogenous source of CO_2. Blood pressure, heart rate, oxygen saturation, end–tidal isoflur-

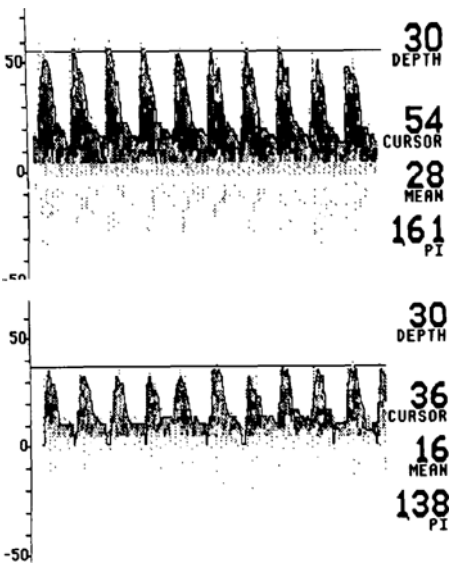

FIGURE 1 Linear regression with 90 per cent confidence limits are shown ($P < 0.05$).

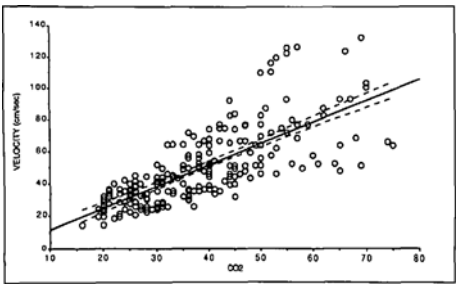

FIGURE 2 Linear regression with 90 per cent confidence limits are shown ($P < 0.05$).

ane, inspired nitrous oxide and oxygen were recorded within the range of PCO_2 values described. Cerebral blood flow velocity was measured with the transcranial doppler monitor (TC2-64B, EMC, Carolina Medical Electronics, Inc.) (Figure 1). Statistical significance was determined using linear exponential regression analysis between cerebral blood flow velocity and PCO_2. Coefficient of determination (r^2) was used.

Results

The mean ± SD age and weight of the 12 children were 3.5 ± 1.9 years and 18.5 ± 8.8 kg. Heart rate, blood pressure and end-tidal isoflurane did not change significantly during the study. The cerebral blood velocity increased linearly as the $PETCO_2$ increased ($r^2 = 0.56$) (Figure 2).

Discussion

Previous studies demonstrated the exponential relationship between cerebral blood flow velocity and PCO_2. Because the calibre of the basal cerebral arteries remains unchanged in the paediatric population with CO_2, the assumption that these data should also be proportional to changes in blood flow in the basal cerebral arteries, actual blood flow can be made.[2] These data indicate that CO_2 has a direct effect on cerebral blood flow velocity in children anaesthetized with isoflurane. Further studies are warranted to determine the effects of anaesthesia and their doses and surgical conditions on cerebral blood flow velocity in infants and children.

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Transcranial doppler sonography: halothane increases cerebral blood flow velocity in children

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It has been stated that halothane may not be the ideal anaesthetic for patients with increased intracranial pressure because it increases cerebral blood flow.[1] Although this statement has been supported by the results of several adult studies, it has not been shown to hold true in paediatric neuroanaesthesia. This study was undertaken to determine the effect of halothane on cerebral blood flow velocity in healthy children.

Methods

With approval from the institution human ethics committee, six healthy children scheduled for elective urological procedures were studied. All children were ASA physical status I, fasting and unmedicated. The children were anaesthetized with an inhalational induction with halothane, nitrous oxide and oxygen, and paralyzed with vecuronium. After tracheal intubation, anaesthesia was maintained with IPPV, fentanyl 2 $\mu g \cdot kg^{-1}$ in 70 per cent nitrous oxide and 30 per cent oxygen. Caudal epidural block was performed immediately after induction of anaesthesia. Normocapnia (35–40 mmHg) and normothermia (36.5° C–37° C) were maintained. Positive end-expiratory pressure was avoided. All children were supine and horizontal throughout the study. Three MAC multiples of halothane were administered in a random order (0.5, 1.0 and 1.5 MAC) until steady-state was reached and then cerebral blood flow velocity measurements were recorded. Systolic arterial pressure was maintained within ten per cent of 0.5 MAC halothane variables by intermittent neosynephrine injections. End-tidal concentrations were adjusted for age by measuring the concentration at the distal end of the tracheal tube.

At each end-tidal concentration, heart rate, systolic arterial pressure, cerebral blood flow velocity and the pulsatile index were determined. Cerebral blood flow velocity was determined using a two megahertz doppler probe (TC2-64B, EMC, Carolina

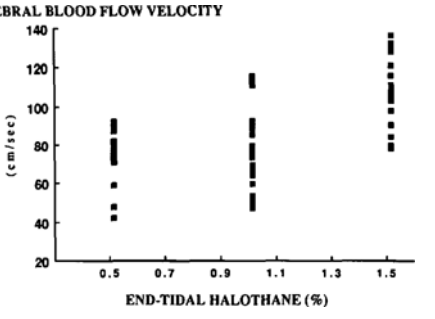

FIGURE Cerebral blood flow velocity vs end-tidal halothane described by the expression $CBFV = 70.6x^2 + 49.7x^2$ ($r^2 = 0.39$) where × is the per cent end-tidal halothane.

Medical Electronics, Inc.) positioned through the temporal window over the proximal stem (MI segment) of the middle cerebral artery. The position of the probe was optimized by maximizing the auditory signal from the probe. Velocity was calculated based on the first harmonic of the Fourier analysis of the doppler waveform. Non-linear regression analysis of the halothane versus cerebral blood flow velocity was determined and the coefficient of determination (r^2) reported.

Results

The mean ± SD age and weight of the six children were 1.5 ± 1.0 yrs and 13.5 ± 6.63 kg. The relationship between cerebral blood flow velocity and halothane was a second-order polynomial ($r^2 = 0.41$) (Figure).

Discussion

Previous investigators have demonstrated a dose-dependent relationship between halothane and cerebral blood velocity in adults.[2] The results of this study suppport this observation in healthy children as well.

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Has acupuncture anti-emesis any place in anaesthesia practice?

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Anti-emetics, although often effective, can cause drowsiness or have extra-pyramidal effects. P6 (Neiguan) acupuncture (ACP) is a new approach to this problem. Here presented are findings in which it has been used in four forms in controlled clinical trials and compared with two standard anti-emetics.

Methods

The subjects of these studies, approved by the Medical Ethical Research Committee were women having minor operations under methohexitone-nitrous oxide-oxygen. On obtaining verbal consent premedication of 10 mg nalbuphine was given IM followed immediately by the adjuvant therapy. Patients were told that the study aimed at reducing side effects of premedication but nausea and vomiting were not mentioned. The study involved a no-treatment (control) group.

P6 point is approximately 5 cm from the right distal wrist crease between the forearm tendons of palmaris longus and flexor carpi radialis: when a needle was used it was inserted to a depth of 1 cm. The "dummy" point was at the right elbow. The treatments shown in the Table were given in random order. Included is the pooled data for two anti-emetics (AE) (cyclizine 50 mg and metoclopramide 10 mg) also included in the study. The active ACP treatments were: m = manual needling for 5 min; e = needle stimulated with 10 Hz for 5 min; s = stud applied over point and stimulated as "e"; x = acupressure for 5 min and thereafter continued with a wrist band.

TABLE Percentage frequency of postoperative sickness

		Postop hours sickness								
		0–1			*1–6*			*Overall*		
Adjuvants	*n*	*V*	*N*	–	*V*	*N*	–	*V*	*N*	–
Nil	56	11	46	43	14	43	43	25	43	32
Dummy ACP	31	13	26	61	6	36	58	19	39	42
P6 ACP										
m	56	12	11	77	0	11	89	12	11	77
e	56	3	3	94	10	6	84	13	6	81
s	93	13	7	80	15	19	66	20	17	63
x	51	6	2	92	14	27	59	14	29	57
AE	62	8	10	82	10	14	76	13	23	64

Patients were seen at the end of the first and sixth postoperative hours when the occurrence of vomiting, including nausea and vomiting and retching (V) or nausea alone (N) was noted. The person making the assessment was unaware of the treatment given. Statistical comparisons were made with the χ^2 test.

Results

This tightly controlled study demonstrates an appreciable anti-emetic activity of P6 ACP. Needling of a dummy point was ineffective. Overall there was a marked reduction in the frequency of N, but V was also reduced. Most effective were the invasive ACPm and ACPe ($P < 0.0001$ at all times). With ACPs and ACPx the most significant effects occurred in the first postoperative hour, but overall these have an effective anti-emetic action (s: $P < 0.001$, x: $P < 0.01$).

Invasive ACP was marginally more effective than AE 0–1 hour ($P < 0.01$) and 0–6 hours ($P < 0.05$). No side effects were seen with ACP.

Discussion

Invasive ACP requires technical skill and explanation to the patient, is time-consuming and must be given at the time of the emetic stimulus. Although effective and non-toxic it is unlikely to be practised widely but these data show that manual pressure by a band applied to the wrist is worthy of more widespread use. Its value should be explored where drug-induced sickness can be life-threatening.

Prevention of CO_2 induced laser tracheal tube fires with the Laser-Guard™ protective coating

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We examined the efficacy of a new commercially available, self-adhesive, sponge-backed, silver foil product (Laser-Guard™, Americal Corp., Mystic, CT), designed to protect

tracheal tube shafts from direct exposure to the surgical CO_2 laser beam.

Materials and methods

A LaserSonics (Santa Clara, CA) 880 CO_2/Nd-YAG laser in the continuous CO_2 mode was used with a Zeiss operating microscope. The laser was directed perpendicularly at Mallinckrodt 8.0 mm ID polyvinylchloride tracheal tubes through which 5 $L \cdot min^{-1}$ O_2 was flowing. A bare tube served as a control while another was protected with the Laser Guard™. Power settings of 10 and 70 watts were used. According to manufacturer's directions, we wet the sponge layer with water after application of the product to the tracheal tube shaft. Laser exposure was continued until either combustion occurred, or 60s had elapsed.

Results

At 10 W, the plain tracheal tube was penetrated after 50 sec of laser exposure. Smoking and minor non-sustained combustion accompanied this trial, although no "blowtorch" fire occurred. At 70 W, laser exposure to the bare PVC tube resulted in combustion and blowtorch fire after only 3 sec. The Laser-Guard-covered tube shaft was not significantly damaged by 60 sec of laser exposure at 10 or 70 W. A small amount of smoke, but no flames, were seen. The sponge coating was missing, with minimal evidence of thermal decomposition of the sponge in a small area surrounding the site of laser impingement, and the bare, corrugated silver foil was plainly visible. The foil was intact.

Discussion

The Laser-Guard™ consists of a 13.5 × 4 cm silver foil layer covered with a thin, absorbent, sponge layer. It is designed to be an easy-to-use highly resistant barrier to laser radiation. The foil is fabricated from silver because this metal has the greatest thermal conductivity. The sponge, when moistened, acts as a heat sink. The Laser-Guard™ covering protected PVC tracheal tube shafts from laser-induced combustion during test conditions of continuous exposure to CO_2 laser light of up to 70 W for 60 sec with 5 $L \cdot min^{-1}$ O_2 flowing through the tube. These conditions are probably more severe than any that will be encountered clinically. The control, a bare PVC ET tube, when exposed to these conditions, burned like a blowtorch almost immediately. Such tracheal tube explosions are the most common and devastating untoward events that may occur during laser surgery near the airway. Previous studies have shown that flammable tracheal tube shafts may be protected from CO_2 laser beam impact by wrapping with either copper or aluminum foil tape. These methods, although in common usage, are not approved by the manufacturers of the metallic foil tapes, and are not approved by government regulatory bodies. The Laser-Guard™ was easier to apply than the foil tapes and has been specifically designed to protect ET tube shafts from direct CO_2 laser impact. The product has governmental approval in the US and approval has been applied for in Canada. Neither the Laser-Guard nor metallic foils protect the cuff of a tracheal tube from combusion induced by laser radiation.

A breath-by-breath metabolic monitor: Proof of utility in the hyperthermic pig model

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The objective of the study was to document the physiological responses to hyperthermia induced by 2–4 dinitrophenol (DNP) in the dog and by halothane in pigs subject to porcine stress syndrome (PSS). There was continuous on-line measurement of carbon dioxide (CO_2) with a Hewlett-Packard capnometer (Model #47210-A), of oxygen (O_2) with an ultraviolet absorption analyzer, and of air flow with a heated Fleisch pneumotachograph (PNT). The output of the PNT was integrated to obtain tidal volume (VT) allowing simultaneous computation and display of breath-by-breath O_2 uptake and CO_2 excretion as well as respiratory waveform, VT, and minute volume. The combination of sensors, electronic processing and display equipment was designated a metabolic monitor (MM). The animal's systemic blood pressure, and superior vena caval and rectal temperature were also measured, recorded, and displayed.

Adult mongrel dogs were anaesthetized with pentobarbital sodium (30 $mg \cdot kg^{-1}$). A period of baseline data was recorded, then the dogs were challenged with 5–10 $mg \cdot kg^{-1}$ of DNP. There was an almost immediate increase in O_2 consumption and CO_2 excretion with a later rise in vena caval and rectal temperatures.

PSS and normal pigs were anaesthetized with thiamylal. A period of baseline data was recorded, then the pigs were challenged with halothane. PSS pigs exhibited a marked increase in O_2 consumption and CO_2 excretion followed by elevation of first SVC, then rectal temperature (see Figure).

Treatment with dantrolene could often reverse (or stabilize) the response; rechallenge with a higher concentration of halothane reinitiated the pathologic response. Normal pigs (no response to halothane) were challenged and rechallenged with DNP with less dramatic increases in O_2 consumption, CO_2 excretion, and temperature than seen in the dog.

Administration of succinylcholine (SC) to normal pigs caused an immediate increase in O_2 consumption and CO_2 excretion that appeared to correlate with the degree of muscle fascicula-

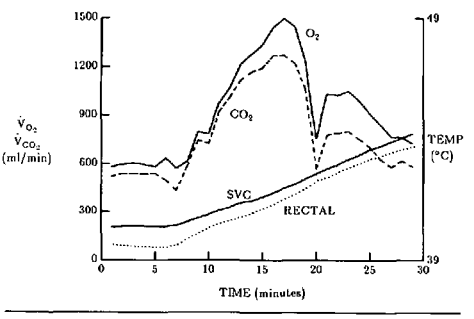

FIGURE PSS pig rechallenged with four per cent halothane.

tion. Repeat doses of SC caused minimal fasciculation and minimal changes in O_2 uptake and CO_2 excretion. This observation suggests trial of the MM as a tool to evaluate pretreatment regimens to prevent SC pain. Use of the MM as a possible tool to differentiate true shivering from anaesthetic muscle shakes (and effects of therapy) seems warranted. The MM can also recognize induced air emboli; we are currently determining the degree of sensitivity.

In summary, we have developed a practical metabolic monitor that will have multiple uses in the operating suite and intensive therapy units. We are upgrading and miniaturizing the components. As development continues, modes for measuring further parameters will be added.

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Prevention of shivering after cardiac surgery using radiant heat

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Postanaesthetic shivering (PAS) represents a significant haemodynamic and metabolic stress following cardiac surgery. Animal[1] and human[2] studies describe the cessation of PAS following the application of radiant heat to the skin, especially to the blush area, even if the core temperature remains low. We performed a prospective randomized trial comparing rewarming with a radiant heater with rewarming with a warming blanket immediately following cardiac surgery to prevent PAS.

Methods

Seventy patients undergoing elective coronary bypass or valve surgery gave written informed consent to the institutionally approved protocol. Anaesthesia was induced and maintained with fentanyl (75–100 $\mu g \cdot kg^{-1}$), pancuronium and oxygen. After arrival in the intensive care unit patients were rewarmed with either a warming blanket (Aquamatic K thermia, Model RK 600, Hamilton Industries), or radiant heater which were set at 38° C. The heater was constructed by our Department of Medical Engineering and consisted of a linear arrangement of three infrared lamps (total 625 watts) on an overhead stand, which was placed 18 inches over the sternum and centered on the trunk. A servo negative feed-back system was incorporated to reduce the risk of skin burns. Both the warming blanket and radiant heater were discontinued when the core temperatures reached 38° C.

Nasal, Swan Ganz, rectal and toe temperatures were recorded hourly for the six-hour duration of the study and observations were made by one of two investigators who graded the severity of shivering on a scale of 0 to 4 with 0 = no shivering, 1 = occasional mild tremors in the jaw and neck, 2 = intensive tremors in the chest, 3 = intermittent vigorous generalized tremors, and 4 = continuous violent muscle activity. Shivering graded 2 or more and of 5 min duration was treated with morphine 0.05 $mg \cdot kg^{-1}$ and diazepam 0.07 $mg \cdot kg^{-1}$. This was repeated once if required. Persistent or recurrent shivering thereafter was treated with vecuronium 0.1 $mg \cdot kg^{-1}$. Statistical analysis was performed using Yates corrected Chi square and Fisher exact tests.

TABLE

	Warming blanket	*Radiant heater*
Age	56±11	61±11
Male/female	30/6	26/8
CPB duration	97±26	103±43
CPB lowest NP temperature	26±2	26±2
ICU admission temperature		
Swan-Ganz	35±0.9	35±0.8
Nasal	34±0.8	34±0.7

Results

Demographic data (Table) and time to reach desired core temperature were similar for both treatment groups. In the radiant heater group 5/34 versus 16/36 in the warming blanket group received vecuronium for persistent PAS.

Conclusion

Neither radiant heater nor warming blanket treatment eliminated PAS post-cardiac surgery. Although rewarming was equally effective in both groups, PAS was significantly less ($P = 014$) in the radiant heater group.

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Idiopathic postoperative delirium in the elderly

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A disturbance of mental function often seen in the elderly during the first week after surgery is "delayed delirium" or "interval psychosis." Although the occasional case can be attributed to a specific aetiology most appear without obvious cause, i.e., they are idiopathic. The aim of this study was to determine the incidence of idiopathic delayed delirium in the elderly and to assess its relationship to (1) patient characteristics, (2) the anaesthetic/surgical procedure, and (3) elements of the postoperative course.

Methods

We conducted a prospective epidemiological survey of 239 patients aged 65 years and older entering hospital to undergo elective surgery not involving the lungs, heart or brain. We also surveyed 100 newly hospitalized patients not undergoing surgery but of the same age. Excluded from both groups were patients with an acute infective, metabolic or neurological

disorder; a history of delirium or dementia; or the potential for ICU admission. All were followed through one week after surgery or admission for the development of idiopathic delirium. Delirium was identified by standard criteria and idiopathic delirium by excluding cases with clinically detectable cause. For all patients, we recorded comprehensive data on (1) personal characteristics – e.g., age, sex, medical history, concurrent medication; (2) the anaesthetic and surgical procedure – e.g., type of anaesthesia (local, regional or general), type of surgery, duration, intraoperative blood pressure change; and (3) the postoperative or post-admission course – e.g., sedative/narcotic use, complications. We then examined the relationship between idiopathic delirium and the various recorded factors, using a multiple linear regression analysis. We also examined the recorded factors in cases and controls matched for age, sex and procedure.

Results

Idiopathic delirium appeared in 29 or 12 per cent of the surgical patients and in one or one per cent of the non-surgical group ($P < 0.01$). The incidence after surgery increased with age. The postoperative cases fell into two distinct types: (1) an "early onset" type, in which delirium appeared on the operative night only, and (2) a "late onset" type, in which delirium developed between the second and fourth postoperative day and lasted variably up to three days. Each type related to one factor in both regression and case control analyses; the "early" cases to hearing impairment (8/11 vs 2/11 in matched controls, $P < 0.05$); and the "late" cases to the amount of narcotic given after recovery through the first postoperative day (0.68 ± 0.30 mg morphine $\cdot$ kg^{-1} vs 0.48 ± 0.28 in matched controls, $P < 0.05$).

Discussion

We conclude that idiopathic delayed delirium is a very common complication of surgery. It has no detectable relationship to type of anaesthesia nor type of surgery. Rather, it seems linked to age and undergoing an operation and, more specifically, to hearing impairment and postoperative narcotic therapy in early and late onset cases respectively. The relationship to hearing loss may reflect the practice of removing hearing aids for the operative day, thereby creating a type of sensory deprivation.[1] The relationship to narcotic therapy may be due to effect of narcotic on sleep, leading to nights of highly intense REM sleep.[2] Both acute sensory deprivation and intense REM sleep could precipitate delirium in the elderly.

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Hazards of a new specially designed plastic endotracheal tube for the use with the Nd-Yag laser

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Nd-YAG laser radiation is not absorbed by clear plastic, water or glass. The use of conventional polyvinylchloride tracheal tubes during Nd-YAG laser surgery on the airway has been considered dangerous because the lettering and radio opaque parts of the tube can absorb laser energy and induce endotracheal tube fires. Sheridan has designed a special clear polyvinylchloride tracheal tube free of any markings, or colouration. We evaluated the flammability of these clear tracheal tubes when exposed to the Nd-YAG laser beam.

Materials and Methods

Clear nonmarked polyvinylchloride tracheal tubes 8.0 mm or 9.0 mm ID (Sheridan YAG Tracheal Tube, Sheridan, Corp., Argyle, NY, USA) were studied. A LaserSonics (Santa Clara, CA, USA) model 880 Nd-YAG laser, coupled to a Zeiss (W. Germany) model S2 operating microscope was used in all trials. The laser was set to 70W in the continuous mode with a beam diameter of 0.68 mm. Five L $\cdot$ min^{-1} of O_2 was directed through the polyvinylchloride tracheal tube which rested on wet towels in air. A conventional 8 mm polyvinylchloride endotracheal tube (Mallinckrodt Critical Care, Glens Fall, NY, USA), was also studied to assess the Nd-YAG laser-induced combustibility of these tubes. The endpoints of all trials were either tracheal tube fire or explosion or 60 sec of laser fire. The Sheridan tubes were evaluated as received and also when covered with blood, proteinaceous secretions or benzocaine ointment.

Results

The Mallinckrodt polyvinylchloride tracheal tube was not perforated and did not burn after 60 sec of 70 W laser radiation was directed at an unmarked portion of the tube. When the 70 W beam was directed at a black printed letter on the tube, combustion resulted in 2.6 sec. The Sheridan YAG tracheal tube was unaffected by 60 sec of laser radiation. When benzocaine ointment was applied to the tube, and laser-fired, the ointment melted but did not burn, nor did the Sheridan tube. When drops of blood were applied to the outside of the Sheridan tube and the 70 W Nd-YAG beam directed at them, tracheal tube explosion resulted in 5.2 sec. Similarly, small amounts of blood inside the tube, when so exposed, caused tracheal tube explosion in 5.75 sec. Saliva and mucus from a healthy volunteer, applied to the outside of the Sheridan tube allowed laser-induced tracheal tube explosion in 5.46 sec. However, similar secretions applied to the inside of the tube did not cause combustion or perforation even after 95 sec continuous laser exposure, although the secretions were blackened.

Discussion

Small amounts of blood, or proteinaceous secretions adherent to the Sheridan YAG Tracheal Tube allowed it to burn on contact with Nd-YAG laser radiation. Geffin *et al.*[1] have shown that markings on a clear polyvinylchloride tracheal tube increase the likelihood of Nd-YAG laser-induced tracheal tube combustion.

Our results confirm this finding. It would appear that the absence of markings, colouration or opacity on the Sheridan YAG Tracheal Tube offers a theoretical, but not a practical, safety advantage with regard to tracheal tube explosion. If polyvinylchloride tracheal tubes are used during laser surgery on the airway, they should be protected with metallic adhesive foil.[2]

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The effect of pretreatment with nondepolarizing muscle relaxants on succinylcholine induced increases in resting jaw tension in children

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Succinylcholine has been reported to cause increased jaw muscle tension in adults[1] and reduced mouth opening and increased jaw stiffness in children.[2] This study was designed to determine whether pretreatment with d-tubocurarine or atracurium prior to the administration of succinylcholine could prevent increases in jaw muscle tension.

Methods

Institutional approval and informed parental consent were obtained. Twenty-one unpremedicated ASA physical status I children, aged three to ten years, undergoing elective day care surgery were studied. Anaesthesia was induced with halothane and N_2O 66 per cent in O_2, or thiopentone 5–7 $mg \cdot kg^{-1}$ IV. Atropine 0.01 $mg \cdot kg^{-1}$ IV was then administered, and tracheal intubation was performed under deep halothane anaesthesia. Supramaximal train-of-four stimulation was applied to the ulnar nerve at the elbow, and to the mandibular branch of the trigeminal nerve inferior to the zygomatic arch, anterior to the madibular condyle. Stimulation of the trigeminal nerve resulted in masseter contraction and jaw closure which was measured by a force transducer system attached to both an oral airway and a metal frame fixed to the operating table 10 cm caudad to the chin. After stabilization of adductor pollicis and masseter muscle twitch, seven patients in each group received by random allocation either a sub-paralyzing dose of d-tubocurarine, 0.05 $mg \cdot kg^{-1}$, a paralyzing dose of atracurium, 0.5 $mg \cdot kg^{-1}$ or saline, 0.02 $ml \cdot kg^{-1}$, followed three minutes later by succinylcholine 1.0 $mg \cdot kg^{-1}$. Time to onset, maximum effect and duration of succinylcholine-induced changes in baseline tension were measured and compared using the Student's t test with the Bonferroni correction where applicable. The frequency of occurrence of muscle fasciculations and increased tension were also noted. Results are expressed as mean values ± SEM. A P value < 0.05 was considered significant.

TABLE Increase in masseter muscle tension after succinylcholine administration means ± SEM.

	Saline (n = 7)	*d-Tubocurarine (n = 7)*	*Atracurium (n = 7)*
Maximum tension (g)	59±13	47±15	3±3*
Time to onset (min)	0.3±.05	0.3±.07	0.03±.03*
Duration (min)	1.7±0.7	1.7±0.7	0.1±0.1*

*P < 0.05.

Results

The groups were similar with respect to age, weight and height. There were no differences in the resting and control twitch tensions between the three groups for each muscle. There was no change in twitch height following d-tubocurarine or saline. All patients had complete neuromuscular block at both muscles within 1 min following succinylcholine, and within 1–2 min after atracurium. All patients in the d-tubocurarine- and saline-treated groups experienced similar increases in masseter tension after succinylcholine, compared with only one patient in the atracurium group (Table). The onset and duration of masseter tension increases in the d-tubocurarine and saline groups were similar. Maximum resting changes occurred during maximal twitch depression. Five patients (all in saline group) had muscle fasciculations.

Discussion

There is ample evidence that muscle fasciculations following succinylcholine are a pre-synaptic phenomenon. The fact that pretreatment with d-tubocurarine prevented fasciculations without effecting increases in masseter baseline tension due to succinylcholine suggests that the latter is a post-synaptic event. Furthermore, blocking the post-synaptic receptors with a paralyzing dose of atracurium did prevent the increase in masseter muscle tension. This suggests again that we are dealing with a post-synaptic phenomenon.

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Dose-dependent prolongation of succinylcholine block by Metoclopramide

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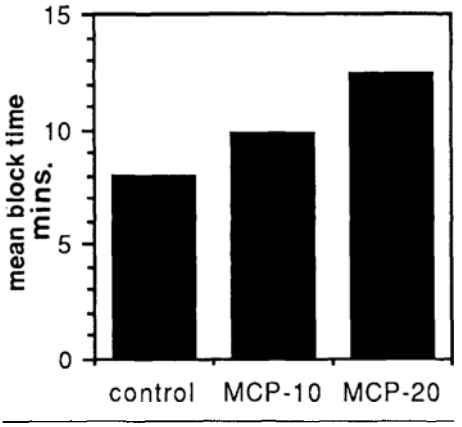
Metoclopramide (MCP) is frequently administered to patients considered to be at increased risk of aspiration in the periopera-



FIGURE

tive period in order to decrease the volume of gastric contents and the incidence of postoperative nausea and vomiting. These same patients are also candidates for rapid sequence induction, and therefore MCP and succinylcholine (Sch) are frequently administered concurrently. Since MCP has been found to inhibit plasma cholinesterase,[1] its interaction with Sch may be clinically important.

Methods

This study was approved by the Institutional Review Board of the Texas Tech University Health Sciences Center. Informed consent was obtained from all patients.

Fifty patients scheduled for postpartum tubal ligations (within 48 hours of delivery) were included in the study. Group I (control, n = 21) received no premedication. Group II (n= 19) and Group III (n= 10) received IV metoclopramide, 10 and 20 mg respectively, one hour prior to the procedure. Anaesthesia was induced with thiopentone, 4 $mg \cdot kg^{-1}$, and succinylcholine, 1 $mg \cdot kg^{-1}$. Muscle relaxation was measured by a Datex Neuromuscular Transmission Monitor (NMT-Puritan Bennett, Inc.), which delivered a TOF supramaximal stimulus at 2 Hz to the ulnar nerve every ten seconds. Sensing electrodes measured the electromyographic (EMG) activity in the adductor pollicis muscle and it was then plotted graphically as a percentage of control. The time from the onset of 95 per cent depression of baseline twitch height to 25 per cent recovery was called the "block time." Data for all three groups were analyzed using the Newman-Keuls multiple range test.

Results

The mean duration of block for the control group was 8.0 minutes. Group II (metoclopramide 10 mg IV) had a mean block time of 9.83 minutes, and Group III (20 mg IV) 12.45 minutes. The mean block times for Groups II and III were significantly longer than that of the control group ($P < 0.05$) and $P < 0.01$, respectively). The difference in mean block times between Groups II and III was also statistically significant ($P < 0.01$) (see Figure).

Summary

Metoclopramide prolongs the duration of succinylcholine block (1 $mg \cdot kg^{-1}$) in the puerperal patient in a dose-dependent manner, producing increases in block times of 23 and 56 per cent over controls when 10 or 20 mg IV are administered 60 minutes prior to induction. It may be advisable, depending on the clinical situation, to reduce the succinylcholine dose in patients being treated with MCP.

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Effects of sevoflurane and halothane on hepatic blood flow in rats

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Sevoflurane, a new inhalational agent, has been shown to maintain cardiovascular stability in an animal model. However, its effect on liver blood flow is undetermined. Therefore, we compared the effects of sevoflurane and halothane on liver blood flow in adult rats.

Methods

After approval from the local Animal Care Committee, 32 fasted male Sprague-Dawley rats weighing 240–290 g were studied. MAC for sevoflurane and halothane were determined using the standard tail clamp technique.[1,2] The rats were anaesthetized with ether and the femoral and carotid arteries were cannulated. The carotid cannula was advanced into the left ventricle. After the rats were allowed to recover for three hours, they were placed in cylindrical plexiglass chambers. Heart rate and mean arterial pressure were monitored continuously. One hundred per cent oxygen was administered at 5 $L \cdot min^{-1}$. Before induction of anaesthesia, ^{57}Co-labelled microspheres were injected into the left ventricle and heart rate and mean arterial pressure were recorded (control measurements). Anaesthesia was then induced with either sevoflurane or halothane in 100 per cent oxygen. Anaesthetic concentrations were monitored using a calibrated Beckman LB2 analyzer and adjusted to deliver 1 MAC. After 30 minutes of anaesthesia, repeat haemodynamic measurements were recorded and ^{46}Sc-labelled microspheres were injected. A reference blood sample (0.6 ml) was withdrawn from the femoral artery during each microsphere injection to determine the cardiac output (CO). The blood samples were replaced with Ficoll (0.3 ml of 13 per cent solution). The rats were then killed, and the gamma counts were measured in the stomach, spleen, small intestine, large intestine, mesentery and liver.

TABLE

	Sevoflurane		*Halothane*	
	Control	*1 MAC*	*Control*	*1 MAC*
Cardiac output	258 ± 66	205* ± 70	244 ± 72	171* ± 40
PVBF	44.7 ± 11	32.8 ± 12	42.7 ± 10	25.8* ± 7
HABF	9.1 ± 5.0	19.8† ± 6.2	7.1 ± 3.0	12.4* ± 5.0
TLBF	53.8 ± 10	52.6 ± 9.0	49.8 ± 10.0	38.2 ± 9.8

Data are means ± SD. All flows are $ml \cdot kg^{-1} \cdot min^{-1}$. *P < 0.05 compared with controls. †P < 0.01 compared with controls.

Calculations

Cardiac output was calculated from the net counts injected times reference sample withdrawal rate divided by the net counts in the reference sample times the body weight. Organ blood flow was calculated from the net counts in the organ divided by the net counts injected times CO. Portal venous blood flow (PVBF) was calculated from the sum of the blood flow to the stomach, spleen and small and large intestines (including pancreas and omentum). Hepatic artery blood flow (HABF) was calculated from the counts in the liver. Total liver blood flow (TLBF) was the sum of PVBF and HABF.

Statistical significance ($P < 0.05$) was determined using paired and unpaired Student's t-test.

Results

The MAC of sevoflurane was 2.8 per cent and that of halothane was 1.1 per cent. Sevoflurane (1 MAC) decreased CO by 20 per cent and PVBF by 26 per cent, but increased HABF by 115 per cent ($P < 0.05$) (Table). Sevoflurane did not decrease TLBF. Halothane (1 MAC) decreased CO by 30 per cent (Table) and PVBF by 40 per cent, but increased HABF increased by 75 per cent ($P < 0.05$). Halothane decreased TLBF by 24 per cent.

Discussion

Sevoflurane increased HABF to a greater extent than halothane, and decreased PVBF to a lesser extent than halothane. In this animal model, sevoflurane acts similar to isoflurane in preserving TLBF. Further studies are required to determine whether sevoflurane maintains liver blood flow in rats with impaired liver function.

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The pharmacokinetics of atracurium and laudanosine in the elderly

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Many non-depolarising muscle relaxants have a prolonged duration of action in the elderly, thought to be due mainly to decreased renal clearance together with decreased hepatic metabolism. This phenomenon has been demonstrated with d-tubocurarine, pancuronium and metocurine.[1,2] As the elimination of atracurium is thought to be largely independent of renal and hepatic function it was decided to study the pharmacokinetics of this drug in the elderly and compare the results with a group of young adult patients as controls. In addition, as one of the important metabolites of atracurium, laudanosine, probably does depend on the kidney and the liver for its excretion in man it was decided to study the pharmacokinetics of this metabolite simultaneously.

TABLE

	VB $(ml \cdot kg^{-1})$	*Clapp* $(ml \cdot kg^{-1} min^{-1})$	$T_{\frac{1}{2}}B$ *(min)*
Atracurium			
Young	172.4 ± 34.2	5.94 ± 0.92	20.1 ± 1.96
Elderly	199.7 ± 50.8 NS	5.95 ± 0.79 NS	23.1 ± 3.83*
Laudanosine			
Young	1729.8 ± 317.3	7.29 ± 1.69	173.1 ± 56.5
Elderly	1505.1 ± 484.9 NS	4.85 ± 2.00*	229.2 ± 54.4*

*P < 0.05; NS = not significant; using Wilcoxon Rank test.

Eleven elderly patients were studied, with a mean age of 80.9 years (range 71 to 97 years) and ten young patients, mean age 23.8 years (range 17 to 32 years). After induction with thiopentone, anaesthesia was maintained with N_2O/O_2/enflurane. All 21 patients were then given a bolus dose of atracurium 0.6 $mg \cdot kg^{-1}$. Samples of blood were taken from the opposite arm at 2, 4, 6, 8, 10, 15, 20, 25, 30, 45, 60, 75, 90, 120, 150, 180, 210, 240, 270, 300, 360, 420 and 480 minutes after the bolus dose. Plasma atracurium levels were measured for 120 minutes and plasma laudanosine levels at all the stated times, according to the method previously described by Parker and Hunter.[3] No further dose of atracurium was given.

The derived pharmacokinetic parameters for atracurium are given in the Table. The $T_{\frac{1}{2}}B$ was significantly longer in the elderly group of patients, but there was no significant difference for the other parameters using the unpaired Wilcoxon rank test. In contrast, the clearance of laudanosine was significantly reduced and the $T_{\frac{1}{2}}B$ significantly longer in the elderly group.

The mean volume of distribution (V_B), apparent clearance (Clapp) and terminal half-life ($T_{\frac{1}{2}}B$) together with the standard deviation for both atracurium and laudanosine in the elderly and young are given in the Table.

Conclusion

With atracurium, the terminal half-life ($T_{\frac{1}{2}}B$) was the only pharmacokinetic parameter found to be altered in the elderly, suggesting possibly some metabolism and excretion of this short-acting relaxant. However, with laudanosine the clearance (Clapp) is significantly reduced and the elimination half-life ($T_{\frac{1}{2}}B$) significantly prolonged in the elderly. This finding might be of clinical importance in elderly patients treated with large doses of atracurium in an ICU.

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The effect of oral ranitidine and preoperative oral fluids on gastric fluid pH and volume in children

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Many children who fast before elective surgery are at risk for pneumonitis flowing gastric fluid aspiration.[1] A number of drug and fluid regimens, including intravenous ranitidine taken orally,[2,3] have been studied in an attempt to reduce this risk. This study was undertaken to evaluate the effect of an oral liquid preparation of ranitidine, with or without oral fluids, on gastric fluid pH and volume.

Methods

A multi-centre prospective randomized trial was undertaken after approval by the respective ethics review committees. Written informed consent was obtained from the parents of 240 children (ASA physical status I or II) scheduled for elective minor surgery. Patients with gastrointestinal disease or receiving regular medications were excluded. At least two hours before surgery, the children received one of four drug/fluid regimens, based on prior randomization: group A – apple juice 5 $ml \cdot kg^{-1}$ + placebo; group B – apple juice 5 $ml \cdot kg^{-1}$ + ranitidine; group C – water 5 ml + placebo; group D – water 5 ml + ranitidine 2 $mg \cdot kg^{-1}$. The investigators were blinded to the presence of ranitidine or placebo. All the children received 1 ml (50 mg) of a non-absorbable marker dye, sulfobromophthalein (BSP). After induction of anaesthesia, each child's stomach was intubated and aspirated with a 16-gauge multi-orifice tube (Salem Sump®) and the gastric fluid volume was measured and tested for pH with a calibrated pH meter. The fluid was then frozen for spectrophotometric measurement of BSP concentration. Statistical significance was determined using a one-way ANOVA.

Results

Preliminary results from 136 children are presented. The groups were comparable for age, weight, sex, and fasting time prior to administration of the study preparations (10 ± 0.3 hours). Gastric fluid pH was significantly greater in both ranitidine groups than in the placebo groups and gastric fluid volume was significantly less in both ranitidine groups than in the juice/placebo group (Table). Fifteen per cent of patients in the two ranitidine groups had the combination of gastric fluid pH less than 2.5 and volume greater than 0.4 $ml \cdot kg$, as compared to 50 per cent in the juice/placebo group ($P < 0.05$). Recovery of BSP from the gastric contents ranged from 0.004 to 1.94 per cent, with no clinically significant retention of the preoperative fluids nor any statistically significant differences in volume among the four groups (Table).

TABLE (mean ± SE)

Drug/fluid regimen	*Volume [ml·kg⁻¹]*	*pH*	*%BSP*
A (juice/placebo)	0.46±0.09*	1.81±0.12*	0.135±0.032
B (juice/ranitidine)	0.24±0.04	3.61±0.39	0.149±0.037
C (water/placebo)	0.40±0.05	2.06±0.23*	0.097±0.014
D (water/ranitidine)	0.25±0.03	3.64±0.40	0.242±0.090

*$P < 0.05$ compared to groups B and D.

Discussion

These preliminary results indicate that the oral liquid preparation of ranitidine (2 $mg \cdot kg^{-1}$), given at least two hours before surgery, significantly increases gastric fluid pH. In view of the dominant role of pH in determining the severity of aspiration pneumonitis,[4] the preparation appears to be of clinical benefit. Furthermore, these results suggest that administration of clear fluids (apple juice) 5 $ml \cdot kg^{-1}$ up to two hours preoperatively is not associated with an increase in gastric fluid volume or a decrease in pH in elective paediatric surgical patients.

This study was supported by a grant from Glaxo Canada Inc.

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Reversibility of intermediate acting continuous infusion muscle relaxants: vecuronium equals atracurium

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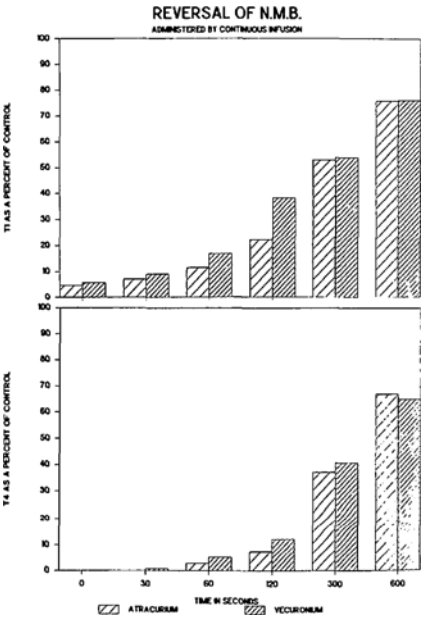
Continuous infusion of the intermediate-acting muscle relaxants offers a stable and easily controllable level of muscle relaxation.[1,2] However, accumulation of drug and difficulty in reversal of the blockade may occur. The present study is a double-blind comparison of the neuromuscular and haemodynamic changes that occur after neostigmine/glycopyrrolate reversal of atracurium or vecuronium given by infusion.

Methods

Institutional ethics approval and informed consent were obtained. Twenty ASA physical status I or II patients were randomly assigned to receive either atracurium or vecuronium. Patients receiving medications known to interfere with muscle relaxants were specifically excluded. No patient received premedication. Anaesthesia was induced with sufentanil 0.5 $\mu g \cdot kg^{-1}$ and 2–5 $mg \cdot kg^{-1}$ thiopentone, and maintained



FIGURE

with N_2O/O_2 (FiO_2 = 30 per cent) and isoflurane as required. The Puritan Bennett NMT 221 was calibrated and a stable baseline obtained prior to administration of atracurium or vecuronium. Over 60 seconds, either atracurium 0.5 mg · kg^{-1} or vecuronium 0.15 mg · kg^{-1} was given. When T_1 returned to a level of five per cent of control, infusions were started using an IVAC 570 infusion pump. Starting dosage for atracurium was 8 μg · kg^{-1} · min^{-1} and for vecuronium 1 μg · kg^{-1} · min^{-1}. Infusion rates were adjusted up or down in 25 per cent increments to maintain T_1 at five per cent of control. Sufentanil was given (10 μg) as required for analgesia. At the end of surgery, neostigmine 50 μg · kg^{-1} and glycopyrrolate 7 μg · kg^{-1} were administered IV. Anaesthesia was continued until T_1 had achieved 90 per cent of its control value. Heart rate, blood pressure, T_1 per cent of control and TOF per cent were recorded at 0, 30, 60, 120, 300 and 600 seconds after administration of reversal agents. Analysis of data was by unpaired t test (significance level $P \leq 0.05$).

Results

Groups were comparable for age and sex. The duration of infusion was 146 + 30 min for atracurium and 157 ± 26 min for vecuronium. The atracurium infusion rate was 93 ± 4 per cent of the initial value at the time of reversal whereas the vecuronium infusion was significantly lower at 62 ± 6 per cent. The Figure shows the return of twitch height. The rate of recovery of T_1 or TOF was not different between the two drugs reaching 90 per cent by about 12 min. The haemodynamic results are shown in the Table. Baseline heart rate was similar. Neostigmine/glycopyrrolate caused a significant increase in heart rate with both drugs between 30 and 60 seconds but no change in blood pressure.

TABLE

	Heart rate ± SEM		*Blood pressure ± SEM*	
Time	*Atracurium*	*Vecuronium*	*Atracurium*	*Vecuronium*
Cont	66.8 ± 7	81.8 ± 8	113 ± 12	121 ± 21
30	70.4 ± 6	91.6 ± 11	115 ± 13	120 ± 19
60	77.4 ± 8	94.2 ± 12	117.8 ± 12	123.2 ± 18
120	82.0 ± 9	87.8 ± 11	119.6 ± 14	125 ± 21
300	75.0 ± 7	80 ± 12	119 ± 9	124 ± 20
600	69 ± 6	77 ± 9	113 ± 10	124.8 ± 18

Discussion

The results of this study show that when twitch depression is maintained at 95 per cent, there is no difference between vecuronium and atracurium in reversal of blockade or haemodynamic response to reversal. When compared with historical controls, reversal is achieved more quickly than with conventional blockade with pancuronium.[3] There is a tendency to reduce the dosage over time to maintain a constant block and this is greater with vecuronium. Continuous infusion of these drugs offers reliable, controllable and easily reversible muscle blockade. The choice of drug does not appear to be important when block is maintained at a constant therapeutic level.

References

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2 *Gargarion et al.* The efficacy of atracurium by continuous infusion. Anesthesiology 1984; 61: A291.
3 *Katz RL.* Clinical neuromuscular pharmacology of pancuronium. Anaesthesiology 1971; 34: 550.

Patient controlled analgesia provides more effective postoperative pain control following pectus excavatum repair in children than does conventional narcotic therapy

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The purpose of this study was to compare the morphine requirements for children receiving traditional modalities of narcotic administration following pectus excavatum repair with children receiving PCA morphine.

Methods

Twelve consecutive patients 10–18 years old undergoing pectus excavatum repair received PCA. These children were allowed to self administer morphine sulfate 0.02 mg · kg^{-1} IV as frequently as every 15 minutes. Twelve historical controls matched by age,

TABLE $mg \cdot kg^{-1} \cdot hr^{-1}$ morphine following pectus excavatum repair

Postop day	*Nursing shift*	*Controls (morphine equivalents)*	*PCA morphine*	*Level of significance*
DOS	EOS	0.019	0.030	$P < 0.025$
1	Days	0.020	0.035	$P < 0.005$
2	Days	0.015	0.029	$P < 0.06$
	Eves	0.012	0.029	$P < 0.006$
3	Eves	0.006	0.019	$P < 0.035$

sex, weight and duration of hospitalization were employed to compare the subjective quality of their postoperative analgesia as well as their narcotic utilization expressed in subcutaneous morphine equivalents (SME)/hour with the PCA patients. The PCA children had their pain intensity monitored by the ward nurse every four hours using a linear analogue pain scale and all were exit interviewed in regards to their satisfaction with their pain management. The historical controls received either IM injections of morphine or meperidine Q 3–4 h PRN for 24 to 48 hours after surgery, followed by PO meperidine or codeine. The following narcotic doses are considered to be equivalent to morphine 10 mg SC: meperidine 100 mg IM, meperidine 200 mg PO, and codeine 200 mg PO.[1]

The mean dosages of IV PCA morphine and SME were calculated as $mg \cdot kg^{-1} \cdot hr^{-1}$ and differences between the two groups were analyzed using analysis of variance.

Results

The amount of IV morphine utilized by children in the PCA group was significantly greater than the SME received by the controls from the evening of surgery (EOS) until the evening of the third postoperative day ($P < 0.0001$). Morphine utilization differed for the two groups by as much as 1.5–3 times during five shifts over the first 72 postoperative hours (Table). There was no significant difference in morphine utilization for the two groups following the evening of the third postoperative day. Eight of 12 children in the control group (75 per cent) voiced complaints regarding pain or inadequate analgesia. None of the children in the PCA group had such complaints nor did they experience any difficulty using the pump.

Discussion

Children who received PCA morphine following pectus excavatum repair used substantially more morphine and had subjectively better pain relief than did comparable controls who received PRN narcotic analgesics. Both groups were troubled by narcotic-related complications such as nausea, abdominal cramping and constipation. The disparity in the amount of narcotic analgesics received by the control group is only magnified by the fact that their narcotic utilization is expressed in terms of SEM. For statistical purposes, this route of administration, SEM, was considered to be equivalent to the IV route (PCA morphine). It would appear that PCA morphine administation is superior to IM/PO PRN narcotics for use in pain control following pectus repair, and that children in the control group who received PRN narcotics were undermedicated.

Reference

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Effect of endrophonium priming on reversal of atracurium neuromuscular blockade

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Antagonism of atracurium-induced neuromuscular blockade has been reported to be accelerated by the administration of edrophonium in divided doses: a "priming effect."[1] However, the measured onset of neuromuscular blockade is affected by the type of stimulation used.[2] Thus, recovery times could also be affected by the type of stimulation. The purpose of this study was to assess the effect of priming with edrophonium, using two methods of stimulation, train-of-four (TOF) and single twitch (ST).

Methods

The protocol was approved by the Hospital Ethics Committee. Twenty adult patients, ASA physical status I and II and scheduled for elective surgery were studied. Anaesthesia was induced with thiopentone 3–5 $mg \cdot kg^{-1}$, and fentanyl 1–2 $\mu g \cdot kg^{-1}$ and maintained with 70 per cent nitrous oxide and 0.5–1 per cent end-tidal enflurane in oxygen. Train-of-four stimulation was applied to both ulnar nerves every 12 s, and the force of adductor pollicis contraction was measured. Atracurium 0.5 $mg \cdot kg^{-1}$ was given. When the first twitch (TI), had recovered to one per cent of control, one arm, randomly allocated, received ST stimulation every 12 s, while TOF was continued on the other. When the mean value of T1 and ST reached 10 per cent, edrophonium 1 $mg \cdot kg^{-1}$ was given either as a single dose or as a divided dose of 0.2 $mg \cdot kg^{-1}$ followed by 0.8 $mg \cdot kg^{-1}$ 3 min later. The value of TI was compared with that of ST in the other arm using the paired Student's t-test. The effectiveness of priming was assessed by comparing ST, TI, and TOF ratios (T4/TI) in the groups given edrophonium in single against divided doses using unpaired Student's t-test. A $P < 0.05$ was considered significant.

Results

The recovery measured by TI was not different from that using ST (Figure 1), with or without priming. The patients who received a divided dose of edrophonium had a slower recovery until the second dose was given. Between 5 and 10 min following the first dose of edrophonium, no significant differences were detected between the primed and unprimed groups (Figures 1 and 2). At ten minutes, TOF was 68 ± 3 per cent and 64 ± 3 per cent respectively (NS).

Discussion

This study demonstrated that the time course of neuromuscular blockade reversal was not affected by the type of stimulation

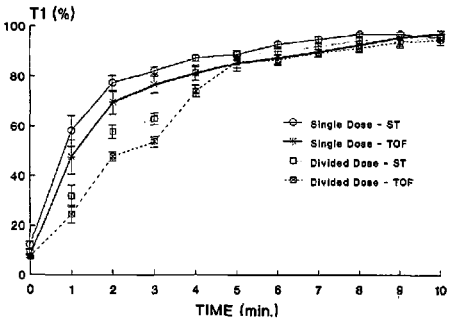

FIGURE 1 Single twitch height (ST) or first twitch of train-of-four (TOF) with edrophonium given in single or divided doses.

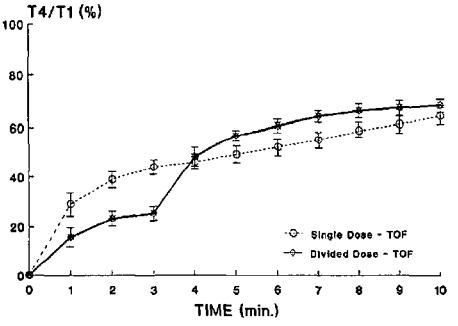

FIGURE 2 Train-of-four ratio with edrophonium given in single or divided doses. Time zero corresponds to first administration of edrophonium.

used (ST or TOF). In addition, the administration of edrophonium in divided doses does not appear to have a compelling advantage over single dose administration.

References

1 *Naguib M, Abdulatif M, Absood GH.* Accelerated reversal of atracurium blockade with priming doses of edrophonium. Anesthesiology 1987; 66: 397–400.

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The effect of thiopental on the incidence of masseter muscle rigidity following succinylcholine in infants and children

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The routine use of succinylcholine (Sch) in paediatric anaesthesia, particularly in those patients undergoing strabismus surgery, has been criticized due to the reported high incidence of masseter muscle rigidity (MMR).[1,2] Our experience, however, indicates that when sodium thiopentone (STP) precedes Sch, MMR is rare even during strabismus surgery.

Methods

To determine the effect of STP on the incidence of MMR after Sch, we reviewed prospectively the anaesthetic experience of all children undergoing tracheal intubation in our institution over an eight-month period. This study was approved by the hospital ethics committee. The anaesthetic technique in each case was chosen by the attending anaesthetist. Induction techniques were recorded on data sheets. The clinical diagnosis of MMR was defined as the transient inability to open the patient's mouth after a sufficient dose of Sch.[1] If MMR did occur, the anaesthetic course and signs of malignant hyperthermia were recorded. Blood gas analysis and serum for CPK concentration determinations were obtained at 6, 12 and 24 hours after surgery.

Results

During the first four months of this study, 2846 infants and children were anaesthetized and intubated (Table). Of these, 2612 received Sch to facilitate tracheal intubation. None of the children who received STP before Sch developed MMR. This indicates a 99.86 per cent likelihood of a zero incidence of MMR in the entire population of children anaesthetized with STP and Sch. One child who received a halothane/Sch anaesthetic did develop MMR. This child demonstrated no further evidence of malignant hyperthermia and the anaesthetic was continued with halothane. The serum concentration of CPK 24 hours after

TABLE Type of surgery

Muscle relaxant	*Non-strabismus*	*Strabismus*	*Total*
Depolarizing (Sch)			
STP	2068 (89)	230 (78)	2298 (88)
Halothane/STP	191 (8)	59 (20)	250 (10)
Halothane	59 (3)*	5 (2)	64 (2)
Total	2318	294	2612
Non-depolarizing			
STP	193 (85)	6 (86)	199 (85)
Halothane/STP	20 (9)	1 (14)	21 (9)
Halothane	14 (6)	0 (0)	14 (6)
Total	227	7	234
Grand total	2545	301	2846

( ) Indicates % of total.
*One child developed MMR (see text for explanation).

surgery was 17,580 IU/L. This child is considered to be MH susceptible.

Discussion

These data indicate that when STP precedes Sch, MMR is an exceedingly rare event in infants and children, even when administered to patients undergoing strabismus surgery. We conclude from these preliminary results that STP prior to intravenous Sch is a safe induction technique in paediatric anaesthesia.

References

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2 *Carrol JB.* Increased incidence of masseter spasm in children with strabismus anaesthetized with halothane and succinylcholine. Anesthesiology 1987; 67: 559–61.

Hyperkalaemia during paediatric craniofacial surgery

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It is believed that hyperkalaemia does not occur during massive transfusion with citrated Packed Blood Cells (cPRBCs) because the plasma volume per unit is small.[1] This assumes that the plasma potassium concentration $[K^+]$ in this plasma fraction is small. We suspected that cPRBC's contain a significant K^+ load. We tested this hypothesis by (1) a prospective analysis of the K^+ content in cPRBC's and by (2) a retrospective chart review of children undergoing intraoperative massive blood transfusion during reconstructive craniofacial surgery.

Methods

The following study was undertaken with institutional approval. The $[K^+]$ in 28 units of cPRBC's aged between 2 and 28 days was determined. The $[K^+]$ in 1 ml samples taken from each unit was measured by flame photometry (IL 943 Automatic flame Photometer, IL®). K^+ content $\{K^+\}$ was calculated such that $\{K^+\} = [(1\text{-Hct}) \times V_{cPRBC} \times [K^+]]$ where the Hct was measured from a well mixed 1–2 ml sample on a Coulter Counter (Model S-Plus IV) and the volume per unit of cPRBC (V_{cPRBC}) was determined from the weight of the unit (Sartorius L2200P Electronic Toploader Scale). Polynomial regression analysis and the coefficient of correlation (r) were used to describe the relationship between changes in $[K^+]$, $\{K^+\}$ and age. Thirty charts were reviewed. All children received a balanced anaesthetic technique. The criteria for inclusion in the study were (1) a sampling frequency of arterial blood for pH, HCO_3^-, K^+, and Hct analysis every hour, (2) a minimum five recorded blood analyses, (3) intraoperative blood transfusion $\geq$ 1 blood volume and (4) haemodynamic stability. The hourly urine output was derived from the anaesthetic record. In addition the hourly rate of blood transfusion was estimated. The age of the blood transfused was traced through the Blood Bank records. From our prospective analysis of cPRBC's an estimate of the K^+ (K_{dose}) delivered during transfusion was made. Paired t test analysis was done between the pre-peak and peak $[K^+]$ values. Statistical significance ($p < 0.05$) was accepted.

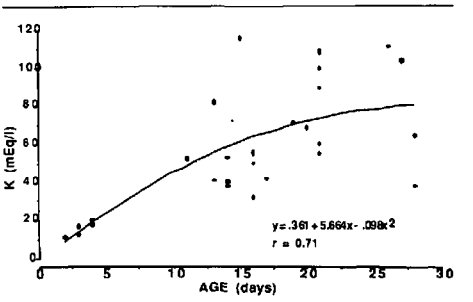

FIGURE 1 $[K^+]$ in cPRBCs vs age

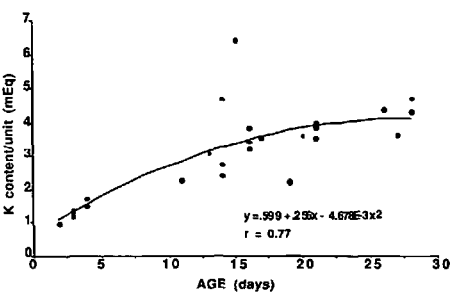

FIGURE 2 (K^+) in cPRBCs vs age

TABLE I Potassium content per unit of cPRBCs (228 ml)

Age of blood	*K^+ content/unit*	*Michael et al.*[3]
<1 week	1.4 mEQ	1.7mEq
1–2 week	3.0 mEq	3.1 mEq
2–3 week	3.7 mEq	4.4 mEq
>3 week	4.3 mEq	

Results

$[K^+]$ in cPRBCs increased with age (Figure 1). The data was described by a second order polynomial $y = 0.361 + 5.664x - 0.098x^2$, $r = 0.71$, $p = 0.0001$. The $\{K^+\}$ per unit cPRBC also increased with age (Figure 2, Table I). This relationship was described with the second order polynomial $y = 0.599 + 0.256x - 0.0047x^2$, $r = 0.77$, $p = 0.0001$. Thirty charts were reviewed. Fifteen failed to meet the inclusion criteria. Four patients suffered an intraoperative cardiac arrest and were excluded. Eleven charts (Table II) met the inclusion criteria. Ten patients had an easily identified acute increase in $[K^+]$ during the course of surgery (Figure 3). The mean increase in $[K^+]$ was 1.39 ± 0.4 $mEq \cdot l^{-1}$. Paired t test analysis of the pre-peak and peak $[K^+]$

TABLE II Range of potassium values and blood volume loss on 11 patients undergoing craniofacial surgery

Pat	Age (yr)	Weight (kg)	Diagnosis	Blood loss ($ml \cdot kg^{-1}$)	$[K^+]$ ($mEq \cdot l^{-1}$)
Br	8.0	20.0	Crouzon's disease	320.0	3.4–6.7
R	0.8	9.5	Apert's syndrome	127.5	3.6–5.9
Bs	0.6	6.0	Craniosystosis	85.0	3.1–4.3
N	1.5	11.0	Cranial dysplasia	80.0	3.9–5.2
Re	0.6	7.6	Crouzon's disease	170.0	3.0–4.2
S	1.5	8.5	Apert's syndrome	300.0	3.8–5.9
Cr	2.0	10.0	Apert's syndrome	640.0	3.8–5.9
Co	7.0	31.5	Pfieffer's syndrome	75.0	3.8–5.6
Bt	0.8	7.0	Apert's syndrome	212.5	4.3–6.0
K	3.0	17.0	Crouzon's disease	112.5	3.2–4.4
Rb	9.0	24.0	OrbNeurofibroplasia	75.0	3.2–5.1

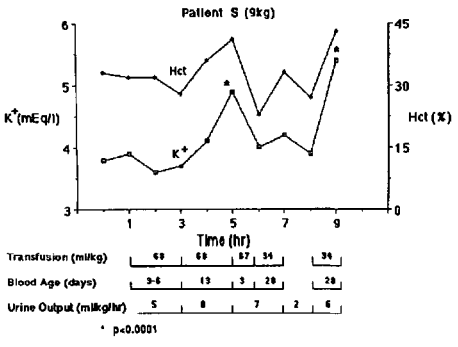

FIGURE 3 Representative trace of the intra-operative trend in $[K^+]$ and Hct

was statistically significant at $p < 0.0001$. In nine patients the $\Delta[K^+]$ was temporally related to blood transfusion. The mean K_{dose} coincident with the increment in plasma $[K^+]$ was 0.66 ± 0.51 $mEq \cdot kg^{-1}$.

Discussion

The $[K^+]$ and $\{K^+\}$ in cPRBCs found in this study are in agreement with those of Michael *et al.*[3] (Table). These concentrations are in excess of the widely quoted $[K^+]$ of 18–26 mEq/l for cPRBCs.[1] In spite of the small plasma volume, cPRBCs may contain a significant K^+ load. Nine out of ten children had an increase in $[K^+]$ during transfusion of cPRBCs supporting the hypothesis that cPRBCs constitute K^+ load.

References

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Model analysis of left ventricular $[K^+]$ during massive blood transfusion in children

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An intravenous K^+ bolus is diluted initially by the venous return, then by the pulmonary circulation, the systemic circulation and finally by the interstitial fluid (ISF). Given that investigators[1] have documented high K^+ concentrations ($[K^+]$) in banked blood cells (cPRBCs), we wondered if it was possible to deliver a high $[K^+]$ to the coronary circulation during massive blood transfusion (MBT).

Methods

In order to identify the factors influencing the $[K^+]$ in the left ventricle, during MBT, the circulatory system has been modeled as shown in Figure 1.

The circulatory system has been modeled as a linear 1 compartment model in which Cpt 1 is the anatomic analogue of the pulmonary circulation (V_{1A}) and the left ventricle (V_{1B}), such that $V_1 = V_{1A} + V_{1B}$. Compartmental volumes are fixed. Flow is constant and unidirectional. $\dot{Q}_T$ and $\dot{Q}_{Pl}$ define two constant flow sources which contain potassium at concentrations K_T and K_{Pl} which mix perfectly within the anatomic analogue of the large veins and the right ventricle to give a total flow $\dot{Q}$Tot of $[K^+]$, $K_1 \cdot \dot{Q}_{Pl}$ is the analogue of the venous return. $\dot{Q}_T$ is the analogue of the transfusion rate. K_1 is determined by the ratio of the flows into the compartment and their respective $[K^+]$ as shown:

$$K_1 = K_T \times \frac{\dot{Q}_T}{\dot{Q}_{Tot}} + K_{Pl} \times \frac{\dot{Q}_{Pl}}{\dot{Q}_{Tot}} \qquad \text{(Eq. 1)}$$

Values for the anatomic analogues which correspond to the model parameters are assigned in Table I.[2] Table II[2] assigns physiologic values, appropriate for an anaesthetized, supine 10 kg child, to the flows described in the model. Since in an acute intervention, K^+ primarily distributes within the plasma fraction of blood, values in the Tables I and II are referenced to plasma. K(t) which had an initial concentration K_0 is determined by Equation 2.[3]

$$K(t) = (K_0\, e^{-k(t)}) + (K1\ (1 - e^{-k(t)})) \qquad \text{(Eq. 2)}$$

where k is a constant equal to $(\dot{Q}_{Tot}/V_1)$.

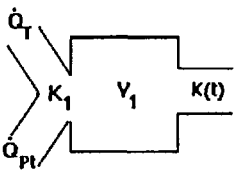

FIGURE 1

TABLE I

Model Anatomic analogue	Large veins	Right ventricle	Cpt 1 (V_{1A}) Pulmonary vasculature	Cpt 1 (V_{1B}) Left ventricle
% Blood volume[1]	35.0	1.5	20.0	1.5
Volume of blood ($ml \cdot kg^{-1}$)*	25.0	1.0	15.0	1.0
Volume of plasma ($ml \cdot kg^{-1}$)†	18.0	0.7	10.5	0.7

*Assuming a BV of 75 $ml \cdot kg^{-1}$ and a +Hct 30%.
†Given an awake pulmonary blood volume of 12% of total BV, and a supine anaesthetized value of 20%.

TABLE II

Model Physiologic analogue	$\dot{Q}_T$ Transfusion rate	$\dot{Q}_{Pt}$ Cardiac output	$\dot{Q}_{Tot}$ ($\dot{Q}_T + \dot{Q}_{Pt}$) Venous return	$\%\dot{Q}_{Tot}$ % Venous return: $\dot{Q}_T$ Transfusion	$\%\dot{Q}_{Tot}$ % Venous return: $\dot{Q}_{Pt}$ Patient
Blood ($ml \cdot kg^{-1} \cdot min^{-1}$)[2]	0.5	120.0	120.5	0.41	99.59
Plasma ($ml \cdot kg^{-1} \cdot min^{-1}$)*					
Awake	0.25	84.0	84.25	0.36	99.64
Anaesthetized†	0.25	70.0	70.25	0.36	99.64
Hypovolemia[2]	0.25	35.0	35.25	0.71	99.29
Hypovolemia + Bolus	5.0	35.0	40.0	12.5	87.5
+ Bolus + CPR	5.0	20.0	25.0	20.0	80.0

*Assuming patient Hct 30%, transfused blood Hct 50%.
†Anaesthetized $\dot{Q}_{Pt}$ 90% of awake value.

Results

Equation 1 of the model predicts that the K_1 is determined by (1) the ratio between the transfusion rate (Q_T) and the venous return (Q_{Pt}) and (2) by the $[K^+]$ of the blood being transfused (K_T). Figure 2 graphs the rate of rise of K(t) (Equation 2), given a Q_{Tot} of 40 $ml \cdot kg^{-1} \cdot min^{-1}$, a K_0 of 4.0 $mmol \cdot L^{-1}$ and a K_1 of 6.6 $mmol \cdot L^{-1}$.

Discussion

K_T of the transfused blood is of critical importance in determining K(t). Hyperkalaemia complicating MBT is determined by more than just the rate of blood transfusion. In addition variables such as (1) the $[K^+]$ in the plasma portion of the transfused blood, (2) the contribution of the rate of blood transfusion to the total venous return and (3) the central blood volume must be taken into account. With large bore intravenous access a child can easily be transfused at rates in excess of 100–200 $ml \cdot min^3$. During severe hypovolaemic hypotension in a child, this rate of blood transfusion may dominate the total venous return. The time course of increase of K(t) in Figure 2 shows that it plateaus within one minute. A falling cardiac output during hypovolaemic hypotension results in a decrease in the rate constant k, the magnitude of which depends on the degree to which the central blood volume (V_1) falls.

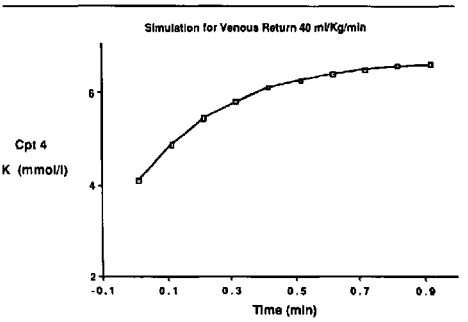

FIGURE 2 Time course of the rate of rise of K(t).

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Variability in Plasma $[K^+]$ during paediatric craniofacial surgery

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University of Toronto

Hyperkalaemia has been reported during massive blood transfusion (MBT) in two situations (1) during neonatal exchange transfusion[1,2] and (2) during rapid administration of whole blood, in excess of 0.3 $ml \cdot kg^{-1} \cdot min^{-1}$.[3,4] Both the quantity of blood transfused and the rate of blood transfusion have been identified as risk factors for the development of hyperkalaemia. Children undergoing major craniofacial surgery (MCFS) are at risk for K^+ intoxication. Therefore, we hypothesized that during MBT, the free K^+ in the plasma portion of transfused blood constitutes an intravenous K^+ challenge.

Methods

With institutional approval a retrospective review of the anaesthetic records of 11 children undergoing craniofacial surgery was conducted. The trend in plasma K^+ concentration ($[K^+]$) with time was documented from the anaesthetic record, as were hourly estimates of the rate of blood transfusion and urine output. The age of the blood transfused was traced through the blood bank records. A retrospective study of ten age-matched controls undergoing a variety of surgical procedures not requiring blood transfusion was undertaken. All children had hourly

TABLE I

Model Anatomic analogue	Large veins	Right ventricle	Cpt 1 (V_{1A}) Pulmonary vasculature	Cpt 1 (V_{1B}) Left ventricle
% Blood volume[1]	35.0	1.5	20.0	1.5
Volume of blood ($ml \cdot kg^{-1}$)*	25.0	1.0	15.0	1.0
Volume of plasma ($ml \cdot kg^{-1}$)†	18.0	0.7	10.5	0.7

*Assuming a BV of 75 $ml \cdot kg^{-1}$ and a +Hct 30%.
†Given an awake pulmonary blood volume of 12% of total BV, and a supine anaesthetized value of 20%.

TABLE II

Model Physiologic analogue	$\dot{Q}_T$ Transfusion rate	$\dot{Q}_{Pt}$ Cardiac output	$\dot{Q}_{Tot}$ ($\dot{Q}_T + \dot{Q}_{Pt}$) Venous return	$\%\dot{Q}_{Tot}$ % Venous return: $\dot{Q}_T$ Transfusion	$\%\dot{Q}_{Tot}$ % Venous return: $\dot{Q}_{Pt}$ Patient
Blood ($ml \cdot kg^{-1} \cdot min^{-1}$)[2]	0.5	120.0	120.5	0.41	99.59
Plasma ($ml \cdot kg^{-1} \cdot min^{-1}$)*					
Awake	0.25	84.0	84.25	0.36	99.64
Anaesthetized†	0.25	70.0	70.25	0.36	99.64
Hypovolemia[2]	0.25	35.0	35.25	0.71	99.29
Hypovolemia + Bolus	5.0	35.0	40.0	12.5	87.5
+ Bolus + CPR	5.0	20.0	25.0	20.0	80.0

*Assuming patient Hct 30%, transfused blood Hct 50%.
†Anaesthetized $\dot{Q}_{Pt}$ 90% of awake value.

Results

Equation 1 of the model predicts that the K_1 is determined by (1) the ratio between the transfusion rate (Q_T) and the venous return (Q_{Pt}) and (2) by the $[K^+]$ of the blood being transfused (K_T). Figure 2 graphs the rate of rise of K(t) (Equation 2), given a Q_{Tot} of 40 $ml \cdot kg^{-1} \cdot min^{-1}$, a K_0 of 4.0 $mmol \cdot L^{-1}$ and a K_1 of 6.6 $mmol \cdot L^{-1}$.

Discussion

K_T of the transfused blood is of critical importance in determining K(t). Hyperkalaemia complicating MBT is determined by more than just the rate of blood transfusion. In addition variables such as (1) the $[K^+]$ in the plasma portion of the transfused blood, (2) the contribution of the rate of blood transfusion to the total venous return and (3) the central blood volume must be taken into account. With large bore intravenous access a child can easily be transfused at rates in excess of 100–200 $ml \cdot min^3$. During severe hypovolaemic hypotension in a child, this rate of blood transfusion may dominate the total venous return. The time course of increase of K(t) in Figure 2 shows that it plateaus within one minute. A falling cardiac output during hypovolaemic hypotension results in a decrease in the rate constant k, the magnitude of which depends on the degree to which the central blood volume (V_1) falls.

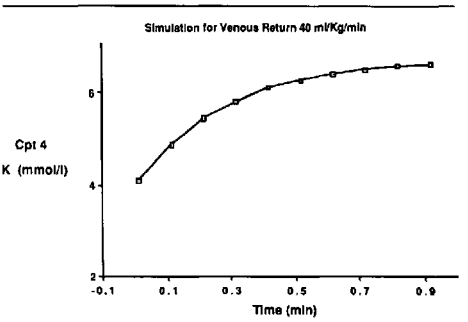

FIGURE 2 Time course of the rate of rise of K(t).

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Variability in Plasma $[K^+]$ during paediatric craniofacial surgery

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Hyperkalaemia has been reported during massive blood transfusion (MBT) in two situations (1) during neonatal exchange transfusion[1,2] and (2) during rapid administration of whole blood, in excess of 0.3 $ml \cdot kg^{-1} \cdot min^{-1}$.[3,4] Both the quantity of blood transfused and the rate of blood transfusion have been identified as risk factors for the development of hyperkalaemia. Children undergoing major craniofacial surgery (MCFS) are at risk for K^+ intoxication. Therefore, we hypothesized that during MBT, the free K^+ in the plasma portion of transfused blood constitutes an intravenous K^+ challenge.

Methods

With institutional approval a retrospective review of the anaesthetic records of 11 children undergoing craniofacial surgery was conducted. The trend in plasma K^+ concentration ($[K^+]$) with time was documented from the anaesthetic record, as were hourly estimates of the rate of blood transfusion and urine output. The age of the blood transfused was traced through the blood bank records. A retrospective study of ten age-matched controls undergoing a variety of surgical procedures not requiring blood transfusion was undertaken. All children had hourly

plasma [K^+] recorded on the anaesthetic record. The trend in plasma [K^+] with time was determined. Differences between [K^+] in the control and MCFS patients were assessed with an unpaired t test. Differences between the peak and pre-peak [K^+] during transfusion in MCFS group was assessed with a paired t test. Statistical significance ($P < 0.05$) was accepted. It is our practice to transfuse cPRBCs reconstituted with plasma (rRBCs). An estimate of the K^+ infused during blood transfusion was made by a prospective *in vitro* survey of age-matched units of packed cells (cPRBCs). The plasma [K^+] of 28 units of cPRBCs aged from two to 28 days was measured from 1 ml samples of each unit by flame photometry (IL 943 Automatic flame Photometer, Instrumentation Laboratory). The haematocrit (Hct) of the cPRBCs was measured from a well mixed 1–2 ml sample on a Coulter Counter (Model S-Plus IV) and the volume was determined from the weight of each unit (Sartorius L2200P Electronic Toploader Scale). We assumed that the K^+ content of a unit of rRBCs was identical to that of its unit of cPRBCs. The free K^+ delivered per ml of rRBCs (K_{rRBCs}) was estimated. The estimated K^+ dose (K_{dose}) during transfusion was the product of K_{rRBC} and the rate of blood transfusion.

Results

Both the range of plasma [K^+] and the coefficient of variation in [K^+] were greater in the MCFS patients ($P < 0.01$) (Table I). The Figure summarizes the ten MCFS patients who demonstrated an obvious increment in plasma [K^+]. Differences between peak and pre-peak [K^+] were statistically significant, $P < 0.001$. There was a striking parallel between the trend in plasma [K^+] and Hct with time. The mean rate of blood transfusion was 27.6 ± 18.1 ml · $kg^{-1} \cdot hr^{-1}$. The mean age of the transfused blood was 16.1 ± 8.4 days. The K_{dose} was 0.66 ± 0.51 mmol · kg^{-1}. (Values given as X ± SD.) Table II details nine patients who demonstrated an increase in [K^+] within two hours of blood transfusion. The %exit was calculated such that:

$$\%\text{Exit} = 1 - \frac{K_o}{K_p}$$

where K_o is the observed increment in plasma [K^+],

$$K_p = \frac{K_{dose}}{ECF}$$

and

$$ECF = 0.2 \times \text{body weight (kg)}.^5$$

TABLE I Comparative data between MCFS and control groups

Group	*Mean [K^+] (mmol · l)$^{-1}$*	*Range [K^+] (mmol · l)$^{-1}$*	*Coefficient of variation*
Control	3.9±0.6	0.6±0.2	5.4%±1.4
MCFS	4.3±0.5	1.8±0.6*	13.7%±5.0*

*P<0.01.

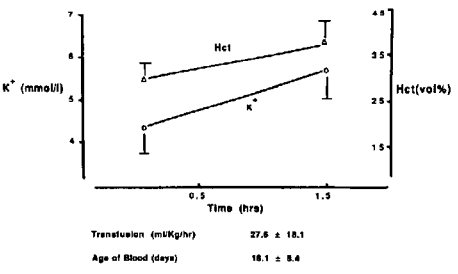

FIGURE Composite graph detailing increment in plasma [K] and Hct for 10 patients undergoing MCFS. Data expressed as mean and standard deviation.

TABLE II Estimated K_{dose} in 9 children summarized in Figure 1

Pat	*Time (hrs)*	*K^{-1} load (mmol · $kg^{-1} \cdot hr^{-1}$)*	*Plasma [K^+] (mmol · l)$^{-1}$*
Br	1	1.06	6.7
Bt	1	1.23	6.0
N	1	0.64	5.2
Cr	1	0.80	5.0
Bs	1	0.21	4.4
K	2	0.21	4.4
Rb	2	0.29	5.1
R 1st peak	1	0.27	
2nd peak	1	0.25	5.9
S 2nd peak	1	0.63	5.4

Pat	*Predicted ΔK^+ (mmol · l)$^{-1}$*	*Observed ΔK^+ (mmol · l)$^{-1}$*	*%Exit*
Br	5.3	2.1	60.4
Bt	6.2	1.4	77.2
M	3.2	0.7	78.0
Cr	8.0	1.4	82.5
Bs	1.1	1.3	−18.2
K	2.1	1.2	44.0
Rb	2.9	1.9	34.0
R 1st peak	1.3	0.6	54.0
2nd peak	1.2	0.9	27.0
S 2nd peak	3.2	1.5	53.0

Discussion

Ten of 11 patients demonstrated an obvious increase in plasma [K^+]. The parallel between Hct and [K^+] with time supports the hypothesis that the increment in [K^+] was related to blood transfusion. Furthermore, there is enough free K^+ in the plasma portion of cPRBCs to act as a K^+ load. In half of the patients the %Exit was < 60 per cent. This suggests that these patients had some impairment of extrarenal defense of the ECF [K^+].

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The influence of position for epidural catheter insertion on oxygen saturation in parturients

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The physiological changes of pregnancy related to lung volumes and oxygen consumption (decreased FRC, TLC, RC and increased oxygen consumption) put the parturient at particular risk for desaturation. Pulse oximetry allows the anaesthetist to monitor this variable non-invasively. Positioning for epidural catheter insertion (flexion of the hips and neck) increases intra-abdominal pressure and may cause aorto-caval compression. While these alterations may not affect the non-labouring parturient for elective Caesarean section, they may create problems in the labouring patient. This study was designed to examine the effect of positioning for epidural insertion on maternal SaO_2 in labouring and non-labouring parturients.

Methods

After obtaining ethical and patient consent, 15 patients presenting for elective Caesarean section and 12 patients in active labour were studied. An initial ten-minute baseline assessment of maternal SaO_2 (using a Nellcor N-100 pulse oximeter) and of fetal heart rate was performed with the patient in the relaxed left lateral position. The patient was then curled for insertion of the epidural catheter and SaO_2 and fetal heart rate were measured. The study period was considered completed once the catheter was *in situ* and the patient had resumed the relaxed position. Data collected included: age, height, weight, parity, duration of insertion of epidural catheter, severity of labour pain, frequency of contractions, cervical dilatation, any obstetrical or maternal complications, SaO_2 (lowest baseline SaO_2 during insertion and number of patients who had periods of saturation less than 95 and less than 90 for greater than 30 seconds) and Kubli scores (before, during and after insertion).

Results

The patients in the two groups were comparable for age, weight, height and length of time to insert the epidural catheter. Three of the Caesarean sections were performed prior to 36 weeks gestation for fetal-maternal reasons (Rh disease, polyhydramnios and fetal anomalies and twins and pregnancy-induced hypertension). Of the labouring patients one had twins and PIH, one had gestational diabetes and one had mitral valve prolapse. The labouring patient with twins and PIH had a saturation during positioning of 87 per cent for over three minutes. Her baseline saturation was also low although the duration was not significant. Three other patients had insertion saturations between 90–95 per cent, lasting greater than 30 seconds (see Table).

TABLE Maternal SaO_2 at baseline and during epidural insertion

	N	*Baseline SaO_2 (range)*	*Insertion SaO_2 (range)*
Caesarian	15	98.2% (96–100)	97.9% (97–100)
Labour	12	94% (85–100)	94.7% (87–99)

Discussion

Two previous studies[1,2] have examined SaO_2 during labour and correlated changes with pain. Neither examined the effect of positioning. As epidural analgesia has proven benefits to mother and fetus, it is important that its initiation does not cause harm. The tightly flexed position might be expected to impinge on lung volumes and to produce haemodynamic changes. While likely insignificant in the normal woman, these may be a problem in those who are obese, have cardiovascular disease (including PIH) or restrictive lung disease. The administration of oxygen during the procedure may improve the situation.

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P300 and the level of consciousness during general anaesthesia

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There is no specific way to detect the unintentional return of awareness in paralyzed patients.[1] The "P300" is a sensory-evoked potential component which occurs only during cognitive tasks requiring conscious awareness. We recorded the P300 immediately before and after general anaesthesia to determine its potential usefulness for detecting awareness.

Methods

Fourteen elective adult surgical patients were tested during anaesthesia with thiopentone, vecuronium, fentanyl (2–4 $\mu g \cdot kg^{-1}$) and isoflurane (0.5–1.5 per cent end-tidal) in air/oxygen or nitrous oxide (60 per cent)/oxygen. Complete recovery from neuromuscular blockade was achieved prior to awakening. Recordings were carried out before induction (control), during induction, emergence and in the recovery room 15–120 min later. (It was not possible to obtain adequate data from all patients at all stages). The patients were instructed to attend to a train of regularly occurring stimuli (500 Hz tones, 50 ms duration, 80 dB peSPL) in order to detect occasional higher frequency (700 Hz) "target" tones. Patients pressed a button following each detected target. Studies in unanaesthetized subjects have repeatedly shown that detected targets ("hits") generate a P300 whereas missed targets ("misses") do not.[2] Our aim was to verify if the link between target detection and the

TABLE P300 amplitude ($\mu V \pm SD$)

	Hits	*Misses*
Pre-induction	*4.0 ± 2.8 n = 14	–
Induction	*2.5 ± 1.6 n = 7	0.1 ± 4.3 n = 12
Emergence	−0.3 ± 2.2 n = 5	0.2 ± 1.1 n = 10
Recovery	*2.9 ± 1.9 n = 12	0.8 ± 1.1 n = 7

P300 remains valid in the peri-anaesthetic period. The EEG was recorded from Fz, Cz and Pz (reference: right mastoid) with a band pass of 0.3–100 Hz. An epoch of 1.5 sec (1024) points was used. Trials contaminated by eye movements were rejected. Waveforms were digitally filtered (1–10 Hz). The P300 was measured as the average Pz amplitude 300 to 400 ms after stimulus.

Results

The P300 amplitude for hits was significantly smaller during emergence than during all other periods ($P < 0.01$) (Table). During induction and recovery the P300 for hits was significantly larger than for misses ($P < 0.01$) indicating that the P300 amplitude is significantly different from zero ($P < 0.01$).

Discussion

The link between signal detection and P300 remained valid during control, induction and late recovery stages (i.e., hits generated a P300 and misses targets did not). We infer that a P300 would be present if similar recordings were carried out in a paralysed, unintentionally conscious patient. During emergence however, only a few targets were detected and they were *not* associated with a P300. Certain technical factors (increased noise, excessive trial-to-trial latency variability, etc.) may have prevented recognition of the P300. This is, however, unlikely since similar factors occurred during recovery. The results probably reflect a true absence of the P300 and suggest that, during the immediate post-anaesthetic period, the detected change in the stimuli did not reach consciousness despite the motor response.

Acknowledgements

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Spinal anaesthesia for Caesarean section

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More than 50 per cent of pregnant women who need a Caesarian section opt for regional anaesthesia. Although, in Canada, epidural anaesthesia is the preferred technique to achieve analgesia, we wanted to study the use of spinal anaesthesia in an effort to improve the quality of analgesia without increasing the incidence of complications.

Methods

Spinal anaesthesia was performed in 45 cases of elective Caesarian section using the following protocol: after infusing 750 to 1000 ml of Ringer's lactate solution through a large bore catheter and positioning each patient in the sitting or lateral position, a 25-gauge needle was inserted at the level of L_{3-4} or L_{4-5}. A mixture of lidocaine 25 $mg \cdot ml^{-1}$ and pontocaine 3.3 $mg \cdot ml^{-1}$ with ten per cent dextrose was injected, the amount (1.6 to 2 ml) depending on the height of the patient. The mother was then brought back to the supine position with left lateral tilt to avoid aortocaval compression, while her head rested on two pillows both for comfort purposes and to avoid excessive cephalad progression of the anaesthetic. Each patient received ephedrine 25 mg IM and O_2 by face mask at least until the birth of the baby. Hypotension (systolic pressure < 100 mmHg) was countered by the following interventions: ephedrine IV in 5 mg increments, phenylephrine IV in 100 μg boluses or by infusion (20 $\mu g \cdot ml^{-1}$) and leg elevation until the IV vasoconstrictors had brought systolic pressure above 100 mmHg. The following parameters were recorded: level and quality of analgesia, incidence and intensity of hypotension per- and postoperatively, incidence of nausea, Apgar score, time to complete recovery from anaesthesia, incidence of post-spinal headache.

Results

Patient data are shown in the Table. We found spinal anaesthesia to be a very efficient technique in providing anaesthesia for Caesarian sections; only in two patients was the analgesia too localised to proceed with the surgery and general anaesthesia was used. In 42 patients the onset of analgesia occurred within a few minutes of the spinal injection; in one case, the onset was delayed by 15 minutes. This fast onset allowed the surgical team to proceed without delay with abdominal prepping, draping and incision. The mean level of analgesia produced was T_3, explaining the quality of analgesia obtained. Hypotension was witnessed in 60 per cent of our patients and ten per cent experienced a fall in systolic blood pressure which went below 75 mmHg. All these hypotension episodes were of short duration and effectively treated with vasoconstrictors and leg positioning. None of the patients displayed hypotension in the

TABLE

Patient's age	*Parity*	*Volume injected*	*Nausea*
Mean 27 Youngest 17 Oldest 38	2	mean 1.85 ml min 1.60 ml max 2.00 ml	15 patients

	Hypotension	*Headache*	*Blood patch*
	<100 mmHg 60% <75 mmHg 10%	5 patients	4 patients

recovery room. Mean Apgar score at one minute was nine. Five patients suffered post-spinal headache, four of them required a blood patch to totally cure this side effect.

Discussion

Spinal anaesthesia offers several advantages over epidural anaesthesia: easier technique, better success rate, faster onset of action, deeper analgesia and muscle relaxation. On the other hand, there are disadvantages such as: a more pronounced fall in blood pressure, post-spinal headache, absence of postoperative analgesia (as no catheter is left). We have shown that spinal anaesthesia has a very high success rate (even if the technique has been done by several different anaesthetists, staff and residents). This success rate is high compared with that of epidural anaesthesia which can require IV supplements or inhalational agents in as many as 46 per cent of the patients. Hypotension episodes can be prevented. The incidence of headache varies from study to study; however, our rate of ten per cent agrees with that of Michie.[1] Despite this occurrence, there was no prolongation in the duration of hospitalisation for these patients. Spinal anaesthesia already is a good alternative to epidural for Caesarian sections. With the increasing use of intra-thecal catheters we might also provide postoperative analgesia and reduce post-spinal headaches.[2]

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The timing of surgical repair of traumatic aortic tears in the polytraumatized patient

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Blunt trauma, especially in cases of high energy transfer deceleration injuries, can be accompanied by intimal thoracic aortic tears. The literature remains unclear as to the optimum timing of repair. Our approach has been to start aggressive blood pressure control by medical means and delay surgical treatment until associated injuries are either adequately assessed or improved. We have undertaken a ten-year retrospective study to determine the safety of this approach.

Patient population and methods

We reviewed the records of 27 blunt polytraumatized patients with thoracic aortic injuries admitted to our trauma unit between 1978 and 1988. The patients were divided into two groups. Group I comprised patients who underwent aortic repair within 24 hours of injury. Group II consisted of patients undergoing aortic repair greater than 24 hours from time of injury or those having no surgical repair. The two groups were compared with respect to mortality, age, and severity of injury (Table I).

Results

Seven patients had thoracic aortic repair within 24 hours of injury. Five were taken to the operating room immediately after admission because of haemodynamic instability. They all died intraoperatively from exsanguination. Two others were repaired within 24 hours of injury. One died from an intraoperative complication while the other survived in a persistent vegetative state. Of the 20 Group II patients, ten were repaired within one week of injury, four were repaired up to 324 days later and six were not repaired. Four of the Group II patients died: two prerepair, one during repair and one post-repair for an overall mortality of 20 per cent. All of these patients were admitted to the intensive care unit prerepair for invasive monitoring and blood pressure control. Groups were similar with respect to age and severity of injury (P = NS, t test). Mortality was significantly greater in the patients undergoing early operative repair (P = 0.004 Fisher's Exact Test). Associated injuries are described in Table II. Prerepair, ten patients had one general anaesthetic, seven patients had two anaesthetics, and one patient three anaesthetics for life- or limb-threatening injuries, without aortic rupture.

TABLE I Timing of repair and mortality, age and ISS

	Age	*ISS*	*Mortality*
Early repair (Group I) ± SD	36 ± 16	40 ± 9.0	85.7%
Delayed repair (Group II) ± SD	36 ± 18	37 ± 8.1	20%

TABLE II Timing of repair and associated injuries

	N	*CNS*	*Chest*	*Abdomen*	*Skeletal*
Early repair (Group I)	7	4	5	3	6
Delayed repair (Group II)	20	13	18	11	16

Discussion

All our patients had significant associated injuries. Delayed operative management of those life- or limb-threatening injuries may greatly increase morbidity and or mortality. Early repair of the thoracic aortic injury may exacerbate coexisting injuries. One lung ventilation, used to facilitate surgical exposure, in the face of an evolving pulmonary contusion may submit the patient to life-threatening hypoxia and hypercarbia. The use of vasodilators after high aortic crossclamping, in order to minimize systolic load to the myocardium during the operation deleteriously affects the traumatized brain with malfunctioning autoregulation. Invasive haemodynamic monitoring in an intensive care setting with aggressive medical treatment with sedatives, beta blockers and vasodilators enables us to delay definitive operative treatment until such time as respiratory, cerebral and cardiac function can tolerate the surgical insult.

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Left lung radiographic abnormalities after aortocoronary bypass surgery

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During aortocoronary bypass surgery, manipulation of the lungs occurs.[1] Because the heart lies predominantly in the left chest cavity, the left lung and especially the left lower lobe are primarily affected. The manipulation of the left lung may be greater if left internal mammary artery grafting is performed. The opening of the left pleural cavity and the placement of the chest tube there is also much more likely when LIMA grafting is done. The right pleural cavity is generally not opened. During cardiopulmonary bypass, the lungs are deflated and their perfusion is altered. These factors may lead to pulmonary morbidity.

The aim of the current study was to determine the percentage of the patients who develop left lung atelectasis, consolidation, effusion and infiltrate after aortocoronary bypass surgery. The occurrence of these abnormalities was correlated with the left internal mammary artery (LIMA) grafting, with the period of postoperative mechanical ventilation[2] and with the period of hospitalization post-surgery.

Methods

After Institutional Review Board approval, informed consent was obtained from 52 patients undergoing aortocoronary bypass surgery. LIMA grafting was performed in 32 patients. None of these patients had acute changes such as atelectasis, consolidation, effusion or infiltrate on the preoperative chest radiograph. Portable chest radiographs were obtained in the Intensive Care Unit immediately post-surgery and at least once a day after that. The occurrence of the above-mentioned abnormalities on any of these radiographs was noted by a radiologist who was unfamiliar with the clinical course of the patient. The number of hours of postoperative mechanical ventilation and the number of days of postoperative hospitalization were also noted. The termination of mechanical ventilation was based on arterial blood gas and clinical criteria.

Results

The number and percentage of the patients who had a given radiographic abnormality are listed in the Table.

TABLE Radiographic abnormalities

	All patients		*LIMA*		*Non-LIMA*	
	#	%	#	%	#	%
Left lung atelectasis	36	69	22	69	14	70
Left lung consolidation	13	25	11	34	2	10
Left lung effusion	16	30	12	38	4	20
Bilateral effusion	5	10	4	13	1	5
Left lung infiltrate	3	6	2	5	1	5

The incidence of left lung consolidation and effusion was higher ($P < 0.05$) in patients who had LIMA grafting compared to the other patients.

There was no correlation between the radiographic abnormalities and (a) the length of postoperative mechanical ventilation, (b) the period of post-surgical hospitalization.

Discussion

The incidence of left lung atelectasis was found to be high after aortocoronary bypass surgery. Patients who underwent LIMA grafting had higher incidence of left lung consolidation and effusion. However, these abnormalities are usually not persistent and do not prolong the period of mechanical ventilation and hospitalization.

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Elevated plasma catecholamine levels in trauma patients do not correlate with intraoperative recall

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Patient awareness and recall of intraoperative events occurring during general anaesthesia remain significant clinical problems. Trauma patients are particularly susceptible to recall with rates reported as high as 11 per cent in anaesthetized trauma patients and 43 per cent in trauma patients too unstable to receive adequate anaesthesia.[1] The biochemical mechanism allowing recall despite apparently adequate anaesthesia remains obscure. One theory claims that there is a reported correlation in animals between elevated epinephrine levels and learning under general anaesthesia.[2] The purpose of this prospective study is to measure plasma catecholamine levels in elective and trauma patients and attempt to correlate elevated epinephrine levels with the incidence of intraoperative recall.

Methods

Sixteen trauma and 13 elective ASA physical status I and II patients were recruited to participate in the study. Patients with facial or head trauma were excluded. After receiving informed consent from the patient or next of kin, the patients were anaesthetized according to the judgement of the anaesthetist assigned to the case. No attempt was made to standardize the anaesthetic. At five specific times during the case blood levels for catecholamines were drawn (1) preinduction, (2) immediately postintubation, (3) skin incision, (4) 30 min post-skin incision, and (5) 60 min post-incision. The samples were immediately centrifuged and the plasma was frozen at −70° C. Catecholamine levels were determined using a standard high

TABLE Mean plasma epinephrine and norepinephrine levels ($pg \cdot ml^{-1}$)*

Level	*1*	*2*	*3*	*4*	*5*
Elective epinephrine	101 ± 24	72 ± 11	134 ± 29	123 ± 31	137 ± 43
Trauma epinephrine	274 ± 60	244 ± 56	153 ± 22	212 ± 59	220 ± 73
Elective norepinephrine	298 ± 51	192 ± 24	179 ± 27	256 ± 47	317 ± 56
Trauma norepinephrine	451 ± 54	481 ± 55	392 ± 43	433 ± 53	447 ± 79

*Differences between elective and trauma patients were significant ($P < 0.01$) in all groups.

performance liquid chromatographic/electrochemical detection technique (BioAnalytic Systems).

Two to three days postoperatively, when patients were alert and oriented, they were questioned about recall of operative events. They were initially questioned about recall of being in the operating room and then more specific questions relating to induction of anaesthesia, intubation, skin incision and operative procedure. The patients were also asked for last memory before going to sleep and first memory upon awakening.

Data was analyzed using a two-way ANOVA for repeated measures. Values are expressed as mean ± standard error.

Results

The trauma patients consisted of five abdominal cases, one thoracotomy, eight orthopaedic procedures and two thigh explorations for gunshot wounds. All of these patients were haemodynamically capable of tolerating at least low levels of inhalational anaesthetic. The elective cases were gynaecological or plastic surgery procedures. The measured plasma levels for norepinephrine and epinephrine are presented in the Table. In both patient groups no particular pattern of catecholamine level changes occurred during the procedure except for a lowering of levels post-intubation. However, there was a highly significant ($P < 0.01$) between-subjects difference both for epinephrine and norepinephrine. These differences ranged from 41–151 per cent increases and 14–239 per cent increases obtained in trauma patients for norepinephrine and epinephrine respectively. The greatest differences were obtained at the time of intubation.

Despite the large differences in plasma catecholamine levels, no patient in the study had any recall of intraoperative events.

Discussion

There was no correlation between plasma catecholamine levels and recall of intraoperative events in our patient population. Despite significant differences between elective and trauma patients in regard to catecholamine levels there was no incidence of recall in either group. We conclude that neither elevated plasma norepinephrine nor epinephrine levels correlate with increased awareness under general anaesthesia. Our 0 per cent incidence of recall in trauma victims is significantly different from the 11 per cent cited by Bogetz and Katz.[1] The specific reason for this remains unclear; however, the difference may relate to different anaesthetic techniques. Further work in this area is required.

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Incidence of post-spinal headache with 25 and 26 gauge needles

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Post-partum tubal ligation (PPTL) is a procedure frequently performed under subarachnoid block (SAB). The incidence of post-dural puncture headache (PDPH) is greater with increasing needle size and is higher in the parturient. In a recent study there was a 23 per cent incidence of PDPH using a 25 gauge spinal needle in the post-partum patient[1] revealing no significant difference between post-partum and pregnant patients. The purpose of this study was to determine if there was a lower incidence of PDPH when using a 26-gauge spinal needle in the post-partum patient compared with the use of a 25-gauge needle.

Methods

Sixty-nine patients who underwent PPTL, 24–48 hours after vaginal delivery, were studied as part of our ongoing Quality Assurance Program. Fifteen to thirty minutes prior to SAB, all patients were premedicated with 30 ml of Bicitra and received 500–1000 ml of lactated Ringer's solution. ECG and blood pressure cuff were used to monitor patients' vital signs before, during, and after SAB injection. Lumbar puncture was performed in either the sitting position or in the lateral decubitus position. A 26-gauge needle was inserted through a 21-gauge introducer needle (4 cm long) with the bevel parallel to the dural fibres. The subarachnoid space was entered through a suitable interspace (L_{2-3}, L_{3-4}, L_{4-5}), under aseptic conditions. There were no inadvertent dural punctures with the introducer needle. Lidocaine five per cent in dextrose was used as the anaesthetic, with supplementary sedation given as needed. Postanaesthetic interview by telephone was completed two weeks following discharge from the hospital, utilizing a questionnaire format. Questions were asked regarding their general condition, any complication intraoperatively. If no mention of headache was elicited, they were asked if they had experienced any headache following anaesthesia. Further questions were asked to determine if the headache was indeed a PDPH.

Results

Thirteen patients were lost to follow up. Fifty-six patients in whom a 26-gauge needle was used were contacted. The incidence of PDPH was 25 per cent in the 26-gauge group versus 23 per cent in the 25-gauge group (Table). There were no

TABLE

Needle size	*Patients*	*# Headache*	*%*	*# Requiring EBP*$^+$
25	65	15	23%	5
26	56	14*	25%	2

*NS.

significant differences between the groups regarding the incidence of headache. Two patients in the 26-gauge group required an epidural blood patch (EBP$^+$) versus five patients in the 25-gauge group. Previous history of headache did not influence the development of postspinal headache. The longest duration of PDPH was 2.5 weeks.

Discussion

It is widely accepted that the cause of PDPH is from CSF leakage through the dural puncture site caused by the spinal needle, resulting in decreased CSF pressure. Assumption of the upright position causes positional changes of brain structures, stretching cerebral vessels which in turn manifest as headache.[1] Factors contributing to higher incidence of PDPH in the parturient and post-partum patient include that of early ambulation, decreased CSF pressure secondary to loss of intra-abdominal pressure after delivery, rapid changes in blood volume following delivery and relative dehydration which are more marked in post-partum patients than in routine surgical cases. The incidence of PDPH in post-partum patients receiving a SAB with a 26-gauge needle, 24–48 hours following vaginal delivery, is approximately the same as that found with the 25-gauge needle. Other studies[3,4] have reported the incidence of PDPH to be much lower (.04 per cent) when using smallbore needles (24-, 25-, 26-gauge needles). We believe the reason for the difference between those studies and our results lies in the fact that our patients were contacted several weeks later, whereas in the other studies the patients were contacted in the hospital following surgery. Because of the high incidence of PDPH in this group which was not altered by needle size, SAB may not be the anaesthetic of choice if PPTL must be performed within 24–48 hours of delivery.

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Brachial plexus block – a combined approach

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Axillary (AxB) and interscalene (IB) block of the brachial plexus each have their own limitations and side effects. The AxB approach may miss the musculocutaneous, intercostobrachialis and axillary nerves and the radial distribution of the posterior cord if large volumes of local anaesthetic (>40 mls) are not used. The IB technique may miss the intercostobrachialis nerve and unless larger volumes are used, the inferior trunks ($C_{7,8}$) of the brachial plexus. Volume-related complications encountered with the IB technique include Horner's syndrome, phrenic nerve block, vertebral arterial injection, recurrent laryngeal nerve block, pneumothorax, epidural or subarachnoid injection and systemic toxicity. An advantage of IB for upper extremity surgery is the lack of tourniquet pain, frequently seen with an AxB approach. A combined interscaleneaxillary (CIA) approach, with half of the local anaesthetic volume injected at each site, might improve the efficiency of the upper extremity block since each approach covers the limitations of the other. Also, a smaller volume injected at each site could theoretically decrease the incidence of volume-related side effects.

Methods

A CIA brachial plexus block (BPB) was performed on 73 patients. For plasma analysis, 15 patients were randomly allocated into AxB, IB or CIA group (five patients in each group). The anaesthetic agent used in all cases was a mixture of 20 ml 1.5 per cent lidocaine (L) and 20 ml 0.5 per cent bupivacaine (B) with epinephrine 1:200,000. In the CIA half the volume of agent was injected at each site. The effectiveness of the BPB was rated as: (1) excellent, (2) adequate with single nerve supplementation and (3) failure. Blood samples were obtained at times 0, 5, 10, 15, 30 and 60 minutes post-block, cold centrifuged and frozen at −70° C for later analysis by gas chromatography. Side-effects and complications were also noted.

Results

CIA blocks were 89 per cent successful including ten cases (13.7 per cent) who required additional nerve supplementation; the most frequent complication was Horner's Syndrome (23.3 per cent). No patient complained of tourniquet pain despite lack of intercostobrachialis nerve (T2) supplementation. The plasma concentration data for L and B are illustrated in Figures 1 and 2. At time 5 through 30 minute post-injection, the plasma concentration of L was significantly higher in the IB than in AxB

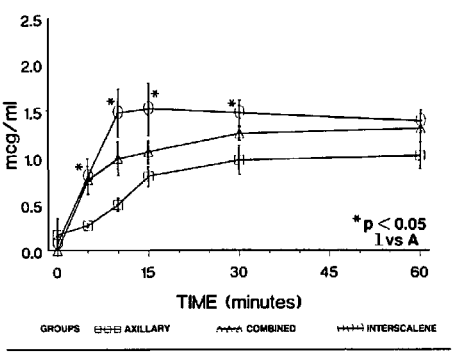

FIGURE 1 Plasma lidocaine.

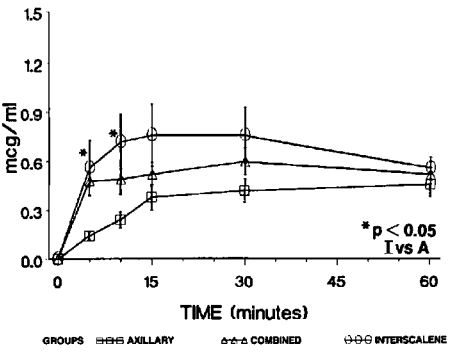

FIGURE 2 Plasma bupicavaine.

group ($P < 0.05$). Similar differences between the I and A groups were noted for B at five and ten minutes after injection ($P < 0.05$). The plasma L and B concentrations for the CIA group fell mid-way between the levels for the I and A groups over most of the 60-minute period of observation but were not significantly different.

Discussion

This study indicates that (1) the CIA approach is an effective anaesthetic alternative for upper extremity surgery, (2) the incidence of volume-related side-effects appeared to be less, (3) the CIA approach eliminates tourniquet pain despite the lack of intercostobrachialis nerve supplementation, (4) although plasma concentration did not approach toxicity in any group, the IB group had significantly higher plasma concentrations of local anaesthetic in the immediate post-block time period than the AxB group, (5) there was no significant difference between the plasma concentrations of the CIA group and the other two groups despite a trend to lie between the other two groups (see Figures 1 and 2), (6) site of injection appeared more important for rate of systemic absorption than surface area/total volume ratio.

Postoperative recovery following induction of anaesthesia with rectal methohexitone

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Rectal administration of methohexitone is a safe, effective technique for induction of anaesthesia in young children and it has been demonstrated that both the concentration of the solution and the total dose of methohexitone administered can alter the clinical effectiveness and plasma concentration of the drug.[1,2] Despite persistence of significant plasma methohexitone concentrations for up to two hours following drug administration, previous investigators have concluded that rectal methohexitone does not prolong postoperative recovery.[3,4] However, in these studies only a single dose of rectal methohexitone was evaluated. The purpose of this study was to compare postanaesthesia recovery following 15 or 30 $mg \cdot kg^{-1}$ rectal methohexitone for induction of anaesthesia in children.

Methods

Twenty-two children were studied after obtaining informed parental consent. Each child was randomly assigned to receive 15 or 30 $mg \cdot kg^{-1}$ two per cent rectal methohexitone and parents remained with their child until the onset of sleep. Sleep was defined as loss of consciousness, unresponsiveness to verbal stimuli and absence of voluntary movement when unstimulated. Time from administration of methohexitone until the onset of sleep was noted and anaesthesia continued with nitrous oxide and halothane in oxygen. Children not asleep 15 minutes following drug administration underwent inhalational induction.

Following completion of surgery, anaesthesia was discontinued and children awakened in the recovery room with their parents. Total operative time, recovery time and recovery room scores were determined by a blinded observer using Steward's postanaesthesia scoring system, which assigns points based upon level of consciousness, ability to maintain an airway and patient movement. Scores for each patient were determined upon admission to the recovery room; at 5, 15, 30 and 60 minutes following admission; and at discharge. Results are expressed as mean ± SD.

Results

The two groups of children were comparable in age, weight and duration of surgery. Recovery time and postanaesthesia recovery scores are shown in Tables I and II.

TABLE I Demographic data

	Methohexitone 15 $mg \cdot kg^{-1}$	*Methohexitone 30 $mg \cdot kg^{-1}$*
Age (*months*)	39.6 ± 9.0	38.8 ± 21.0
Weight (kg)	14.8 ± 2.5	14.3 ± 4.4
Total dose (mg)	221 ± 37	430 ± 131
Induction time (min)	9.3 ± 2.2	6.7 ± 2.0
Surgical time (min)	75 ± 38	74 ± 23
Recovery time (min)	70 ± 26	101 ± 71

TABLE II Recovery room scores

Recovery room time	*Methohexitone 15 $mg \cdot kg^{-1}$*	*Methohexitone 30 $mg \cdot kg^{-1}$*
Admit	2.6 ± 1.7	1.3 ± 1.2
5 minutes	3.6 ± 1.6	2.3 ± 2.1
15 minutes	4.6 ± 1.4	3.3 ± 2.0
30 minutes	5.3 ± 1.2	4.8 ± 1.5
60 minutes	6.0 ± 0.0	5.3 ± 0.9
Discharge	6.0 ± 0.0	5.6 ± 0.5

Discussion

Although increasing the dose of rectal methohexitone improves the speed and efficacy of induction, it also prolongs postoperative recovery. In addition, among the children monitored by pulse oximetry in the recovery room, desaturation ($SaO < 95$ per cent) occurred more frequently following 30 $mg \cdot kg^{-1}$ methohexitone (45 vs 0 per cent). We conclude that large doses of rectal methohexitone prolong recovery and may increase the risk of postoperative hypoventilation and hypoxia.

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Anaesthetic outcomes at a children's hospital 1982–87

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There have been few studies looking at the outcomes of anaesthetic care for the paediatric population. For this study, we used a computerized database of 29,220 anaesthetics which had been administered at the hospital from mid-1982 to 1987 inclusive. For each child attended by a paediatric anaesthetist, an anaesthetic record was completed which included information about preoperative medical conditions, age, physical status (ASA), preoperative tours, airway management, and anaesthetic drugs administered. During the course of the procedure, any intraoperative events requiring action on the part of the anaesthetists were recorded on the same form. Adverse events occurring in the recovery room were added to the record by the recovery room nursing staff. Within three days of the procedure, a designated anaesthesia follow-up nurse reviewed all anaesthesia records and available hospital charts recording any adverse events which occurred after surgery. For in-patients an interview was carried out with the child or parents whenever possible. This information was added to the record. The final record was returned to the attending anaesthetist for review prior to data processing.

Of the children, 1.24 per cent were less than one month, 8.71 per cent were 1–12 months, 46.15 per cent were 1–5 years, 24.95 per cent were six to ten years and 19.33 per cent were 11+ years. 76.69 per cent were classified as physical status (ASA) I, 18.13 per cent were ASA II, 4.23 per cent were ASA III, 0.70 per cent were ASA IV and 0.12 per cent were ASA V. The majority of children had no preoperative medical conditions (71.7 per cent). Of those with preoperative conditions, 5.7 per cent had upper respiratory problems, 4.4 per cent had a lower respiratory condition, 2.8 per cent had cardiovascular disease, 4.5 per cent had musculoskeletal conditions, 2.0 per cent had metabolic disease (mainly diabetes), 1.1 per cent had renal problems, 2.6 per cent were on drug therapy, and 14.5 per cent of the cases had other conditions.

The surgical site varied considerably with the age of the child. Among neonates, the most frequent surgical sites were intraabdominal (42.1 per cent), major vascular (12.7 per cent) and endoscopy (8.3 per cent). For children 1–12 months, the most common sites were EENT (18.2 per cent), intraabdominal (17.6 per cent) and operations on the extremities (12.0 per cent). For children over one year of age the most frequent sites were EENT (about 50 per cent) followed by other head and neck and extremities. Of 228 major vascular procedures, 39 per cent were performed on children less than one year of age.

There were relatively few intraoperative events noted during the study period. (Note all rates expressed per 10,000 anesthetics.) Among children less than one month, the most commonly seen events were classified as "other respiratory" (croup, larygnospasm, apnoea) with a rate of 720 per 10,000 anesthetics; hypotensive episodes were seen at a rate of 388 per 10,000. The majority of the neonates (85.32 per cent) and 93.08 per cent of infants had no intraoperative problems. Children aged one to five years had the lowest rate of intraoperative events with arrhythmia accounting for the highest rate (391 per 10,000). 93.33 per cent of these children had no problems during operation. For children over six years of age, arrhythmias were the most frequently seen events (933 for children six to ten years and 561 for children over 11 years). Overall 91.5 per cent of all children had no problems during the course of the procedure.

In the recovery room, the most common events for neonates were problems with "other respiratory" and temperature regulation (rates of 1163 and 471 per 10,000 respectively). For the older children vomiting became more of a problem. More postoperative events (occurring within three days of surgery) were seen than for recovery room occurrences. For children under one year, the most frequent events were respiratory and temperature regulation. For children over one year, the most common postoperative events related to nausea and vomiting. For all children included in the study, the rate of nausea and vomiting postoperatively was 2451 per 10,000, "other respiratory" incidents was 241 per 10,000 and problems with temperature regulation was 233 per 10,000.

Children under one month of age had the highest rate of intraoperative and immediate psotoperative problems. However, these children were more likely to be rated with higher physical status scores (13 per cent of neonates were physical status IV or V compared to 0.8 per cent of the whole series) and were more likely to undergo major vascular procedures. The clinical management of these children is an evolving challenge to the skills and knowledge of the practising anaesthetist.

Propofol versus diazepam in outpatient arthroscopy

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A randomized double-blind study was undertaken to compare the safety and efficacy, and the speed and quality of recovery of propofol with diazepam in adult patients undergoing outpatient arthroscopic procedures. Sixty adult patients (ages 18–65) underwent arthroscopy of the knee utilizing intra-articular local anaesthetics (lidocaine and bupivicaine) and IV sedation with

fentanyl $\mu g \cdot kg^{-1}$) and propofol or diazepam. The propofol and diazepam were administered in lipid emulsions which were prepared by a pharmacist such that all patients received equivalent volumes for initiation and maintenance of sedation. A loading dose of 0.8 $mg \cdot kg^{-1}$ of propofol, or 0.07 $mg \cdot kg^{-1}$ of diazepam, was given five minutes after the fentanyl. An infusion of 3 $mg \cdot kg^{-1} \cdot hr^{-1}$ of propofol, or 0.2 $mg \cdot kg^{-1} \cdot hr^{-1}$ of diazepam, was started immediately after the loading dose and titrated to maintain the patient with his eyes closed but rousable to command. Boluses of 25 per cent of the loading dose were also given as needed. Heart rate (HR), blood pressure (BP), respiratory rate (RR), oxygen saturation and depth of sedation were monitored throughout the procedure. The infusion was discontinued at the end of surgery and the time to eye opening, response to command, orientation and suitability for discharge was recorded by a blinded research nurse. The patients completed a digit symbol substitution test (DSST) prior to surgery and repetitively postoperatively until discharge. The patients were shown a series of six pictures pre- and postoperatively, which they were asked to recall at discharge. All patients were contacted 24 and 48 hours postoperatively and queried about their experience and side-effects.

Fifty-nine cases were evaluable. The groups were comparable in age, sex distribution, ASA class, and duration of surgery. The procedures performed were arthroscopic meniscectomy, chondroplasty and diagnostic arthroscopy. The patients received a mean dose of 2.26 ± 1.20 $mg \cdot kg^{-1}$ of propofol and 0.26 ± 0.11 $mg \cdot kg^{-1}$ of diazepam. Despite vigorous attempts to achieve a standard level of sedation, the propofol patients were more heavily sedated (eyes closed but rousable or unrousable) than the diazepam group (60 per cent versus 29 per cent, $P < 0.01$). All patients tolerated the procedure well. One patient in the diazepam group developed severe urticaria; no allergic reactions were evident in the propofol group. There were no clinically significant changes in HR, BP, or RR in either group. Three patients in each group required supplemental oxygen for a saturation below 90% for several minutes. Three propofol patients and two diazepam patients had upper airway obstruction relieved by chin lift. The surgeon rated the operating conditions in all cases as equivalent to those available with general or spinal anaesthesia.

There were no differences between the groups in time to eye opening, response to command, or orientation. The propofol patients were suitable for discharge in 31 ± 22 minutes, compared with 34 ± 21 minutes in the diazepam group. All patients were ready for discharge in less than 90 minutes. The postoperative performances on the DSST were similar in the two groups. Picture recall in the propofol group was greater than in the diazepam group ($P < 0.05$).

In summary, intra-articular analgesia with local anaesthetics plus supplemental sedation with propofol or diazepam is a simple, safe technique for outpatient arthroscopic surgery which provides excellent operating conditions, a pleasant experience for the patient, and rapid discharge.

Sufentanil-nitrous oxide-pancuronium anaesthesia and low-dose isoflurane

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Sufentanil is a potent narcotic analgesic with marked hypnotic properties even at modest dosage. Caution has been expressed with regard to supplementation of sufentanil anaesthesia with volatile agents lest potentiation and prolonged recovery result. However, there are no data specific to isoflurane and sufentanil to support this view although some pharmacokinetic data exist for an interaction between halothane and fentanyl.[1,2] Thus the current study was designed to determine whether low-dose isoflurane supplementation of sufentanil-nitrous oxide-pancuronium anaesthesia influenced cardiovascular stability or postoperative recovery.

Methods

Following institutional approval, cardiovascular stability and postoperative recovery were studied in 40 consenting healthy patients who received either standardised balanced anaesthesia of sufentanil ($1.7 \mu g \cdot kg^{-1}$)-nitrous oxide-pancuronium (Group I) or the same technique with the addition of 0.5 per cent isoflurane (Group II). All patients underwent elective major gynaecological surgery and a randomised single-blind design was used. The patients were premedicated with diazepam 0.25 $mg \cdot kg^{-1}$ orally two hours preoperatively. In the operating room, following preoxygenation, d-tubocurarine 50 $\mu g \cdot kg^{-1}$ and droperidol 15 $\mu g \cdot kg^{-1}$ were given intravenously. Anaesthesia was induced with thiopentone 1–2 $mg \cdot kg^{-1}$ and succinylcholine 1.5 $mg \cdot kg^{-1}$ was given to facilitate tracheal intubation. Then nitrous oxide (66 per cent) was commenced and pancuronium 0.07 $mg \cdot kg^{-1}$ given as an initial dose with further increments as necessary. All patients received sufentanil $1.7 \mu g \cdot kg^{-1}$; isoflurane (0.5 per cent) was given according to the randomization using a vaporiser outside a closed circle system with a fresh gas flow of three litres per minute with a ventilation of 100 $ml \cdot kg^{-1} \cdot min^{-1}$. Cardiovascular variables were measured using an automatic oscillometric device and a continuously reading electrocardiograph monitor. Times from reversal of neuromusclar blockade to correct response to verbal command, tracheal extubation and orientation were recorded.

Results

There were no significant between-group differences with respect to demographic variables, length of surgery or ASA class. Both groups showed significant reduction from control for systolic (SAP), diastolic (ADP) and mean arterial pressure (MAP) at all times of measurement to five minutes post-incision. There was no significant difference from control in heart rate (HR) in Group I; however, Group II continued to demonstrate a significant reduction in heart rate (HR) to 30 minutes post-incision. There were no differences between groups in change from control value for SAP, DAP, MAP, or HR. There was no evidence of a change of these variables (absence of treatment × time interaction). Comparison of the range for each variable during surgery showed no difference with respect to arterial pressures but a significantly greater

fluctuation in heart rate in Group I. There were no significant between-group differences in any measure of recovery examined. There was, however, a trend towards an increased time to correct orientation in Group II. There was no reported awareness in either group. Adverse effects occurred in nine patients in Group I and in six patients in Group II (P = 0.2987, Fisher's exact). The most common adverse effect was nausea and/or vomiting (occurring in five patients in each group). Postoperative analgesic and antiemetic requirements were similar in both groups.

Conclusion

The authors conclude that low-dose isoflurane may be used in conjunction with moderate dose sufentanil for major surgery. Cardiovascular stability and good recovery conditions are maintained.

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Alfentanil-nitrous oxide anaesthesia for cystoscopy in elderly patients. A comparison of bolus versus incremental techniques

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Alfentanil is an opioid chemically related to fentanyl but with a more rapid onset, shorter duration of action and one-third as potent.[1] Studies in young patients having minor surgical procedures have shown that alfentanil, given as a bolus, is an acceptable alternative to fentanyl with more rapid recovery and thus significant advantage for outpatients. However, there have only been limited studies in elderly patients, such as those undergoing cystoscopy.[2] Therefore the present study was designed to assess the efficacy of alfentanil in both bolus and incremental doses in patients scheduled for cystoscopy under general anaesthesia.

Methods

Following institutional approval, 18 unpremedicated consenting patients were randomised to two groups (B and I). In the operating room noninvasive monitoring of blood pressure, ECG and pulse oximetry were established. All patients were preoxygenated for two minutes and following droperidol 1 mg IV received either received 15 $\mu g \cdot kg^{-1}$ of alfentanil as a bolus (Group B – age, 60.8 sd 19.3), or 7 $\mu g \cdot kg^{-1}$ of alfentanil with increments (Group I – age, 57.4 sd 8.8) of 0.1–0.2 mg as indicated in response to surgical stimulation. Thiopentone was given to abolish the eyelash reflex and then 70 per cent nitrous oxide was added to the inspired gas mixture. Increments of thiopentone, to a maximum of 7 $mg \cdot kg^{-1}$, were given to both groups in response to hypertension, tachycardia, lacrimation or movement; if this was unsatisfactory isoflurane was added to the inspired gas mixture. Heart rate, blood pressure, apnoea, muscle rigidity, movement and sweating were recorded. Time from the end of surgery to eye opening, response to patient's name and ability to place a finger on the nose were also recorded. Discharge time was defined as the first ten-minute period when the patient was considered fit, by virtue of state of orientation, wakefulness and comfort, to be returned to the daycare unit waiting area.

Results

There were no demographic differences between the two groups or significant differences in cardiovascular variables, surgical time or recovery criteria. Total doses of thiopentone and use of isoflurane were not significantly different for the two groups. However, there was 100 per cent incidence of apnoea in Group B (P = 0.0001) accompanied by rigidity and movement in three of the nine patients. As instrumentation was deemed potentially harmful under these conditions the study was concluded. In Group I only one patient became apnoeic after induction of anaesthesia and rigidity and movement were not significant.

Conclusion

Alfentanil is only suitable for outpatient cystoscopy in elderly patients when given in small doses, with increments in response to surgical stimulus. Bolus doses cause an unacceptable incidence of centrally mediated apnoea, rigidity and movement with potential hazard when instrumentation is performed.

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Pharmacokinetics of two methods of intranasal nifedipine administration after cardiac surgery

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Intranasal (IN) rather than sublingual administration of nifedipine (NIF) 10 mg is more attractive to anaesthetists because of its faster onset of antihypertensive effect (2 vs 5 min)[1] and its higher peak serum concentrations (58 vs 10 $ng \cdot ml^{-1}$).[2,3] This study sought to determine which of two methods of IN NIf administration was more reliable.

Methods

Sixteen patients undergoing elective coronary bypass surgery gave written informed consent to the institutionally approved protocol. Patients who developed hypertension, defined as a mean arterial pressure (MAP) > 95 mmHg within four hours of surgery, were randomized to receive IN NIF 10 mg by one of

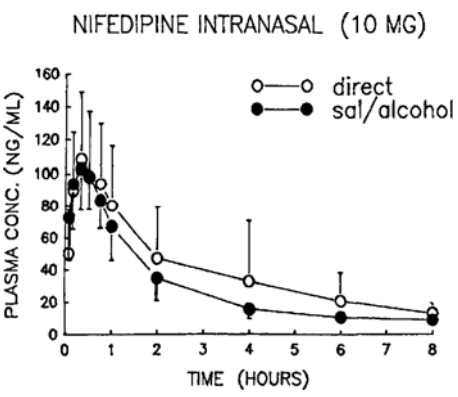

FIGURE Mean serum concentrations.

TABLE Pharmacokinetic/demographic data

	Sal/alcohol	*Direct*
Age (yr)	53 ± 17	58 ± 10
Weight (kg)	84 ± 14	70 ± 14
C_{max} (ng · ml^{-1})	107 ± 23	116 ± 41
T_{max} (hr)	0.38 ± 0.2	0.37 ± 0.26
$T_{\frac{1}{2}}B$ (hr)	2.39 ± 1.31	2.91 ± 1.74
AUC (ng · ml^{-1} hr^{-1})	230 ± 78	299 ± 217

two methods. Either the contents of a 10 mg capsule were squeezed directly (direct) into the nasal cavity or the contents of a 10 mg capsule were aspirated into a foil covered syringe containing 1 ml normal saline and 0.5 ml of 80 per cent ethyl alcohol (sal/alcohol)[2] and instilled into the nasal cavity. Haemodynamic data were recorded and plasma samples obtained at 0, 5, 10, 20, 30, 45 minutes and 1, 2, 4, 6, 8, 12 hours for measurement of NIF concentrations.

Results

Mean NIF profile (Figure), mean peak concentration (C_{max}), time to C_{max} (T_{max}) and the area under the curve (AUC) were similar between groups (table). However, the standard deviation of all kinetic parameters was larger with the direct method indicating increased variability. This variance was significantly different for AUC ($P = 0.015$). Onset of action occurred within five minutes with a 22 per cent and 5.7 per cent decrease in MAP with sal/alcohol and direct methods respectively. Baseline mean MAP was 105 mmHg in both groups. Mean MAP < 90 mmHg was obtained within five minutes with sal/alcohol but not until 45 minutes with the direct method.

Discussion

The sal/alcohol method is more reliable (less variability) and appears more effective.

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Large conductance calcium channel in malignant hyperthermia sarcoplasmic reticulum membranes is blocked by dantrolene

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Malignant hyperthermia (MH) is a pharmacogenetic disorder of skeletal muscle which has been associated with a malfunction of intracellular calcium homoeostasis. Dantrolene is a direct muscle relaxant which has been used in the treatment of MH. We have recorded single channels conductance present in native membranes of sarcoplasmic reticulum (SR) vesicles isolated from MH skeletal muscle (Poland China) swine and studied the effect of dantrolene. Muscle free of adipose and connective tissue was homogenized in 20 ml of 0.3 M sucrose, 10 mM Hepes (pH 7.4). The sarcoplasmic reticulum fraction was immediately prepared following the method described by Martonosi and Feretos (J Biol Chem 1964, 239: 648). At the end of the isolation procedure, aliquots of 100 µl of the preparation were resuspended in 0.3 M sacarose and stored at −70° C at a final protein concentration of about 5 mg · ml^{-1}. Channels were incorporated into Mueller-Rudin planar bilayers (POPE:PC:PS = 5:3:2) and studied in 37 mM trans Ba-Hepes and 225 Hepes tris in the cis compartment to which micromolar calcium and drugs were added. Single channel conductance was 180 + 10 pS as obtained from the linear I/V relationship (−30 to +25 mV applied in cis) that extrapolated to + 30 mV indicative of

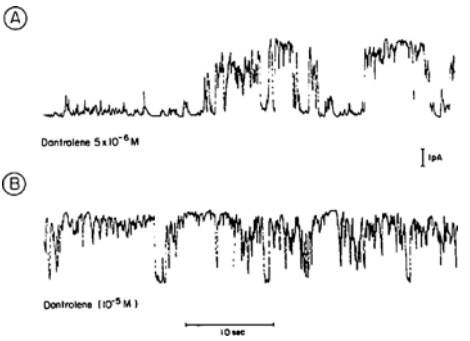

FIGURE Effects of dantrolene at two different concentrations on single calcium channel conductance.

PBa/pTris of 10. Fractional open time (PO) was voltage-independent but showed strong dependence to dantrolene concentration (Figure). The effect was due to a significant increment of the time constant (slow) associated with a slow component of the closed interval distribution that accounted for more than 60 per cent of all closures. This effect of dantrolene might be associated with its prophylactic and therapeutic effect observed in MH susceptible subjects.

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The enflurane sparing effect of hypothermia

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Hypothermia reduces the anaesthetic requirements (MAC) for the volatile agents halothane[1] and isoflurane.[2] An extensive literature search failed to find a similar report concerning the effects of hypothermia on enflurane MAC (EMAC). This study determined the anaesthetic efficacy of hypothermia in terms of its ability to reduce EMAC in the dog.

Methods

Mongrel dogs (n = 9) weighing 18.7 ± 2.9 kg (values expressed as mean ± SD) were anaesthetized by mask with five per cent enflurane in oxygen. After tracheal intubation, mechanical ventilation maintained normal blood pH and gas values. Lactated Ringer's solution at 10–15 ml · kg^{-1} · hr^{-1} was infused. Variables monitored included urinary output, heart rate, temperature (from the tip of the pulmonary artery catheter (core) and bladder catheter (n = 1)), pressure (systemic arterial, pulmonary arterial and pulmonary artery occlusion), arterial blood gases, cardiac output by a thermodilution technique, and end-tidal enflurane concentration recorded by a Puritan Bennett 222 Anaesthesia Agent Monitor (sensitivity 0.1 per cent). EMAC determinations were made according to the tail-clamp method.[1] Graded degrees of hypothermia were induced with the aid of a cooling/warming blanket. EMAC was determined in sequence for all dogs 36–38° C (control 37°); 33–35° C (33° down); 28–30° C (28° C); and during rewarming at 33–35° C (33° up) and 36–38° C (37° up). Differences between normothermic EMAC and EMAC measured at any other temperature level were determined by a one-way analysis of variance. $P < 0.05$ was considered statistically significant.

Results

EMAC was 2.23 ± 0.33 per cent for dogs maintained under normothermic conditions (36.8 ± 1.0° C) (Table). Hypothermia produced increasing degrees of EMAC reduction (9.9 ± 10.9 per cent at 32.5 ± 0.6° C (NS); 35.1 ± 11.5 per cent at 29.6 ± 0.5° C; ($P < 0.05$ vs control, 33° down, 33° up)). Gradual rewarming resulted in a return towards the control MAC (12.8 ± 16.1 per cent at 32.8 ± 0.5° C (NS); 0.6 ± 14.1 per cent at 36.1 ± 0.5° C (NS) (Table)). There was no hysteresis of effect of hypothermia on EMAC reduction.

TABLE Per cent reduction of EMAC due to hypothermia (mean ± SD)

Measurement point	*Control*	*33° down*	*28° C*
Temp (°C)	36.7 ± 1.0	32.5 ± 0.5	29.6 ± 0.5
EMAC (%)	0	9.9 ± 10.9	35.1 ± 11.5

Measurement point	*33° up*	*37 ° up*
Temp (°C)	32.8 ± 0.5	36.1 ± 0.5
EMAC (%)	12.8 ± 16.1	0.6 ± 14.1

$P < 0.05$ vs control and 37° up.
$P < 0.05$ vs 33° down and 33° up.

Discussion

Hypothermia reduced EMAC by 3.9 per cent per °C fall in temperature but the decline was non-linear with the degree of reduction at 32.5° C not statistically different from the control value at 36.8° C. This is in contradistinction to halothane in dogs[1] and rats[2] and isoflurane in rats.[2] Possible reasons for this discrepancy include a larger number of animals studied in this study, or fewer measurement points in this study. It is concluded that hypothermia produces a reduction in enflurane anaesthetic requirements but the degree of reduction produced over the temperature range encountered for most anaesthetics is minimal.

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Propofol vs Thiopental for the induction and maintenance of total intravenous anaesthesia

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Sixty unpremedicated ASA physical status I or II adult patients undergoing elective surgical procedures were randomly assigned to receive either propofol (n = 30) or thiopentone (n = 30) as total intravenous anaesthesia. Preoperative baseline psychomotor function assessments included: (1) deletion of p's; (2) Trieger dot; (3) visual analogue of symptoms and (4) Rhomberg test.

The induction sequence consisted of d-tubocurarine 3 mg, fentanyl 1.5 μg · kg^{-1}, followed in three minutes by either propofol 2.0–2.5 mg · kg^{-1} or thiopentone 4.5–5.0 mg · kg^{-1}, intravenously. Following loss of eyelash reflex succinylcholine 1.5 mg · kg^{-1} was given prior to intubation. Anaesthesia was maintained with an infusion of either one per cent propofol (0.1–0.2 mg · kg^{-1} · min^{-1}) or 2.5 per cent thiopentone (0.16–0.32 mg · kg^{-1} · min^{-1}), titrated to patient response. Relaxation was maintained by a 0.2 per cent succinylcholine infusion, and the lungs were ventilated with air/oxygen mixtures only.

TABLE I Induction/maintenance dosages and times

	Propofol	*Thiopentone*
Induction dose (mg · kg)	2.18 ± 0.37	4.81 ± 0.43
Cessation of counting (sec)	42.2 ± 27.1	29.8 ± 6.1*
Loss of lid reflex (sec)	48.6 ± 29.6	37.3 ± 8.0†
Total dosage administered ($mg \cdot kg^{-1}$)	6.2 ± 2.5	12.8 ± 4.0
Duration of anaesthesia (min)	25.3 ± 16.5	24.1 ± 12.0

*$P < 0.02$.
†$P < 0.05$.

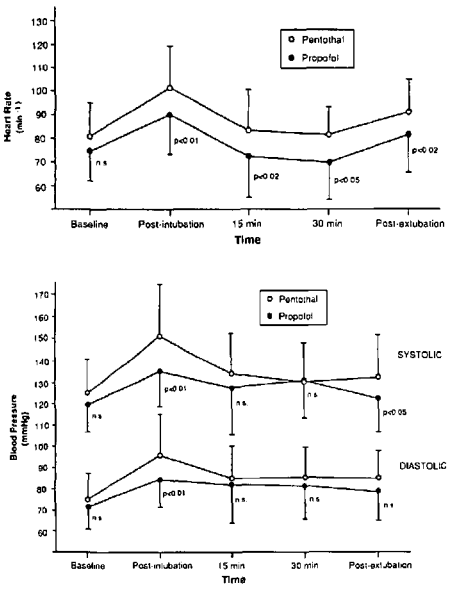

FIGURE Perioperative heart rate and BP.

Although induction times (Table I) were 40 per cent longer following propofol, all inductions were smooth and uncomplicated. Supplemental boluses of 1–2 ml of intravenous agent were required to treat signs of light anaesthesia in six propofol patients and two thiopentone patients; in no case were more than two such boluses necessary. Only one patient (thiopentone group) complained of intraoperative awareness.

Mean peak heart rates and blood pressures post-intubation were significantly lower under propofol anaesthesia (Figure). Mean intraoperative heart rates were likewise lower with propofol at 15 and 30 minutes, and post-extubation.

Recovery times (Table II) from discontinuation of infusions were shorter by 37–54 per cent in those receiving propofol. Dizziness sufficient to prevent standing in the recovery room

TABLE II Recovery times

	Propofol	*Thiopentone*	*P*
Eye opening (min)	6.4 ± 4.3	13.9 ± 15.9	<0.02
Response to verbal command (min)	7.6 ± 6.30	15.4 ± 16.6	<0.02
Orientation (min)	22.7 ± 12.8	36.2 ± 23.1	<0.01
Aldrete score of 10 (min)	34.0 ± 22.0	56.6 ± 24.8	<0.001
Tolerate fluids (min)	24.1 ± 24.0	25.1 ± 32.3	N.S.
Sit independently (min)	44.9 ± 22.8	41.1 ± 30.7	N.S.
Ability to walk at discharge (no.of patients)	19	8	<0.01
PARR discharge (min)	71.1 ± 12.4	78.4 ± 14.6	<0.05

was experienced by 16 patients receiving thiopentone versus only four receiving propofol ($P < 0.01$). Trieger dot tests in the recovery room showed that the mean number of dots missed was significantly lower following propofol (6.0 ± 6.4 vs 10.3 ± 8.0, $P < 0.05$). The incidence of nausea and vomiting (18% overall) did not differ between groups.

Post-operative adverse symptoms as assessed by visual analogue at 24 hours showed no difference in 14 of the 15 symptoms; a subjective decreased ability to concentrate was found in the thiopental group.

We conclude that propofol compares favourably to thiopental for total intravenous anaesthesia and enables earlier recovery of psychomotor and cognitive function.

Cardiovascular effects of combination of non-depolarizing neuromuscular blockers in patients with coronary artery disease

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Combining two non-depolarizing relaxants achieves a degree of neuromuscular blockade and reduction of cardiovascular effects with lower dosage than would be anticipated from individual agents. The blood pressure and heart rate effects of the combination of pancuronium and metocurine are less than of pancuronium alone. The present study was undertaken to compare the cardiovascular responses with the combination of pancuronium + atracurium (P+A), atracurium + vecuronium (A+V), and pancuronium + vecuronium (P+V) when used with sufentanil in patients with coronary artery disease.

Methods

All patients were premedicated with morphine sulphate 0.15 $mg \cdot kg^{-1}$ and scopolamine 0.2 to 0.4 mg IM. Induction of anaesthesia was standardized to sufentanil 8 $\mu g \cdot kg^{-1}$ diluted to 100 ml in normal saline and infused over eight to ten minutes. Four mg of lorazepam was given during this infusion. Pancuronium 0.1 $mg \cdot kg^{-1}$ + atracurium 0.5 $mg \cdot kg^{-1}$ or atracurium 0.5 $mg \cdot kg^{-1}$ + vecuronium 0.1 $mg \cdot kg^{-1}$ or pancuronium 0.1 $mg \cdot kg^{-1}$ + vecuronium 0.1 $mg \cdot kg^{-1}$ were administered during the infusion of sufentanil. Haemodynamic measurements were

TABLE

	Period 1	*Period 2*	Period 3	*Period 4*
HR				
A+P	69.3 ± 15.7	66.8 ± 11.4	64.8 ± 11.9	70.6 ± 13.4
A+V	71.8 ± 17.3	66.3 ± 14.6	64.1 ± 14.9	74.0 ± 15.7
P+V	70.0 ± 18.1	73.0 ± 22.5	72.3 ± 24.1	76.3 ± 25.1
MAP				
A+P	86.6 ± 15.5	69.6 ± 12.9	70.3 ± 9.7	81.1 ± 7.9
P+V	101.3 ± 25.1	75.5 ± 15.8	75.4 ± 15.3	77.5 ± 11.3
P+V	94.2 ± 16.0	79.3 ± 16.6	78.7 ± 15.2	80.5 ± 15.7
PCWP				
A+P	18.1 ± 5.8	14.2 ± 4.9	14.2 ± 5.2	16.1 ± 6.1
A+V	15.1 ± 7.9	10.4 ± 4.3	11.1 ± 4.2	11.6 ± 4.8
P+V	16.0 ± 4.6	13.3 ± 3.8	13.3 ± 4.4	12.8 ± 4.3
CI				
A+P	2.5 ± 0.4	2.4 ± 0.5	2.3 ± 0.4	2.5 ± 0.6
A+V	2.4 ± 0.4	2.4 ± 0.8	2.4 ± 0.7	2.4 ± 0.9
P+V	2.5 ± 0.5	2.7 ± 0.9	2.7 ± 0.8	2.8 ± 1.2

recorded at the following time: *Period 1*: In OR before induction; *Period 2*: Two minutes after completion of sufentanil + muscle relaxant; *Period 3*: Five minutes after completion of sufentanil + muscle relaxant; *Period 4*: Immediately after intubation. Differences in patterns of mean responses between the three study groups were analyzed by analysis of variance (repeated measures) and the least significant difference test. Probability levels of 0.05 or less are used to indicate statistical significance.

Results

Baseline measurements as well as haemodynamic responses to induction of anaesthesia and intubation are presented in the Table. Although there are some changes observed in individual combinations but when they are compared against each other (combinations) this study did not show any statistically significant differences in the variables observed.

Discussion

Pancuronium is known to cause tachycardia which may be detrimental in patients with poor ventricular function while atracurium and vecuronium produce very little haemodynamic changes. Heart rate change in all of the combinations of the study showed no significant changes from base line and there was no significant intergroup difference. Same is true for cardiac index. However, mean arterial pressure and PCWP was lowered significantly in all combinations but again when compared against each other there was no difference. None of the changes in the parameters observed required any intervention with medication. Since the combination of muscle relaxants when combined with sufentanil as used in this study did not show any major cardiovascular changes, provided good intubating conditions and have no intergroup differences, it is proposed that combination of muscle relaxants offer a good alternative to the standard technique of using a single muscle relaxant which might individually have untoward effect on the haemodynamics.

Comparison of single patch multi-day versus multiple patch single day TTS fentanyl

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Inadequate analgesia can be a major complaint following most surgical procedures. One concern with parenteral administration of narcotics for postoperative pain relief is the wide fluctuations observed in the plasma concentrations and the associated periods of inadequate analgesia or the risk of respiratory depression. Fentanyl, a potent synthetic opioid, has been incorporated into a transdermal therapeutic system (TTS)[1] which consists of a fentanyl reservoir and a rate-limiting membrane to provide constant release of fentanyl.[2] The purpose of this investigation was to evaluate the safety and efficacy and the pharmacokinetics of fentanyl following TTS patch applications for analgesia in post-surgical patients.

Methods

Patients were selectively assigned to two groups. All patients were ASA physical status I–III undergoing intra-abdominal colorectal surgery. Informed consent was obtained from each patient in this IRB approved study. Two hours prior to surgery the TTS patch delivering 75 $\mu g \cdot hr^{-1}$ of fentanyl was placed on the upper chest of the patients. Premedication was diazepam (10 mg, PO) one hour prior to induction. Anaesthesia was induced with thiopentone (4 $mg \cdot kg^{-1}$) with intubation facilitated by succinylcholine (1.5 $mg \cdot kg^{-1}$). Maintenance of anaesthesia consisted of N_2O/O_2 (60/40 ratio), isoflurane, pancuronium as needed and 300 μg fentanyl (given in the first hour). Group one had the initial TTS patch replaced, at different sites, by a second and third patch at 24 hours and 48 hours, respectively. Group two had the TTS patch remain in place for 72 hours.

Twenty serial blood samples were obtained over 120 hours. If needed additional postoperative analgesia consisted of morphine sulfate (2 mg IV) in the recovery room, and (5 mg IM) every four hours thereafter. Vital signs, degree of pain, and degree of sedation were monitored frequently.

Results

Tables I and II summarize results. In group one and two the mean terminal elimination half-life of fentanyl was 16.6 (8.7) hrs and 19.6 (5.2) hrs respectively, with the mean steady-state serum concentration of fentanyl being 2.58 (1.95) $mg \cdot ml^{-1}$ and

TABLE I Summarizes results Group I

	Day 1	*Day 2*	*Day 3*
Range: mean visual analog pain score	2.4–7.6	0.6–4.6	1.2–5.3
Range mean respiratory rates	12.4–27	13.9–21.4	13.3–20.9
Nausea	27	36	9
Vomiting	9	18	0
Mg supplemental morphine/pt	16	3.6	4.9
Number patients	10	3	4

TABLE II Summarizes results Group II

	Day 1	*Day 2*	*Day 3*
Range: mean visual analog pain score	1.12–7.1	1.12–5.37	0.87–4.87
Range mean respiratory rates	15–20.5	15.2–21.5	17.2–23.7
Nausea	0%	0%	0%
Vomiting	0%	0%	0%
Mg supplemental morphine/pt	11.5	11.25	10.6
Number patients	10	6	7

1.5 (0.5) $mg \cdot ml^{-1}$ respectively. Skin reactions to the patch were minimal.

Discussion

The TTS (fentanyl) patches were well tolerated in all patients. Pain control was good with 10 of 11 patients in Group I and eight of nine patients in Group II saying that they would want the patch in future surgeries. Although the mean plasma fentanyl concentration seems elevated, clinical respiratory function was good with isolated blood gases showing normal PH and PCO_2. Documentation of the degree of respiratory depression was not done. Overall the system appears to be an important advance in the treatment of perioperative pain.

References

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The haemodynamic effects of doxacurium (BWA938U) in patients undergoing coronary artery bypass grafting

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Doxacurium (BW A938U) is a new long-acting non-depolarising neuromuscular blocking agent. Initial studies have shown it has minimal cardiovascular effects and a similar duration of action to pancuronium.[1] The purpose of this study was to assess the haemodynamic effects of a single 1.5 x ED_{95} dose of doxacurium in nine patients during anaesthesia for coronary artery bypass grafting.

Methods

Ethics Committee approval and informed written consent were obtained. Premedication was with oral lorazepam (2–4 mg) and IM papaveretum (15–20 mg) with hyoscine (0.3–0.4 mg). A radial artery cannula, peripheral venous cannula and a pulmonary artery thermodilution catheter were inserted under local anaesthesia before induction of anaesthesia with fentanyl 500 μg, diazemuls 5-10 mg, and thiopentone 50–500 mg. After succinylcholine 1 $mg \cdot kg^{-1}$ and topical tylocaine, the patients were intubated and ventilated to normocarbia with 50 per cent N_2O in O_2. A 1.5 x ED_{95} dose of doxacurium (0.037 $mg \cdot kg^{-1}$), was administered when measurements were stable and at least 20 minutes after intubation.

TABLE

	Control	+1	+5	+10
MAP	D 73.9(2.3)	72.8(1.8)	75.4(1.9)	74.6(2.0)
HR	D 59.4(2.8)	58.7(2.8)	58.3(3.0)	57.9(3.1)
CI	D 2.3(0.1)	2.4(0.1)	2.5(0.2)	2.4(0.2)

Continuous recordings were made of BP, pulmonary artery pressure (PAP), and ECG. Recordings of pulmonary capillary wedge pressure (PCWP) and central venous pressure (CVP), and measurements of cardiac output were made before and one, five and ten minutes after administration of doxacurium (Table). Results showed no significant changes in mean arterial pressure (MAP), heart rate (HR) and cardiac index (CI). Mean (± SEM) of MAP (mmHg), HR ($beats \cdot min^{-1}$), CI ($L \cdot min^{-1} \cdot m^{-2}$), PAP (mmHg), PCWP (mmHg), and CVP (mmHg) before (control) and at one, five, and ten minutes after administration of relaxant.

Reference

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Effect of enflurane on edrophonium-assisted recovery

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Enflurane potentiates the effect of neuromuscular relaxants and may impair recovery. Thus, in the presence of enflurane, a larger dose of edrophonium may be required, and if enflurane is discontinued, the effectiveness of edrophonium might be increased. This study was designed to measure this effect quantitatively by obtaining dose–response curves for edrophonium, in the presence of 0, 1 or 2 per cent end-tidal concentrations of enflurane, and when two per cent enflurane was discontinued.

Methods

The protocol was approved by the Hospital Ethics Committee. In 100 ASA physical status 1 or 11 adults, anaesthesia was induced with thiopentone, 3–5 $mg \cdot kg^{-1}$. The maintenance anaesthetic consisted of either fentanyl nitrous oxide (25 subjects), nitrous oxide-enflurane 1 per cent (end–tidal) (25) or oxygen-enflurane two per cent (end–tidal) (50). Atracurium, 0.5 $mg \cdot kg^{-1}$, was given. Train-of-four stimulation was applied to the ulnar nerve every 12 seconds. At the end of the surgery, when first twitch height recovered to ten per cent of control, edrophonium, 0, 0.1, 0.2, 0.4 or 1 $mg \cdot kg^{-1}$, was administered. Neuromuscular recovery was measured for at least 10 min. The enflurane concentration was maintained constant during this time, except that half the patients receiving two per cent enflurane had the inhalational agent discontinued at the time of edrophonium administration. Train-of-four ratio (TOF) and first

TABLE Expected effect of edrophonium, 0.5 mg·kg^{-1}, 10 min after its administration, according to enflurane concentration. (2 > 0 indicates 2% discontinued).

Enflurane concentration	*TI (% ± SEM)*	*TOF (% ± SEM)*
0%	96 ± 1	66 ± 2
1%	90 ± 2+	52 ± 3+
2%	82 ± 3+	40 ± 2+
2 > 0	91 ± 2*	60 ± 6*

+P < 0.05 compared with 0%.
*P < 0.05 compared with 2%.

twitch height compared with control (TI) were measured 10 min after edrophonium administration and dose–response curves were constructed.

Results

The doses expected to produce 80 per cent TI recovery (ED80, TI) were (mean ± SEM) 0.08 ± 0.03, 0.21 ± 0.06, and 0.42 ± 0.18 mg·kg^{-1} for 0, 1 and 2 per cent enflurane, respectively (P < 0.05). With enflurane two per cent discontinued, T1 response was inconsistent. The doses expected to yield 50 per cent TOF recovery (ED_{50}, TOF) were 0.13 ± 0.05, 0.46 ± 0.10 and 1.04 ± 0.38 mg·kg^{-1}, respectively (P < 0.05), and 0.17 ± 0.12 mg·kg^{-1} with discontinuation of two per cent enflurane (P < 0.05 compared with two per cent). The expected effect of edrophonium, 0.5 mg·kg^{-1}, is shown in the Table.

Discussion

This study showed that enflurane causes a dose-related impairment in edrophonium-assisted recovery of atracurium-induced neuromuscular blockade. This occurred in spite of the fact that twitch height was the same when edrophonium was administered. To achieve the same effect, five to ten times as much edrophonium has to be given with two per cent enflurane compared with nitrous oxide-narcotic anaesthesia. This effect is reversed somewhat by discontinuation of enflurane. When high concentrations of enflurane are administered, larger doses of edrophonium are required for adequate antagonism.

Clinical assessment of the adult bullard laryngoscope

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The adult Bullard laryngoscope uses the combination of an anatomically shaped, rigid blade with fibre optics to aid in direct laryngoscopy and intubation. It is useful in the management of the normal airway and the difficult airway. Tracheal intubation can be performed using various laryngoscopes, a previous study found that multiple attempts at intubation were required in nearly 20 per cent of patients and in four per cent successful intubation was performed with a laryngoscope blade other than that originally chosen.[1] We have evaluated the Bullard laryngoscope and report its characteristics, advantages and disadvantages.

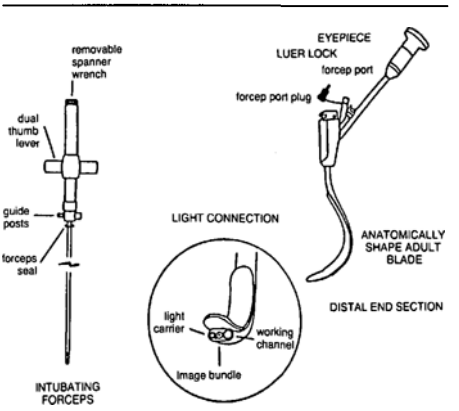

FIGURE 1 Diagram of the Bullard laryngoscope.

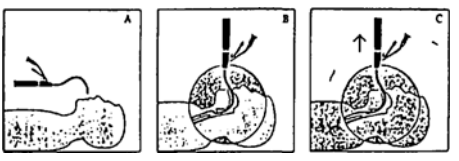

FIGURE 2

Dscription of the laryngoscope

The complete laryngoscope is shown in Figure 1. The combination of the rigid blade with fibre optics results in a robust instrument. Use of the intubating forceps mechanism requires that the anaesthetist hold the laryngoscope in the right hand. The tracheal tube can be introduced over a stylette with the laryngoscope being held in the customary left hand. The direction of insertion and the direction of pull to expose the larynx are slightly different from the classical laryngoscope (Figure 2).

Assessment

Laryngoscopy and intubation were performed by the primary author and in all cases a fibre optic light source was used, with the oral tracheal tube being introduced over a stylette.

Patients

Group I – Forty patients undergoing surgery in whom no problems with intubation were expected.[2]
Laryngoscopy and intubation were performed following relaxation with vecuronium (0.1 mg·kg^{-1}).
Group II – Five patients with unstable cervical spines and

TABLE Time to visualisation & intubation (mean)

	Visualisation	*Intubation*
Uncomplicated (Gp I)	6.6 s (n = 40)	16.4 s (n = 37)
Cervical spines (Gp II)	8.3 s (n = 5)	23.5 s (n = 5)
Rapid sequence (Gp III)	4.5 s (n = 10)	12.0 s (n = 10)
Awake (Gp IV)	0	0

fractures requiring laminectomy cervical fusion. This group received succinylcholine (1.5 $mg \cdot kg^{-1}$).
Group III – Ten patients requiring rapid sequence induction.
Group IV – Three patients having awake intubation under topical anaesthesia.

Characteristics noted
- Visualisation of the vocal cords (time to visualisation and clarity)
- Intubation time
- Trauma (lips, teeth and oro-pharynx).

Results
The mean times to visualisation and intubation are shown in the Table. In Group I there were three failed intubations which all occurred in the first ten patients studied. In the awake patient good visualisation was difficult to obtain and other means of intubation were required. No trauma to the lips or teeth was noted, although evidence of blood in the oro-pharynx suggested slight tissue damage in four patients.

Conclusions
Advantages
Rapid visualisation of the vocal cords
Rapid oral tracheal intubation
Low risk of "failed intubation"
Less trauma to lips and teeth
Easier to master than the fibreoptic laryngoscope
No neck extension or flexion required

Disadvantages
Difficult to introduce in the awake patient
Intubating forceps require right handed laryngoscopy

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Effects of inspiratory pressure on delivered tidal volume in an anaesthesia breathing circuit

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A prescribed tidal volume (V_T) is necessary during controlled ventilation to avoid atelectasis and an unfavourable ratio of dead space volume to V_T.[1] Gas compression and compliance of the breathing circuit can decrease V_T delivered to the patient during mechanical ventilation.[2] Decreases in lung compliance (C_L) that occur commonly during anaesthesia increase peak inflation pressure (PIP), which increases volume losses within the breathing circuit. The purpose of this study was to evaluate the relationship between C_L and delivered V_T and the sites at which volume is decreased by compression in the anaesthesia breathing circuit.

Methods
An anaesthesia machine (Ohio Heidbrink Kinet-o-Meter), an electronic ventilator (Ohmeda 7000), a canister filled with soda lime, and a circle system (Intertech/Ohio ▽225-3719-804) were attached to a test lung (Michigan Instruments Vent-Aid) by which C_L could be varied. V_T was measured with a rotating vane spirometer (Wright Haloscale MX) at the bellows inlet, bellows outlet, canister inlet, proximal inspiratory limb, and patient airway at 4 C_Ls (80, 40, 12.5, and 7 $ml \cdot cm\ H_2O^{-1}$). Pressure in the circuit was measured with a pressure transducer (Gould-Statham). Ventilator settings were a rate of 10 $breaths \cdot min^{-1}$, inspiratory-to-expiratory ratio 1:2, minute ventilation 8 $L \cdot min^{-1}$, and V_T of 800 ml measured at the bellows inlet; fresh gas flow was set at 1 $L \cdot min^{-1}$. V_T was measured three times for consecutive breaths at each site and each C_L.

Results
As C_L decreased, V_T delivered to the bellows compartment decreased from 800 ml at a C_L of 80 $ml \cdot cm\ H_2O^{-1}$ to 750 ml at a C_L of 7 $ml \cdot cm\ H_2O^{-1}$ (Table). V_T delivered to the lung (measured at the airway) over the same range of C_L decreased from 750 to 50 ml. PIP increased from 10 to 66 cm H_2O.

TABLE Effect of changes in lung compliance (C_L) and peak inflation pressure (PIP) on tidal volume (V_T) measured at different sites

		V_T (ml)	
Measurement site	C_L: PIP:	*80 ml · cm H_2O^{-1} 10 cm H_2O*	*40 ml · cm H_2O^{-1} 17 cm H_2O*
Bellows inlet		800	800
Bellows outlet		780	750
Canister inlet		775	730
Proximal inspiratory limb		780	705
Airway		750	660

		V_T (ml)	
Measurement site	C_L: PIP:	*12.5 ml · cm H_2O^{-1} 41 cm H_2O*	*7 ml · cm H_2O^{-1} 66 cm H_2O*
Bellows inlet		790	750
Bellows outlet		675	510
Canister inlet		635	420
Proximal inspiratory limb		475	160
Airway		390	50

Discussion

VT set to be delivered by a ventilator may not correspond to the volume delivered to the patient. The ventilator in this study consistently delivered adequate volumes to the bellows compartment, whereas volume losses throughout the circuit indicate that the effects of gas compression and tubing expansion are significant even at modest decreases in CL. Fresh gas flow may augment VT and help to offset volume reductions, although a low-flow technique minimizes this effect.[3] Monitoring VT, ideally between the Y-piece of the breathing circuit and the tracheal tube, is essential to avoid undetected hypoventilation and atelectasis in patients at risk from even modest reductions in CL because of factors such as obesity, abdominal surgery, or severe pulmonary disease.

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Activation of complement by the Haemonetic cell saver 4 system

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Autologous blood recovery systems are designed to separate red cells from shed blood in the operating field. They basically have three functions, filtration, centrifugal separation, and cell washing.

Despite the numerous advantages, autotransfusion has some disadvantages. Reinfusion of salvaged blood containing activated coagulation factors, free haemoglobin, dilutional fluids, anticoagulants, emboli, and activated complement could lead to complications such as DIC and pulmonary insufficiency.

The complement system consists of several enzymes which undergo sequential activation in a cascade fashion. There are two pathways of complement activation, the classical and the alternative. Antigen-antibody complexes activate the classical pathway whereas foreign substances and bacteria will activate the alternative pathway. Activated C3 and C5 exert some biologic activities such as smooth muscle spasm, release of histamine and other active amines from mast cells and basophils, increased vascular permeability, platelet aggregation, and formation of microaggregates.

During the use of Haemonetic Cell Saver 4 System, activation of C3 and C5 was studied in 11 young healthy patients undergoing orthopaedic procedures in which massive blood loss was expected.

Method

Perioperatively, after induction of anaesthesia, five blood samples were taken (5 ml each in EDTA-coated tubes): from the patients (base-line), from the reservoir bag, from the reinfusion bag, from the waste bag, and from the patients 30 minutes after transfusing the washed red blood cells.

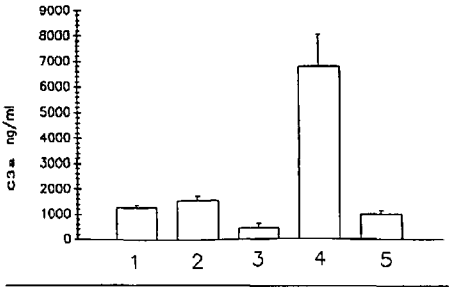

FIGURE C3a levels in cell saver blood, scores are mean ± SEM. (1) samples from patients before transfusion, (2) samples from reservoir bag, (3) samples from reinfusion bag, (4) samples from waste bag, (5) samples from patients 30 minutes after transfusion.

Results

When compared with levels in the base-line samples, C3a levels in the waste bag were significantly high, while those in the reinfusion bag were low. Post-transfusion levels of C3a did not show any significant change compared with base-line. Very low plasma levels of C5a were detected in all samples possibly because of extensive adherence of C5a to granulocytes which took place before separation of plasma (Figure).

Conclusion

Although the results had shown activation of complement during processing of blood in the Cell Saver System (mainly in the polycarbonate plastic centrifusing chamber), they also showed that the machine is capable of washing out all unwanted fragments to provide safe, complement-free blood to the patient.

A new breath monitor for use in anaesthesia

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Respiratory monitoring is important in anaesthesia, medical transport, sleep research, apnoea monitoring and in other clinical fields. Techniques for monitoring spontaneously breathing patients include spirometry, capnometry, pneumotachography, electrical inductance and impedance plethysmography and thermistor-based methods. These techniques are often awkward, technically complex, subject to motion artifacts, and the apparatus may be expensive. There are additional problems when monitoring infants and children in whom respiratory volumes are smaller and airway dead space must be kept to a minimum. We have evaluated a new portable breath monitor

based on the detection of sudden temperature changes at the airway during respiration. This monitor overcomes many of the problems of previous designs and promises to be suitable for paediatric anaesthesia.

Description and methods

The sensor (Figure 1) consists of a small, thin-walled cylindrical chamber which is placed in the path of respiration (Figure 2). The open end of the chamber is connected via a long, small-bore plastic tube to a monitor containing a sensitive pressure transducer. During expiration the warm expired air heats the sensor increasing its internal pressure, while during inspiration the ambient inspired air cools the sensor reducing its internal pressure. The pressure variations are converted to an electrical signal by the monitor and this signal is processed electronically and displayed on a bar-graph. The beginning of each expiration is also indicated by an audible tone, the intensity of which is user adjustable. An analogue output jack on the monitor allows the respiratory signal to be displayed on an oscilloscope or recorded on tape or strip-chart recorder (Figure 3). The unit is pocket-sized and uses a rechargeable battery, which lasts about five hours when fully charged.

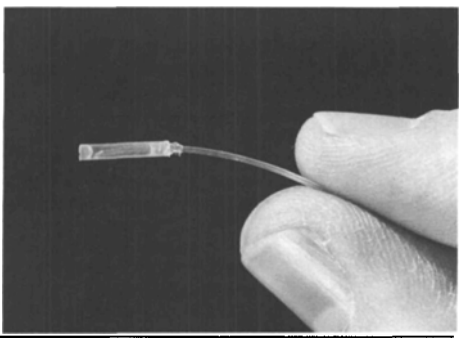

FIGURE 1 Closeup view of sensor.

FIGURE 2 View of the monitor and the placement of the sensor.

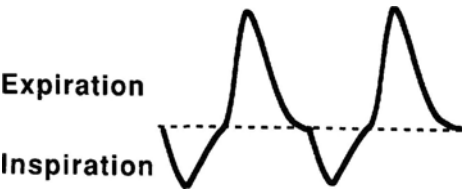

FIGURE 3 Sample waveform.

In a preliminary evaluation, the monitor was used on 25 infants and children during transport from the operating room (OR) to the post-anaesthetic recovery room (PAR). Immediately following extubation in the OR the sensor was placed adjacent to or just inside a nostril and taped to the cheek. In addition to the usual clinical monitoring means, the visual display and audio signal were available to the anaesthetist during transport. The monitor was assessed on arrival at the PAR by the completion of a questionnaire concerning its ease of use, reliability, usefulness and acceptability.

Results and discussion

The patients were from four months to 15 years old. The monitor was deemed to be unreliable in two out of 25 patients due to problems with the audible breath indication. This problem can be overcome by adjusting the manual sensitivity control on the monitor. In 23 out of 25 cases the monitor was well accepted by the medical and nursing staff and was found to be useful and reliable. The ease of sensor placement, portability and simplicity of the monitor were the features most frequently favoured by the users.

Acknowledgements

The monitor used for this study was provided by and is available from Voltek Enterprises, 36 Gatehead Road, Willowdale, Ontario, Canada, M2J-2P5.

Assessment of transconjunctival oxygen monitoring in experimental hyperoxia and hypoxia

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The palpebral conjunctiva is a unique accessible tissue in which a capillary bed is separated from the epithelial surface by two to three cell layers.[1] The surface oxygen tension of palpebral conjunctiva may reflect both the oxygen content of arterial blood and conjunctival blood flow because of the low tissue oxygen consumption rate and the lack of a barrier to oxygen diffusion. A miniature Clarke electrode mounted on an ophthalmic conformer and requiring meticulous membraning and twopoint gas calibration has been tested over a range of inspired oxygen

concentrations.[2] A premembraned sensor (TO_2M 2000 Biomedical Sensors) ready to use following a period of immersion in saline to activate the electrode has recently become commercially available.

This study was undertaken to evaluate the effects of changes in FiO_2 from 1.0 to 0.05 on $PcjO_2$ and its relationship to PaO_2, oxygen delivery (DO_2) and oxygen extraction.

Methods

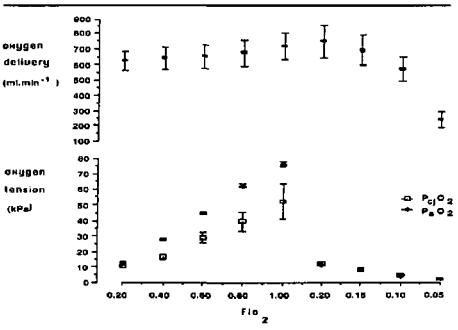
Following institutional research committee approval, ten greyhound dogs (weight 20–30 kg) were studied. Anaesthesia was induced with thiopentone 20 $mg \cdot kg^{-1}$ and was maintained with a 20 $mg \cdot kg^{-1}h \cdot ^{-1}$ infusion. The trachea was intubated and controlled normocapnic ventilation was instituted. The femoral artery was cannulated for direct arterial pressure monitoring and arterial blood sampling. A triple lumen pulmonary catheter was placed via the external jugular vein for thermodilution cardiac output and mixed venous oxygen tension measurements. Continuous ECG, arterial pressure, end–tidal CO_2 and temperature readings were displayed.

The transconjunctival oxygen sensor was inserted into the right eye with the electrode applied to the palpebral conjunctival surface. The inspired O_2/N_2 mix was altered in incremental steps to give an FiO_2 of 0.21 (baseline) 0.40, 0.60, 0.80, and 1.00. Following restabilisation at an FiO_2 of 0.21, the FiO_2 was reduced to 0.15, 0.10 and 0.05. The FiO_2 was measured using a polarographic oxygen sensor. The haemodynamic and oxygen tension variables measured at each FiO_2 after ten-minute stabilisation time were heart rate, mean arterial pressure, central venous pressure, pulmonary capillary wedge pressure, cardiac output, $PcjO_2$, PaO_2, and PvO_2. Systemic vascular resistance, oxygen delivery and oxygen extraction were calculated.

The data were expressed as mean ± SEM. The statistical significance of changes in the variables with $PcjO_2$ at each FiO_2 was evaluated by paired Student's t test and Pearson product moment correlation. $P < 0.05$ was considered significant.

Results

The $PcjO_2$ closely approximated PaO_2 values in normoxic and hypoxic ranges. During the hyperoxic range the $PcjO_2/PaO_2$ ratio decreased as the FiO_2 was increased. A positive correlation between PaO_2 and $PcjO_2$ was observed ($r = 0.99$, $P < 0.001$). There was no correlation between $PcjO_2$ and either oxygen delivery, oxygen extraction, PvO_2 or cardiac output (Figure).



FIGURE

Discussion

The $PcjO_2/PaO_2$ ratio or conjunctival index[3] was constant during hypoxia and normoxia. In the presence of an abnormally high PaO_2, the $PcjO_2/PaO_2$ ratio fell and the range of $PcjO_2$ values increased, possibly due to a reduction in conjunctival perfusion. In haemodynamically stable normovolaemic patients $PcjO_2$ may provide a simple continuous non-invasive indicator of PaO_2 in hypoxic and normoxic states.

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Psychomotor performance following laparoscopic surgery: Induction with methohexitone and fentanyl

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Serial four-choice reaction time (4CRT) has been shown to be a useful method of assessing psychomotor performance decrement (PPD). A large number of studies has looked at the PPD caused by fentanyl in combination with different anaesthetics both IV and inhalational. Some studies have shown little effect while others have suggested more marked PPD's. We have assessed the effect of increasing doses of fentanyl on PPD's using a clinical model in which we have already measured the effects of the other anaesthetic drugs.

Methods

With the approval of a hospital ethics committee, informed consent was obtained from 30 female patients scheduled for laparoscopic tubal ligation. Patients were ASA physical status I or II and were randomly assigned to one of three groups, but were not blinded. No patients received premedication. All patients received droperidol 1.0 mg and gallamine 20 mg prior to induction. Patients in group FO received methohexitone 1.5 $mg \cdot kg^{-1}$, group F2 received methohexitone 1.0 $mg \cdot kg^{-1}$ and fentanyl 2.0 $\mu g \cdot kg^{-1}$ while group F4 received methohexitone 0.5 $mg \cdot kg^{-1}$ and fentanyl 4.0 $\mu g \cdot kg^{-1}$ for induction of anaesthesia. Succinylcholine was used to facilitate intubation and to maintain muscle relaxation. Ventilation was controlled with a fresh-gas flow of 75 $ml \cdot kg^{-1}$. Anaesthesia was maintained with oxygen (40 per cent), N_2O, and enflurane (1.5 per cent) until mean blood pressure was ten per cent below preinduction value after which inspired enflurane concentration

was reduced. 4CRT tests lasting eight minutes were recorded on tape and analyzed after the study was completed. Variables derived include average, median and 95th centile response time and number of errors per test. Preoperatively patients completed one practice 4CRT, a control 4CRT and three 10 cm visual analog scales (VAS) representing their assessment of pain, nausea and drowsiness. Postoperatively 4CRT and VAS's were completed two, four, and six hours after cessation of anaesthesia and after an overnight stay in hospital (approximately 24 hr). Differences between treatments were sought using repeated measures analysis of variance with preoperative score as a covariance factor. Differences between times pre- and postoperatively were tested using analysis of variance and pairwise t tests with Bonferroni correction.

Results

Two subjects failed to complete the study protocol and their treatments were reassigned to new subjects. One subject (FO) was excluded because there were more than ten per cent errors in pre- and postoperative 4CRT tests. Values reported are mean values. There were no significant differences between the three groups in body weight (63.0 kg), per cent body fat (30 per cent), operative duration (25.6 min) or time to respond to commands (5.5 min). The F4 group was significantly ($P < 0.01$) younger (mean age 28.8 yr) compared to the FO group (35.3 yr) but not the F2 group (32.9 yr). There were no significant differences between treatments in pain or nausea VAS postoperatively. Nausea score was increased 2 hr (43 mm) and 4 hr (44mm) postoperatively compared with 24 hr (30 mm). Pain scores were also increased between 2 hr (29 mm) and 6 hr (21 mm) postoperatively compared with 24 hr (11 mm). Sleepiness VAS was significantly ($P < 0.05$) higher (55.4 mm) 2 hr postoperatively in patients who received methohexitone 1 $mg \cdot kg^{-1}$ and fentanyl 2 $\mu g \cdot kg^{-1}$ (group F2) compared with group F4 (33.7 mm) and group FO (17.7 mm). There were no significant differences between the three groups at 4 hr (27.6 mm), 6 hr (20.7 mm) or 24 hr (2.9 mm) postoperatively. Average, median and upper 95th centile of individual 4CRT tests were all highly correlated therefore only median reaction times are reported. There were no significant differences between median 4CRT of the three treatment groups postoperatively. Median 4CRT was significantly ($P < 0.05$) higher at 2 hr (556 msec) and 4 hr (555 msec) compared with preoperatively (462 msec). It subsequently decreased at 6 hr (520 msec) and 24 hr (497 msec). Overall there were no significant changes in error scores postoperatively and no differences between treatments.

Discussion

The PPD following methohexitone fentanyl induction and N_2O/enflurane maintenance persists for up to six hours postoperatively. It was not influenced by the relative doses of the two induction agents. Subjects' perception of drowsiness was higher in patients receiving fentanyl at 2 hr postoperative but not subsequently. Pain and nausea scores were not influenced by the amount of fentanyl administered.

Gastroesophageal reflux in anaesthetized patients

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We used continuous oesophageal pH monitoring to detect the frequency of gastroesophageal reflux (GER) in awake and anaesthetized subjects. We further hypothesized that head-down positioning, increased abdominal pressure, obesity, or a history of symptoms of reflux would be positively correlated with the occurrence of GER.

Methods

A total of 44 patients scheduled for elective surgery were enrolled in the study. Sixteen patients (Group I) were studied in awake and anaesthetized states. About an hour prior to induction of general anaesthesia, fasting patients were asked to swallow a nasally placed bipolar pH probe which was placed in the lower oesophagus 5 cm proximal to the acid-alkali junction defined at a pH of 4.[1] A second probe was placed in the pharynx of most patients after induction. pH measurements were made every five seconds and stored by a portable pH monitor. A further 28 patients (Group II) were studied using the above method with the exception that the probe was inserted shortly after induction of anaesthesia. Episodes of GER were compared in the horizontal and Trendelenburg positions. Fifteen patients underwent laparoscopy as a method of raising intra-abdominal pressure. A significant reflux episode was represented by an abrupt fall in pH below a value of four. Statistical analysis was performed using Yate's Chi-squared analysis and Student's t tests with each patient serving as his or her own control. Significance level was set at $P < 0.05$.

Results

A highly significant fall in mean pH occurred shortly after induction of anaesthesia from a value of 6.02 to a value of 5.47 ($0.01 < P < 0.001$) (Table). Of the 44 patients studied GER occurred during anaesthesia in six (13.6 per cent). This was associated with bucking or coughing in five subjects. Two of these patients had reflux to the level of the pharynx as detected by a pH change in the pharynx probe. Five of 23 patients who bucked had GER. No episodes of GER were detected during position changes after exclusion of reflux associated with

TABLE

Group I (n = 16):	*Awake*	*Anaesthetized*
Median time – monitored (mins)	45.5	91.5
pH < 4 (episodes)	2	4
Mean pH ± SD*	6.02 ± 6.27	5.47 ± 5.57

Group II (n = 28):	*Trendelenburg (10°)*	*Horizontal*
Median time monitored (mins)	16.5	15.0
pH < 4 (episodes)	0	2

*Average pH over one minute, 10 minutes prior to and 30 minutes after induction of anaesthesia. Statistically significant difference $0.01 < P < 0.001$.

bucking. No GER was demonstrable in patients undergoing laparoscopy. History of symptomatic reflux oesophagitis (n = 5), as defined by symptoms present at least once a week, predicted reflux in two patients. In contrast, four of 39 patients without a history of reflux oesophagitis subsequently developed GER under anaesthesia. Of seven obese patients, one had GER during anaesthesia. None of these associations achieved statistical significance utilizing Yates corrected Chi-squared test.

Discussion

Although we failed to show any statistically significant associations with GER we have demonstrated the presence of GER during anaesthesia, particularly during periods of straining on the tracheal tube. It is not felt that the decrease in mean pH occurring shortly after induction of anaesthesia change represented gastric regurgitation, for the [H+] was many times less than that demonstrated intragastrically during positioning of the probe. The poor predictive values of history, body habitus, positioning or raised intra-abdominal pressure in predicting GER in this study, suggests a need to re-evaluate these traditional risk factors in anaesthesia practice.[2]

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Residual gastric volume in out-patient surgery

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It is routine practice in many hospitals for elective patients to fast from midnight, irrespective of their scheduled time of surgery.[1] Although gastric emptying of liquids is rapid, fasting guidelines have only recently been questioned.[2] It has been shown that 150 ml of fluid taken 2 to 3 hr before the expected time of elective surgery has no effect on mean gastric volume or pH at the time of induction of anaesthesia when compared to those values in patients who are "NPO from midnight".[3] Based on these studies, our institutional policy has been modified for day-care surgery for which patients arrive at the hospital at least 2 hr before the anticipated time of surgery. They are advised not to eat solid food after midnight, but to drink 150 ml of coffee, tea, fruit juice or water 1/2 to 1 hr before leaving home.

Methods

Since implementation of this new policy we have completed a followup study of 174 ASA physical status I or II patients scheduled for elective day-care surgery. All patients gave written informed consent and received no premedication. Their age, sex, weight, smoking habit, history of heartburn within the previous two weeks and time of last fluid ingestion were recorded. Following induction of anaesthesia a #18 FG Salem orogastric tube was passed into the stomach and all available gastric contents were aspirated into a 60 ml syringe. The residual gastric volume (RGV) was recorded and the pH measured using a calibrated Corning pH metre. The interval from last ingestion to induction of anaesthesia was calculated and the patients were divided into four groups according to this fasting interval: less than 3 hr; 3 to 5 hr; 5 to 8 hr; NPO from midnight (Table).

TABLE

		Fast (hr)		*RGV (ml)*	
Group	*n*	*Median*	*Range*	*Median*	*Range*
<3 hr	30	2.5	(1.7–3.0)	24	(0–63)
3–5 hr	63	4.0	(3.1–5.0)	23	(0–88)
5–8 hr	33	6.2	(5.1–8.0)	31	(1–90)
NPO	48	12.6	(8.5–25.5)	28	(0–120)

	pH	
Group	*Median*	*Range*
<3 hr	1.69	(1.18–1.78)
3–5 hr	1.79	(1.02–7.27)
5–8 hr	2.25	(1.08–7.87)
NPO	1.69	(1.04–5.94)

Analysis of variance and Mann-Whitney U test were used for statistical evaluation and values of $P < 0.05$ were considered to be statistically significant.

Results

The groups were comparable with respect to sex, age, weight and the types of surgery. Median RGV and pH values were similar, whether patients ingested oral fluids less than 3 hr before surgery or fasted from midnight. Despite the liberalisation of the fasting rules, 48 patients did not drink on the morning of surgery. Of these, some had been booked for surgery before the policy change, some were not thirsty, and others had unforeseen delays in their operating times.

Discussion

In healthy, unpremedicated day-care patients there is a wide range in values for RGV and pH which bears no relationship to the duration of fluid fast. Fasting guidelines for fluid in elective surgical patients should be reviewed, but our findings should not be extrapolated to solid food, emergency patients, and patients who receive opioid premedication.

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An improved nasal prong apparatus for end-tidal carbon dioxide monitoring in the awake/sedated patient

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End-tidal CO_2 ($ET\text{-}CO_2$) is useful in assessing the adequacy of ventilation in patients undergoing anaesthesia. However an effective method of monitoring $ET\text{-}CO_2$ in awake, sedated patients has yet to be established. Several methods have been advocated for the measurement of $ET\text{-}CO_2$ in awake patients,[1,2] but there is insufficient evidence establishing either the accuracy or reliability of these methods. The following report describes a new technique for monitoring $ET\text{-}CO_2$ in awake, sedated patients using a modified nasal cannula and further describes an evaluation of the accuracy of this new technique.

Methods

20 patients ASA physical status II–IV qualified for this institutional review board approved study. The $ET\text{-}CO_2$ monitoring setup consisted of a 5 cm 14-gauge intravenous catheter inserted into one limb of the oxygen supply tubing of a standard dual-prong nasal oxygen cannula. The cross-over passage between the two prongs was intentionally blocked with the end of a cotton-tipped applicator to effectively isolate the two oxygen supply limbs. Hence, one limb functioned to sample exhaled gases, while the other limb delivered supplemental oxygen. On-line $ET\text{-}CO_2$ readings were obtained from a calibrated Datex 254 gas analyzer with a Datex 250 video display. Supplemental oxygen (2, 4, and 6 $L \cdot min^{-1}$) was administered through the modified nasal cannula in a random sequence with flow rate changed at five-minute intervals. In the last minute of each interval, all expiratory CO_2 waveforms with a plateau were averaged and recorded as Ave $ET\text{-}CO_2$. In the last 30 seconds a value for the best waveform was recorded as Peak $ET\text{-}CO_2$, and an arterial blood gas sample was obtained from an indwelling blood pressure catheter and analyzed immediately. The data were analyzed by comparing $PaCO_2$ with peak/average $ET\text{-}CO_2$ values using the paired Student's t test; $ET\text{-}CO_2/PaCO_2$ ratios were analyzed with ANOVA.

Results

The data indicate that the modified $ET\text{-}CO_2$ sampling cannula yields measurements which correlate closely with $PaCO_2$ values proportionate to the supplemental oxygen flow rate (Table). Accuracy of correlation, defined as $ET\text{-}CO_2/PaCO_2$, was 98, 94, and 85 per cent for peak values, at 2, 4, and 6 $L \cdot min^{-1}$ O_2 flow rate (with correlation coefficients of r = 0.81, 0.85, and 0.63, respectively). Accuracy of average $ET\text{-}CO_2$ values was 94, 89 and 81 per cent, respectively. Both average and peak $ET\text{-}CO_2$ values were not significantly different from the corresponding $PaCO_2$ at 2 and 4 $L \cdot min^{-1}$ but were different at 6 $L \cdot min^{-1}$, while the $PaCO_2$ values did not vary significantly. The Figure is a scatter plot of the raw peak $ET\text{-}CO_2$ vs $PaCO_2$ data at three different O_2 flows illustrating the degree of variation around the calculated line (linear regression).

TABLE $PaCO_2$, $ET\text{-}CO_2$, and PaO_2 values at different nasal oxygen flow rates (mean ± SD)

Variable	*2 $L \cdot min^{-1}$*	*4 $L \cdot min^{-1}$*	*6 $L \cdot min^{-1}$*
$PaCO_2$	*41.2 ± 4.2*	41.1 ± 4.4	42.1 ± 4.9
$ET\text{-}CO_2$	38.7 ± 5.2	36.6 ± 5.7	34.1 ± 5.8†
Peak $ET\text{-}CO_2$	40.5 ± 5.5	39.1 ± 5.7	36.5 ± 6.1†
PaO_2	114 ± 26*	154 ± 45*	183 ± 55*

*P < 0.05 by ANOVA; †P < 0.05 by t test.

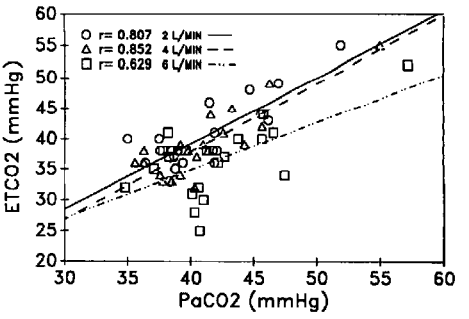

FIGURE Peak $ET\text{-}CO_2$ vs $PaCO_2$.

Discussion

This study indicates that the nasal cannula with the improved $ET\text{-}CO_2$ sampling port can provide accurate data reflecting arterial PCO_2 values in the awake, sedated patient, and it proved to be reliable and well tolerated by all patients during the study period. This new configuration eliminates many of the problems encountered with prior $ET\text{-}CO_2$ monitoring setups such as intra-nasal irritation, blockage of the sampling catheter, and mechanical interference by the surgeon, particularly during intraoral procedures. It should be noted that the flow rate had a significant effect on the accuracy of this monitor when 6 $L \cdot min^{-1}$ flow rates were used. This may have resulted from increased mixing of fresh gas flow with exhaled gases in the posterior nasopharynx/oropharynx region. It is also possible that the 14-gauge IV catheter did not completely occlude the sampling limb in all cases and allowed some flow of O_2 to pass directly into the sampling catheter. The authors therefore recommend that an O_2 flow rate of less than 6 $L \cdot min^{-1}$ should be used.

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Echocardiographic assessment of the haemodynamic effects of induction of anaesthesia with either propofol or thiopentone

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In this study we compare the haemodynamic effects seen during induction of anaesthesia with propofol or thiopentone using echocardiography. Echocardiography allows visualisation of cardiac structures and permits continuous assessment of cardiac dimensions throughout the cardiac cycle. Doppler ultrasound gives a measure of blood velocity in the ascending aorta. Integration of the resultant velocity/time curve gives the stroke distance which if multiplied by the aortic cross-sectional area allows derivation of stroke volume and hence cardiac output.

Methods

Following institutional approval informed consent was obtained from 20 ASA physical status I patients. Premedication was with papaveretum 0.3 $mg \cdot kg^{-1}$ and anaesthesia induced with either propofol 2.5 $mg \cdot kg^{-1}$ (group P) or thiopentone 4.5 $mg \cdot kg^{-1}$ (group T). All patients breathed 100 per cent O_2 throughout the study period. During this period blood pressure, blood flow in the ascending aorta and heart rate were recorded continuously. As an estimate of contractility, fractional shortening was measured by echocardiography.

TABLE Results. Haemodynamic data

Group	*P*	*T*
n	*10*	*10*
Heart rate at time (mins)		
0	78 ± 14	69 ± 11
1	89 ± 10	86 ± 11
2	79 ± 9	77 ± 13
3	76 ± 4	77 ± 13
4	72 ± 4	72 ± 12
5	70 ± 5	71 ± 12
Mean B.P. (mmHg)		
0	86 ± 12	91 ± 15
1	66 ± 23	78 ± 14
2	66 ± 9	84 ± 12
3	67 ± 9	83 ± 12
4	64 ± 9	84 ± 11
5	67 ± 8	83 ± 11
Minute distance (cm/min)		
0	1611 ± 442	1216 ± 248
1	1763 ± 475	1417 ± 210
2	1491 ± 468	1216 ± 254
3	1386 ± 445	1190 ± 249
4	1353 ± 368	1172 ± 238
5	1334 ± 345	1143 ± 184
Stroke distance (cm)		
0	20.3 ± 2.95	18.3 ± 3.4
1	19.8 ± 5.6	17 ± 3.3
2	18.7 ± 4.8	16 ± 3.4
3	18.3 ± 5.9	16 ± 3.2
4	18.9 ± 4.9	17 ± 3.5
5	19 ± 4.7	17 ± 3.8
Fractional Shortening (%)		
0	35 ± 5	30 ± 4
5	29.9 ± 4.7	33.1 ± 5.6

Results

In both groups induction of anaesthesia was followed by a transient but significant increase in heart rate ($P < 0.05$). A significant fall in mean blood pressure was observed in group P. No significant differences in minute distance were observed between groups P and T although significant depression of minute distance did occur in group P (Table).

Discussion

The preservation of stroke distance induced in this study suggests that the reduction in minute distance (a good correlate of cardiac output) seen in the propofol group is largely due to a reduction in heart rate and not contractility. These data support the suggestion that prophylactic administration of an anticholinergic might be appropriate to minimise cardiovascular changes occurring with propofol induction.

Intravenous fluid administration does not reduce nausea and vomiting in children

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The administration of intravenous fluids to adults patients undergoing minor surgical procedures has been shown to improve the quality of postoperative recovery.[1] We studied 102 children undergoing minor dental procedures under general anaesthesia, to determine the effect of intravenous fluid on postoperative minor morbidity.

Methods

Following institutional review and with informed consent patients were randomly allocated into two groups; Group I received no intravenous fluids and Group II received intravenous Ringer's lactate solution (RL). Parents and children were blinded to the administration of intravenous fluids. Anaesthesia was similar in all patients. No premedication was used. Induction of anaesthesia with thiopentone 5–6 $mg \cdot kg^{-1}$ and atropine 10–20 $\mu g \cdot kg^{-1}$ was followed by succinylcholine to enable nasotracheal intubation and maintenance with nitrous oxide 70 per cent and oxygen 30 per cent with halothane 1–2 per cent inspired concentration as required.

The volume of Ringer's lactate solution to replace the fluid deficit was calculated as follows.[2] Hourly fluid deficit (a) 0–10 kg = 4 $ml \cdot kg^{-1}$; (b) 11–20 kg = 2 $ml \cdot kg^{-1}$ + a; (c) >20 kg = $ml \cdot kg^{-1}$ + a + b. Fluids were given intraoperatively and the intravenous infusion was discontinued before leaving the operating room.

TABLE

	Preoperative		*Postoperative*	
	Child	*Parent*	*Child*	*Parent*
Group I (N50)	1.2 ± 4	1.1 ± 3.5	1.4 ± 4.4	1 ± 4.3
Group II (N52)	2 ± 4.2	1.7 ± 3.1	1.1 ± 4.9	1.3 ± 3.9

	At home	
	Child	*Parent*
Group I (N50)	5.34 ± 16.2	3.7 ± 3.1
Group II (N52)	2.1 ± 4.5	2.4 ± 4

The effect of treatment was assessed in three ways.

1 A modified linear analog scale completed by the child and by one of the parents on three occasions, preoperatively, before discharge and at home the following day to assess general wellbeing.[3]
2 A questionnaire completed by the same parent the day after operation was used to assess the incidence of nausea and vomiting and activity level.
3 The incidence of nausea and vomiting and use of narcotic as recorded in the recovery room record.

Results

Of 102 patients studied 52 received fluids. Chi-Square or unpaired t test analysis of the results obtained from the questionnaire and anaesthetic record showed no statistical difference between the two groups for age, duration of anaesthetic, dental extractions or the use of codeine. Nausea and vomiting, in the recovery room, en route from the hospital and at home and the level of activity on the day following surgery were not significantly different between groups.

Measurements from the linear analog scale were entered into an Excel spread sheet and analyzed using the unpaired, 2-tailed t test. These results are shown in the Table.

Discussion

Fasting causes some degree of dehydration due to insensible losses. Children are usually permitted clear fluids until four hours preoperatively. Dehydration is normally not a problem as paediatric patients usually tolerate oral fluids immediately upon recovering from minor surgery and we therefore do not routinely administer intravenous fluids for these minor cases. The administration of intravenous fluids is not without risk. Thrombophlebitis, air embolism, administration of infected fluid, and administration of an inappropriate intravenous fluid can cause serious sequelae. The cost of the intravenous fluid, administration set and cannula also increase operating room costs.

Our results show that intraoperative replacement of the fluid deficit caused by preoperative fasting in children does not affect the incidence of nausea and vomiting in the immediate postoperative period, en-route from the hospital, or on the day following conservative dentistry under general anaesthesia. The level of activity on the first postoperative day was similar whether patients received fluid or not. This is in contrast to the results reported by Keane in the adult population. Using a modified linear analogue scale completed by the child and parent, to assess happiness or sadness, we were unable to detect any difference between the two groups of patients preoperatively, postoperatively or on the first postoperative day.

In summary we have been unable to demonstrate any improved well being in the paediatric population following the administration of intravenous fluids to replace the deficit caused by preoperative fasting.

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Does inspired gas humidification prevent intraoperative hypothermia in infants and children?

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Heat and moisture exchangers ("artificial noses"), provide *passive* airway humidification, and prevent intraoperative hypothermia in adults.[1] The efficacy of these filters has not been evaluated in infants and children, nor have they been compared with *active* humidification. Therefore, we compared central temperature, airway humidity, and recovery time in children given active, passive, or no respiratory gas humidification.

Methods

With approval from our Ethics Committee, we studied 27 children weighing 5–30 kg undergoing peripheral surgery lasting 1–3 h. Ambient temperatures were maintained at ≈22° C and a heating blanket, thermostatically-controlled at 37° C, was placed under each patient. Halothane/N_2O anaesthesia was administered with a modified Ayre's t piece. Fresh gas flow was calculated using the formula of Rose and Froese[2] respiratory rate ($\approx 30 \cdot min^{-1}$) and tidal volume ($\approx 12\ ml \cdot kg^{-1}$) were adjusted to maintain an end–tidal PCO_2 near 35 mmHg. The patients were randomly assigned to *active* airway humidification and warming using a Fisher and Paykel® warmer set at 37° C (n = 10), *passive* airway humidification using the Humid-Vent® 1 heat and moisture exchanger (n = 8), or no airway humidification and heating (control, n = 9). Tympanic membrane temperatures were recorded every 10 min during surgery. Inspired relative humidity was measured using a Humidcap®. Rectal temperatures were recorded at 10 min intervals during recovery from anaesthesia. Patients were released from the recovery area by an anaesthetist who was unaware of the type of airway humidification used. Fitness for discharge was based on standard criteria

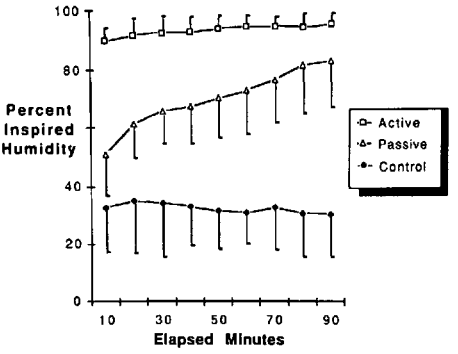

FIGURE 1 The mean inspired relative humidity (±SD) in 27 infants and children given active, passive, or no airway humidification. The humidity in the active and passive groups did not differ significantly after 80 min of anaesthesia. At other times, humidity in each of the groups differed significantly.

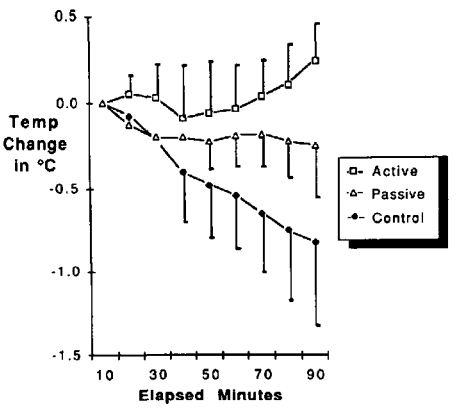

FIGURE 2 The mean change (±SD) in tympanic membrane temperature in 27 infants and children receiving active, passive, or no airway humidification. After 60 min of anaesthesia, temperature differences among each of the groups were significant.

which included rectal temperature ≥36° C. Differences between groups were determined using ANOVA and Student-Newman-Keuls tests; $P \leq 0.05$ was considered significant.

Results

Figure 1 shows that the relative humidity of the inspired gas was ≈90 per cent in patients given active airway humidification and ≈30 per cent in those given unconditioned gases. The heat and moisture exchanger increased airway humidity from ≈50 to ≈80 per cent during the first 90 min of surgery; after 80 min of anaesthesia, inspired humidity in these patients was not significantly different from those in the active group. However, patients less than 12 kg of body weight never showed any significant increase of airway humidity and were not significantly different from the control group at any time during the anaesthesia. Tympanic membrane temperatures increased in the patients given active airway humidification, remained relatively constant in those given passive humidification, and decreased in the control group. After 70 min of anaesthesia, tympanic membrane temperature differences among each of the groups were significant (Figure 2). Rectal temperatures increased 0.5° $C \cdot h^{-1}$ following anaesthesia and the duration of recovery (≈60 min) was not significantly different among the groups.

Discussion

The Humid-Vent® heat and moisture exchanger significantly increased airway humidification in patients greater than 12 kg body weight and, after 80 min of anaesthesia, provided humidification similar to that provided by an active humidifier. Passive airway humidification prevented hypothermia whereas active humidification and heating increased central body temperature in these patients. Recovery was rapid in all patients and did not correlate with central temperature or type of humidification. It is likely that differences between the groups would have been greater in patients undergoing larger operations in colder operating rooms.

Supported in part by a grant from Gibeck Respiration, Inc.

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Glycine 1.5% and dextrose 5% irrigation fluids for transurethral prostatectomy – a prospective comparison

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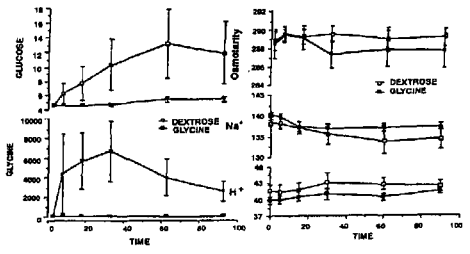
The excessive absorption of irrigation fluid during transurethral prostatectomy may result in changes in haemodynamic variables and disturbance of neurological function.[1] Glycine 1.5 per cent is popular as an irrigation fluid because it is non-haemolytic, non-electrolytic, relatively inexpensive and because of its good optical properties. However, glycine's role as an inhibitory neurotransmitter has been implicated in cases of visual disturbances and neurological deficits following transurethral prostatectomy.[2] An isoosmolar dextrose five per cent irrigation fluid has been used but concerns have arisen because of possible hyperglycaemia-associated intracellular lactic acidosis on neurological outcome following an ischaemic or hypoxic insult.[3]

The objectives of this study were to compare the acid-base, biochemical and metabolic changes associated with glycine 1.5 per cent and dextrose five per cent irrigation fluids for transurethral prostatectomy.



FIGURE

Methods

Following Ethics Committee approval and informed patient consent 20 male patients, ASA Physical Status I–III, scheduled for transurethral prostatectomy were randomly assigned to one of two groups. Group I – dextrose five per cent irrigation fluid. Group II – glycine 1.5 per cent irrigation fluid. 500 ml physiological saline intravenous infusion was completed before surgery. Subarachnoid anaesthesia was performed by the administration of 3–3.5 ml isobaric bupivacaine 0.5 per cent through a 25-gauge spinal needle placed in the subarachnoid space at L3-4 to achieve regional blockade to a level of T10. The volume of irrigation fluid used and the volume of washout were measured and the volume absorbed calculated. Arterial pressure and the electrocardiogram were recorded continuously during the perioperative period. Blood samples were obtained from a radial artery cannula before resection and at 5, 15, 30, 60 and 90 minutes after commencement of resection for measurement of serum sodium, glucose, lactate, osmolarity, glycine, ammonia, magnesium, phosphate and arterial blood gases. Data are expressed as mean ± SEM. Statistical analysis included two-sample Student's t test and Mann-Whitney U-test, for abnormally distributed data. $P < 0.05$ was considered significant.

Results

Patients in Groups I and II were comparable with respect to age, weight, duration of resection and irrigation fluid absorption. The metabolic, biochemical and acid–base changes in both groups during resection are illustrated in the Figure. A significant elevation in serum glucose was noted in Group I at 15 and 30 minutes following the start of resection. A significant elevation of serum glycine was noted in Group II at 60 and 90 minutes after the start of resection. There were no significant differences between the groups with respect to arterial oxygen tension, acid–base status, serum sodium and osmolarity.

Discussion

Intravascular absorption of irrigation fluids during prostatic irrigation depends on the number of open venous sinuses, the duration of resection and the hydrostatic pressure used. Dextrose five per cent irrigation fluid is associated with significant hyperglycaemia and less satisfactory optical conditions compared with glycine 1.5 per cent irrigation fluid. Dextrose five per cent irrigation fluid was not associated with any obvious clinical patient benefits in the patients studied.

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Early indicators of acute blood loss

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Evidence of acute blood loss is important for optimal patient management in the perioperative and post-trauma situation. Evaluation of such loss and the adequacy of fluid replacement is often difficult. To identify early and sensitive parameters we measured a broad spectrum of clinical and physiological variables in a porcine model of acute ongoing blood loss.

Methods

Seven Yorkshire swine, 36–40 kg, were anaesthetized with IV fentanyl 40 $\mu g \cdot kg^{-1} \cdot hr^{-1}$ and ketamine 5 $mg \cdot kg^{-1} \cdot hr^{-1}$. Ventilation was controlled to keep $PaCO_2$ 40 ± 3 mmHg. FiO_2 was titrated to prevent arterial desaturation (range 0.24–0.40). Fibreoptic catheters were inserted in the carotid and pulmonary arteries for vascular pressures, haemoglobin (Hb) saturations and sampling for blood gases and Hb content. A gas exchange analyzer measured FiO_2 and calculated the respiratory quotient (RQ). A personal computer was programmed to calculate, display and record cardio-respiratory parameters.[1] After stable baselines, animals were bled by a roller pump, one litre in 40 min. Arterial and mixed venous blood was sampled every 10 min for blood gases and Hb. During exsanguination no change was made in the ventilation or FiO_2. Total IV fluids were restricted to 150 $ml \cdot hr^{-1}$. Data at baseline (pre-haemorrhage) was compared with values every 10 min during bleeding by paired t tests. A $P < 0.01$ was considered statistically significant.

Results

The results are summarized in Tables I and II. Exsanguination was accompanied by a steady decrease in cardiac output (CO), mean arterial pressure (MAP), central venous pressure (CVP) and Hb. In mixed venous blood, Hb saturation ($S\bar{v}O_2$), oxygen tension ($P\bar{v}O_2$), and pH decreased and CO_2 ($P\bar{v}CO_2$) increased. There was an increase in the dead space (VD/VT) and oxygen extraction (SX%). There was no significant change in arterial blood gases.

Discussion

$S\bar{v}O_2$ is the earliest and most sensitive indicator of acute ongoing blood loss. Arterial blood gas analysis does not indicate

TABLE I

	CO	VCO_2	VO_2
Baseline	4.5 ± 1.2	189 ± 43	217 ± 61
10 min	4.1 ± 1.4	187 ± 37	213 ± 48
20 min	3.6 ± 0.7	183 ± 34	201 ± 42
30 min	2.7 ± 0.8†	174 ± 30‡	187 ± 39‡
40 min	2.0 ± 1.1†	153 ± 34‡	150 ± 58‡

	RQ	HR	MAP
Baseline	0.88 ± 0.09	105 ± 35	115 ± 20
10 min	0.87 ± 0.06	121 ± 10	111 ± 23
20 min	0.91 ± 0.07‡	144 ± 29	95 ± 24‡
30 min	0.94 ± 0.09†	164 ± 32‡	71 ± 21†
40 min	1.10 ± 0.26‡	147 ± 22	51 ± 25*

	CVP	V_DV_T	$SX\%$
Baseline	7 ± 5	0.40 ± 0.10	43 ± 12
10 min	6 ± 5	0.41 ± 0.09	46 ± 13
20 min	5 ± 5‡	0.42 ± 0.08	52 ± 12
30 min	4 ± 4†	0.46 ± 0.08†	58 ± 12‡
40 min	4 ± 4†	0.52 ± 0.09†	25 ± 13†

TABLE II

	pHa	PaO_2	$PaCO_2$
Baseline	7.46 ± 0.05	89 ± 23	39 ± 5
10 min	7.44 ± 0.06	91 ± 20	40 ± 8
20 min	7.45 ± 0.06	88 ± 18	40 ± 7
30 min	7.45 ± 0.05	91 ± 23	39 ± 6
40 min	7.45 ± 0.06	87 ± 16	37 ± 8

	$pH\bar{v}$	$p\bar{v}O_2$	$P\bar{v}CO_2$
Baseline	7.42 ± 0.06	38 ± 4	46 ± 8
10 min	7.41 ± 0.06	37 ± 6	47 ± 9
20 min	7.40 ± 0.05	34 ± 4	48 ± 8‡
30 min	7.39 ± 0.05	27 ± 4*	49 ± 8†
40 min	7.36 ± 0.07	22 ± 4*	50 ± 12

	HgB	SaO_2	$S\bar{v}O_2$
Baseline	8.9 ± 0.7	96 ± 4	56 ± 11
10 min	9.0 ± 0.7	97 ± 4	53 ± 13
20 min	8.8 ± 6	97 ± 4	45 ± 9†
30 min	8.2 ± 0.5†	97 ± 4	26 ± 16
40 min	7.7 ± 0.7†	97 ± 4	20 ± 11

* = $P < 0.001$; † = $P < 0.01$; ‡ = $P < 0.05$.

any metabolic or respiratory compromise in this situation (loss of more than 30 per cent predicted blood volume). Though Hb does decrease by a statistically significant extent, the fall is one not many would consider clinically significant. In agreement with reported results in cardio-pulmonary resuscitation,[2,3] we noted a decrease in the mixed venous pH and an increase in $P\bar{v}CO_2$. Our results confirm that mixed venous blood is more representative of capillary blood and hence of phenomena occurring at tissue level.[2] Arterial acidaemia, reflective of compromised tissue perfusion, is preceded by other indicators of haemorrhage. In conclusion, arterial blood gas analysis may be inappropriate detecting perioperative or post-trauma blood loss. Mixed venous oxygenation is much more sensitive as is systemic arterial pressure, though this may be modified by surgical or traumatic stimuli.

Refereces

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Pharmacokenetics and pharmacodynamics of atracurium with or without previous succinylcholine administration

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Succinylcholine increases the potency of non-depolarizing relaxants administered subsequently.[1] The magnitude of this effect has been investigated for vecuronium, but not for other relaxants. Furthermore, no data have been obtained regarding the concentration-effect relationship after succinylcholine administration. This study was designed to determine the plasma concentration and effect of atracurium, with and without previous succinylcholine administration.

Methods

The protocol was approved by the Hospital Ethics Committee. Informed consent was obtained from all patients. This study included 18 ASA physical status I or II adults scheduled for elective surgery for which an arterial cannula was indicated. Anaesthesia was induced with thiopentone, 3–5 $mg \cdot kg^{-1}$, and maintained with nitrous oxide (70 per cent) and isoflurane (0.5 per cent end-tidal), in oxygen. Train-of-four stimulation was applied to the ulnar nerve and the force of contraction of the adductor pollicis muscle was measured. Atracurium, 0.2 $mg \cdot kg^{-1}$, was administered either after full recovery from succinylcholine, 1 $mg \cdot kg^{-1}$, or without previous succinylcholine injection. Plasma samples were taken at 0, 0.5, 1, 1.5, 2, 3, 5, 7, 10, 15, 20, 30, 45, 60, 90 and 120 min after atracurium injection. They were analyzed for atracurium levels using an HPLC assay. Non-compartmental analysis of pharmacokinetic data was performed. Results are expressed as means ± SEM. Statistical analysis was performed using the Student's t test and a P value less than 0.05 was considered to indicate statistically significant differences.

Results

The pharmacokinetic characteristics were the same in both groups of patients (Table I). Neuromuscular blockade occurred

TABLE I Pharmacokinetic values (mean ± SEM)

	Volume of distribution ($ml \cdot kg^{-1}$)	*Clearance* ($ml \cdot kg^{-1} \cdot min^{-1}$)	*Mean residence time* (*min*)
With sux.	190 ± 26	9.09 ± 0.84	20.4 ± 1.2
Without sux.	167 ± 7	7.50 ± 0.33	22.7 ± 1.4
	NS	NS	NS

TABLE II Pharmacodynamic values (mean ± SEM)

	Time to 50% block (min)	*Max. block (%)*	*Time to 50% recovery Cp50*	
			(min)	($ng \cdot ml^{-1}$)
With sux.	1.75 ± 0.25	95.2 ± 2.0	31.8 ± 2.2	172 ± 22
Without sux.	3.3 ± 0.3	85.1 ± 3.8	24.4 ± 1.6	291 ± 23
	$P < 0.001$	$P < 0.05$	$P < 0.02$	$P < 0.002$

faster, was more profound, and recovered later in the group which received succinylcholine (Table II). The atracurium concentrations corresponding to 50 per cent recovery (Cp50) were 69 per cent higher in the group without succinylcholine (Table II).

Discussion

This study showed that previous administration of succinylcholine does not alter the kinetics of atracurium, but increases its potency. This effect still persists more than 30 min after atracurium administration, or 40 min after injection of succinylcholine. The mechanism for this long-lasting interaction of succinylcholine is uncertain. Clinically, the atracurium requirements are reduced if succinylcholine has been administered previously.

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A comparison of propranolol, diazepam, and placebo for anxiolysis

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Propranolol has been shown to be effective in the prevention of stage fright.[1] It may therefore be a nonsedating anxiolytic agent useful for outpatient surgery. The use of propranolol as an anxiolytic premedication has never been studied. We undertook a study to compare the effects of propranolol, diazepam, and placebo for anxiolysis prior to outpatient surgery.

Methods

The study was approved by the Hospital Ethics Committee and consent was obtained from 62 healthy ASA physical status I females aged 18–35 years undergoing outpatient dilatation and curretage (D&C). In a randomized double-blind fashion the patients received one of the following oral medications 1–1.5 hr preoperatively: (1) diazepam 10 mg (n = 21), (2) propranolol 80 mg (n = 21), (3) placebo (n = 20).

Assessments of anxiety using the State Trait Anxiety Inventory (STAI) were performed on arrival at the hospital, in the holding area outside the OR (one hour after the premedication) and 2 hrs postoperatively. Postoperative recovery was assessed using the Treiger Test and Digit Span on admission to hospital and at one, two, and three hours after the operation. Vital signs were collected on admission to hospital, in the holding area outside the OR, immediately before induction of anaesthesia, during dilatation of the cervix, on admission to the recovery room, and at one, two, and three hours postop. The anaesthetic was standardized to include fentanyl 0.5 $\mu g \cdot kg^{-1}$, thiopentone 5 $mg \cdot kg^{-1}$ with an additional 1 $mg \cdot kg^{-1}$ prior to dilatation of the cervix. Maintenance was with 60 per cent N_2O, and enflurane titrated to signs of light anaesthesia. Statistical analysis was performed using repeated measures analysis of variance within groups and analysis of variance with Bonferroni correction between groups, accepting $P < 0.05$ as significant.

Results

There were no significant differences between the groups with respect to age, weight, admission vital signs, duration of the operation, or baseline scores on the State Trait Anxiety, Treiger, or Digit Span tests. Between group comparison of anxiety showed no significant difference among patients receiving propranolol, diazepam, or placebo (Figure 1). Only the patients given diazepam and placebo showed a significant within-group decrease in anxiety between admission to hospital and the holding area outside the operating room (Figure 1). By two hours after completion of the procedure all groups showed a significant decrease in their anxiety scores. Between group comparison of the vital signs showed a significant difference only in heart rate of patients taking propranolol.

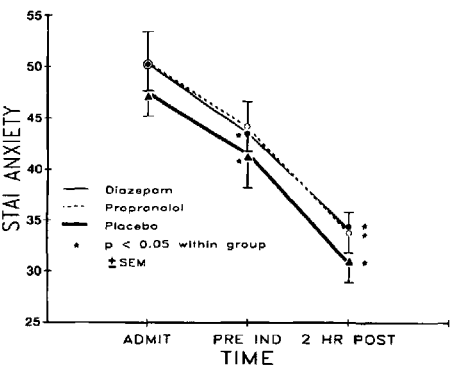

FIGURE 1 Outpatient anxiety vs time.

Within group comparison of psychomotor testing revealed significant impairment only in the group receiving diazepam. In this group, Digit Span testing at one hour postop and Treiger Testing up to two hours postop were impaired. No significant postoperative impairment was evident with placebo or propranolol, and the propranolol group showed a significant improvement in Digit Span testing over time.

Discussion

Propranolol was not as effective as diazepam and placebo in the treatment of preoperative anxiety for outpatient suction D&C. Diazepam caused postoperative psychomotor impairment while propranolol improved performance, likely through lowering anaesthetic requirements to maintain haemodynamic control. Placebos appear be a more desirable premedication than diazepam or propranolol for patients undergoing outpatient D&C procedures.

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Low intravenous bolus dosing of labetalol for prevention of the hypertensive/tachycardic response to tracheal intubation

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Tracheal intubation may result in a brief but marked increase in blood pressure and heart rate. Labetalol is an unique beta blocker as it is also an antagonist of post-synaptic alpha receptors. Bolus intravenous labetalol administration has been shown to produce maximum hypotensive effects by one minute after dosing.[1] Because labetalol is then rapidly and extensively redistributed to other tissues it was hypothesized that a low intravenous bolus dose would provide quick and effective but transient activity.

Methods

In a parallel-designed study to determine efficacy, single intravenous doses of 0.0, 0.0625, 0.125, 0.250 $mg \cdot kg^{-1}$ labetalol were given in a randomized, double-blind manner to 40 consenting healthy patients who were undergoing tracheal intubation prior to dental surgery. Rate pressure product (RPP), systolic (SBP) and diastolic (DBP) blood pressure and heart rate (HR) were measured at one minute intervals using an automatic device (Critikon, Dinamap 1846 SX). Procedures were standardized: baseline measurements (−6 to −4 min); 100 per cent oxygen, d-tubocurarine 0.04 $mg \cdot kg^{-1}$ and fentanyl 1 $\mu g \cdot kg$ (−3 min); thiopentone to cause loss of eyelid reflex and succinylcholine 1.5 $mg \cdot kg^{-1}$ (−2 min); labetalol dose over 15 seconds followed by tracheal intubation (0 min); 66 per cent nitrous oxide, 33 per cent oxygen and 1.0 per cent isoflurane (+1 to +5 min). Statistical comparisons were made among the four labetalol doses using one-way ANOVA followed by Tukey's Test if significance ($P < 0.05$) was observed.

TABLE Maximum change

	Labetalol dose, $mg \cdot kg^{-1}$	
	0.0	*0.0625*
RPP (mmHg · bpm)	4484 ± 3320	5642 ± 2506
SBP (mmHg)	39 ± 23	41 ± 18
DBP (mmHg)	22 ± 11	29 ± 15
HR (bpm)	5 ± 9	14 ± 9

	Labetalol dose, $mg \cdot kg^{-1}$	
	0.125	*0.250*
RPP (mmHg · bpm)	3851 ± 1623	3657 ± 2397
SBP (mmHg)	30 ± 16	32 ± 18
DBP (mmHg)	19 ± 11	27 ± 12
HR (bpm)	8 ± 6	6 ± 8

Results

Maximum change (mean ± SD) in RPP, SBP and DBP occurred by +1 minute and was significantly increased from −1 minute ($P < 0.01$). However, there were no differences among the treatment groups (Table). Between +5 and +10 min, the RPP for patients receiving labetalol 0.250 $mg \cdot kg^{-1}$ was statistically lower than for placebo.

Conclusions

Intravenous bolus labetalol in the dosage range utilized in this study did not protect from increases in RPP, SBP and DBP associated with intubation when administered one minute prior. The lower RPP seen between times five to ten minutes in the group given the highest labetalol dose may reflect:

1 a longer time to maximum labetalol effect after bolus administration than previously shown;

2 an isoflurane response as dosage was not standardized during this time.

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Occupational exposure to nitrous oxide during paediatric anaesthesia: A comparison of two induction techniques

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The risk to operating room personnel of chronic exposure to trace concentrations of nitrous oxide has been the subject of numerous epidemiological studies.[1] A recent study of dentists has provided evidence of bone marrow depression following prolonged nitrous oxide exposure.[2] During paediatric anaesthesia, considerable potential exists for exposure to nitrous oxide when this agent is used as part of an inhalational induction

technique. The aim of this study was to measure the concentrations of nitrous oxide to which operating room personnel were exposed and to determine whether the method of induction of anaesthesia influenced the degree of exposure.

Methods

Approval for this study was granted by the Institutional Research Committee, and consent for participation of subjects was not required. All measurements were made in one operating room, in which air underwent 11.5 exchanges per hour. Exposure to nitrous oxide was measured during 12 routine paediatric ENT lists by means of passive atmospheric samplers (Nitrox nitrous oxide dosimeters, Landauer).[3] Four dosimeters were employed during each surgical list. One was placed at a room air vent behind the anaesthetic machine. The others were attached to the collars of the surgeon, anaesthetist, and circulating nurse. Two anaesthetists each completed three lists using nitrous oxide/oxygen/halothane inductions (Group I) and three lists using intravenous inductions with thiopentone (Group II). Anaesthesia was maintained in all patients with 66 per cent nitrous oxide and halothane in oxygen delivered via a Bain coaxial system using fresh gas flows calculated by body weight according to the recommendations of Rose *et al.*[4] Passive scavenging of waste anaesthetic gases was employed in all cases. Nitrous oxide exposure was expressed as a time weighted average (TWA) which denotes average exposure in parts per million (ppm) per hour. Group comparisons were made for patients' age and weight, fresh gas flow rates, and duration of surgery. Significance was assessed at a P- value of 0.05 using unpaired t tests for parametric data and the Mann-Whitney U test for non-parametric data.

Results

There were 66 patients in Group I and 80 in Group II. Between the groups there were no significant differences with regard to demographic data, mean fresh gas flow rates or mean duration of the surgical procedures. The percentage of patients who underwent tracheal intubation was comparable in both groups. Readings from 5 of the 48 dosimeters (two surgeons, one nurse and two vents) were below the lower limit of detection; these results were markedly inconsistent with TWA values obtained from other dosimeters at the same locations and were therefore excluded from analysis. The remaining results are summarised in the Table. Mean nitrous oxide exposure, assessed by TWA values obtained at all four sampling locations, was significantly greater during those operating lists in which an inhalational induction technique was used.

TABLE

Dosimeter	*TWA (ppm $N_2O \cdot hr^{-1}$)* *Group I*	*Group II*
Anaesthetist	532 (101)	220 (93)
Surgeon	204 (25)	181 (72)
Nurse	299 (66)	71 (19)
Room vent	87 (20)	83 (47)
All dosimeters	302 (50)	137 (32)*

All values expressed as mean (SEM).
*P < 0.001 Group I vs Group II (Mann-Whitney U test).

Discussion

A universally "safe" level of occupational nitrous oxide exposure has yet to be established. Although the use of an intravenous induction technique significantly reduced nitrous oxide exposure, mean TWA values obtained at all sampling locations demonstrated considerably greater nitrous oxide concentrations than the current NIOSH[5] recommendation of 25 ppm, irrespective of the method of induction. This value may be unattainable when high flow rates of nitrous oxide are used during paediatric anaesthesia. As expected, the highest TWA values in both groups were found in the breathing zone of the anaesthetist. Overall, a very wide range of TWA values (6–880 ppm) were obtained under comparable clinical conditions. This, and the occurrence of a number of unexpected zero results, calls into question the suitability of this technique for measuring individual occupational exposure to nitrous oxide over short (<6 hour) periods.

References

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Cardiovascular depression during halothane anaesthesia in neonate

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The marked decreases in blood pressure that occur with halothane anaesthesia in human neonates suggests that myocardial depression is more severe in the human neonate than in the older infant and adult.[1,3] The cardiovascular depression that occurs during halothane anaesthesia in neonates has not been quantitated at defined anaesthetic concentrations or compared with older infants.[2] The purpose of this study was to measure cardiovascular changes, using two-dimensional and pulsed Doppler echocardiography, during halothane anaesthesia in neonates.

Methods

After informed written parental consent was obtained, ten unpremedicated full-term neonates who required elective surgery had non-invasive cardiovascular measurements recorded

TABLE

	Awake	*1.0 MAC*	*1.5 MAC*
HR (beats·min^{-1})	144.4 ± 5.6	143.1 ± 4.1	132 ± 4.8*
MBP (mmHg)	57 ± 0.6	46.5 ± 1.6*	42.4 ± 1.4*
SV (ml·beat^{-1})	5.6 ± 0.6	4.0 ± 0.4*	3.4 ± 0.4*
CI (L·min^{-1} m^{-2})	3.6 ± 0.4	2.6 ± 0.3*	2.1 ± 0.3*
EF (% of control)	100 ± 8	75 ± 5*	66 ± 4*

prior to anaesthesia induction. Blood pressure, heart rate and two-dimensional and pulsed Doppler echocardiographic measures of left ventricular dimensions, pulmonary artery diameter and mean pulmonary artery velocity were recorded.

Following mask inhalation induction with halothane in O_2 and air, a second set of cardiovascular measures was made at end-expired halothane levels of 1.0 MAC (0.87 per cent)[3] approximately 15 minutes following induction. A third set of haemodynamic measures was collected after increasing the inspired halothane level to achieve 1.5 MAC (1.34 per cent) end-expired halothane levels (approximately ten minutes following the measurement made at 1.0 MAC). Measurements were completed prior to tracheal intubation and the start of elective surgery. Ventilation was controlled during the study period and mass spectrometry was used to measure and record capnograms and inspired and expired halothane and CO_2 concentrations.

Results were analyzed by a randomized block analysis of variance. Significance was accepted at $P < 0.05$. Results are presented as mean ± SEM.

Results

The mean age and weight of the neonates was 13.8 ± 2.8 days and 3.1 ± 0.1 kg. Heart rate decreased significantly during 1.5 MAC halothane. Significant decreases in mean blood pressure (MBP) were dose-related and occurred at both 1.0 MAC and 1.5 MAC halothane (Table). Stroke volume (SV), ejection fraction (EF) and cardiac index (CI) decreased significantly at 1.0 and 1.5 MAC halothane (Table).

Discussion

In this study, we found decreases in blood pressure of similar magnitude to prior clinical studies of neonates.[1,3] It has been suggested that the cardiovascular depression produced by inhalation anaesthetics may be similar in prematures, neonates and older infants, if measured at equivalent anaesthetic concentration.[1] In prior studies of older infants and small children (mean age 12 mos), changes in cardiac index and stroke volume index at 1.0 MAC and 1.25 MAC halothane were of lesser magnitude (approximately 15 per cent) than reported in these neonates despite the greater absolute anaesthetic requirement that exists for halothane in the older infants.[2] We found decreases in cardiac index, stroke volume and ejection fraction that indicate relatively severe myocardial depression (− 25 per cent decreases of EF, CI, SV) at concentrations of halothane equivalent to 1.0 MAC in neonates.

In summary, this study suggests that more profound myocardial depression does occur in the neonate than in the older infant and adult even when measured at equipotent anaesthetic concentrations.

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Intraoperative temperature monitoring sites in infants and children

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Previous studies indicate that "central" (e.g., tympanic membrane, oesophageal, and rectal) temperatures are similar in anaesthetized adults undergoing non-cardiac surgery.[1] We tested the hypothesis that the temperature of these sites is similar in children undergoing non-cardiac surgery. We also tested the hypothesis that airway heating and humidification influences lower oesophageal temperature.

Methods

With approval from our Ethics Committee, we studied 20 children weighing 5–30 kg undergoing peripheral surgery. Halothane/N_2O anaesthesia was administered with a modified Ayre's t-piece. Fresh gas flow was calculated using the formula of Rose and Froese,[2] respiratory rate (≈30·min^{-1}) and tidal volume (≈12 ml·kg^{-1}) were adjusted to maintain and end-tidal PCO_2 near 35 mmHg. The patients were randomly assigned to *active* airway humidification and warming using a Fisher and Paykel warmer set at 37° C, *passive* airway humidification using the Humid-Vent 1 heat and moisture exchanger, or no airway humidification and heating (control). Tympanic membrane, oesophageal, rectal, axillary, forearm, and fingertip temperatures were recorded every 10 min during surgery. The temperature of each measurement site was subtracted from tympanic membrane temperature and the results from each site at each time were averaged to determine temperature differences. Differences between groups were determined using ANOVA and Student-Newman-Keuls tests ($P \leq 0.05$ was considered significant).

Results

Figure 1 shows that oesophageal, rectal, and axillary temperatures usually differed from tympanic membrane temperatures by < 0.2° C ($P > 0.05$). In contrast, the peripheral skin-surface temperatures were 1–3° C below tympanic membrane temperatures. Oesophageal temperatures in patients receiving active and passive airway humidification were ≈0.25° C *higher* than tympanic temperatures whereas temperatures in patients without airway humidification were ≈0.25° C *below* tympanic temperatures ($P \leq 0.05$) (Figure 2).

Discussion

Oesophageal, rectal, and axillary temperatures rarely differed from tympanic membrane temperatures by more than 0.2° C.

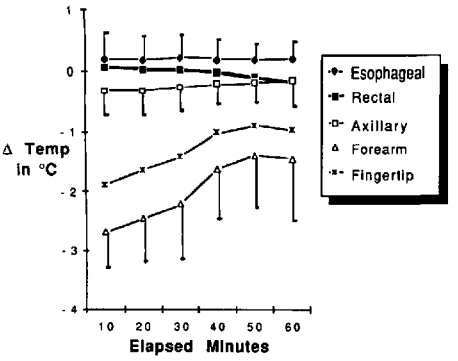

FIGURE 1 The mean difference between temperature at five different measurement sites and tympanic membrane temperature during the first 60 min of surgery in 20 infants and children. Vertical bars show the standard deviation of the mean. Tympanic membrane oesophageal, rectal, and axillary temperatures did not differ significantly. In contrast, the peripheral skin-surface temperatures (forearm and fingertip) were significantly lower than the central temperatures and significantly different from each other. Fingertip temperatures were warmer than forearm temperatures in these relatively warm, vasodilated patients.

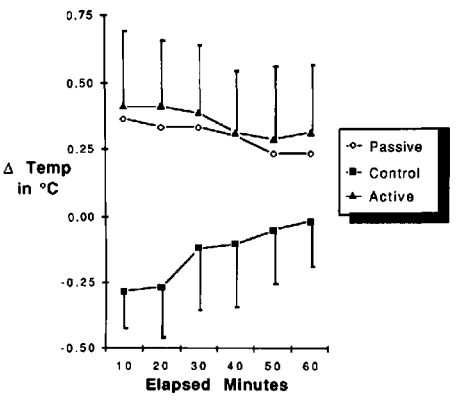

FIGURE 2 The average difference between oesophageal temperature and tympanic membrane temperature in infants and children receiving different airway humidification and/or heating. Vertical bars illustrate the standard deviation of the mean. Oesophageal temperatures in the control group differed significantly from those of the groups given passive and active humidification.

This difference is small, compared with the physiological differences among individuals, and the decrease in temperature needed to trigger thermoregulatory responses in anaesthetized humans.[3] Thus, any one of these temperatures identifies the bulk of central thermoregulatory responses input in children undergoing non-cardiac surgery. In contrast, forearm and fingertip skin-surface temperatures differed significantly from tympanic membrane temperatures, indicating that skin-surface measurements are not a substitute for determining central temperatures. Oesophageal temperatures were slightly, but significantly, increased when patients were ventilated with warmed and/or humidified respiratory gases.

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Transcutaneous CO_2 monitoring during spinal anaesthesia in patients under 6 months of age undergoing inguinal hernia repair

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Spinal anaesthesia is frequently employed in high-risk infants undergoing inguinal hernia repair. This study examines the effects of spinal anaesthesia to the upper thoracic (T4) level on oxygenation and ventilation of infants under 6 months of age.

Methods

With institutional approval and informed consent, we studied 11 patients under the age of 6 months undergoing inguinal hernia repair. The patients were unpremedicated, neurologically normal ASA physical status II and III patients, ten of whom were expremature. A Sensor Medics transcutaneous CO_2 (TCO_2) monitor was placed on the infant's chest prior to induction of anaesthesia. Other routine monitors were applied in the operating room prior to administration of spinal anaesthesia. Hyperbaric tetracaine one per cent in a dose of 0.4 $mg \cdot kg^{-1}$, with dextrose ten per cent 0.4 $ml \cdot kg^{-1}$ was used for all patients in this study, with a minimum dose of 1.0 mg tetracaine. The level of sensory anaesthesia was tested using patient response to a peripheral nerve stimulator set at tetanus. Supplemental sedation was provided with ketamine in two patients and N_2O/O_2 in three patients. TCO_2 monitoring was continued until patient discharge from the post-anaesthesia recovery room. Data examined included baseline values and intraoperative ranges for both SaO_2 and TCO_2.

Results

All patients had a history of pulmonary dysfunction and/or currently required home apnoea monitors. Postconceptual age ranged from 34 to 56 weeks; weights from 1.5 to 7 kg. Nine of the 11 patients maintained an SaO_2 of 100 per cent while breathing room air (see Table). Two patients who were on home O_2 therapy received supplemental O_2 in the perioperative period equivalent to that which they required at home (FiO_2 0.25–0.30), and maintained an SaO_2 of 94–100 per cent. Preoperative

TABLE

Patient	*PC age*	*SaO_2*	*baseline/range*	*TCO_2*	*baseline/range*
1	56 wks	%	100/100	mmHg	44/40–50
2	41		100/100		32/30–34
3	44		100/100		38/30–44
4	40		100/100		38/30–35
5	47		100/100		34/34–39
6	86		96/96-100*		48/33–44
7	45		100/99-100		44/30–44
8	41		94/96-100*		55/55–62
9	44		100/100		38/36–40
10	37		100/100		44/40–48
11	46		100/100		36/34–36

*Received supplemental oxgyen at same FiO_2 as required at home.

TCO_2 values ranged from 32–44, with the exception of the two patients mentioned above who had baseline TCO_2's of 48 and 55. Individual variation in TCO_2 during the perioperative period was ±13 from baseline. There were no consistent patterns of change in TCO_2 during the monitoring period. Values recorded were within acceptable limits for activities of daily life consistent with the baseline TCO_2 readings.

Discussion

Our results indicate that spinal anaesthesia to the T4 level had no deleterious effects on oxygenation or ventilation in this group of high-risk infants, who required minimal or no sedation during inguinal hernia repair with this regional anaesthetic technique.

Effect of time on the serum concentration of Ranitidine and gastric fluid pH in young children

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Ranitidine increases gastric fluid pH by suppressing acid secretion by the gastric mucosal parietal cells. Blumer *et al* reported that the serum concentration of ranitidine was maximum and the acid secretions were minimum 2-3 hours after administration of oral ranitidine in adolescents.[1] However, the time interval for maximum acid suppression in younger children is unknown. Therefore, we investigated the relationship between the serum concentration of ranitidine and gastric fluid pH after administration of an oral preparation of ranitidine.

Methods

This prospective randomized multi-centre trial was approved by the local ethics review committees. Informed written consent was obtained from the parents of 240 children. All children were one to six years of age, ASA physical status I or II and unmedicated. The children were randomly assigned to one of four oral regimens: Group I – placebo and 5 $ml \cdot kg^{-1}$ apple juice; Group II – 2 $mg \cdot kg^{-1}$ ranitidine with 5 $ml \cdot kg^{-1}$ apple juice; Group III – placebo and 5 ml water; and Group IV – 2 $mg \cdot kg^{-1}$ ranitidine with 5 ml water. These regimens were administered at least two hours preoperatively. After induction of anaesthesia, a Salem 16-gauge orogastric tube was inserted into the stomach and gastric fluid was aspirated. The pH of the aspirate was measured using a calibrated pH meter. A 5 ml venous blood sample was obtained at the time of gastric fluid aspiration to measure the serum concentration of ranitidine. Statistical significance ($P < 0.05$) was determined using ANOVA.

Results

The preliminary results of 66 patients with a mean age of 4.5 ± 0.2 years are presented. Both the serum concentration of ranitidine and gastric fluid pH decreased as the time interval after administration of oral ranitidine increased from two to six hours in Groups II and IV (Figures 1 and 2). None of the children in these groups had serum concentrations of ranitidine of <32 $ng \cdot ml^{-1}$.

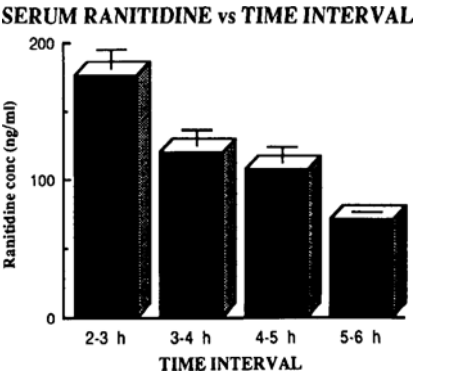

FIGURE 1 Data are means ± SEM.

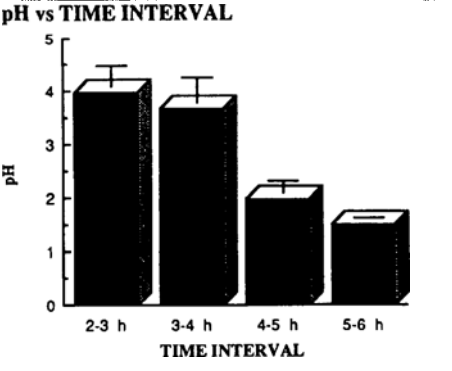

FIGURE 2 Data are means ± SEM.

Discussion

This preliminary report demonstrates that 2 $mg \cdot kg^{-1}$ of the oral liquid preparation of ranitidine maintains the mean serum concentration of ranitidine above 100 $ng \cdot ml^{-1}$ for up to five hours. However, the mean gastric fluid pH decreased to 1.9 after four hours. The results of this study suggest that gastric fluid pH is effectively maintained above 2.5 for four hours after administration of 2 $mg \cdot kg^{-1}$ of an oral liquid preparation of ranitidine.

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$P_{ET}CO_2$ as a monitor of change of $PaCO_2$ in children with congenital heart disease

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End–tidal PCO_2 ($P_{ET}CO_2$) measurement underestimates arterial PCO_2 ($PaCO_2$) in children with certain congenital heart defects.[1,2] In the studies cited above the children were examined under haemodynamically stable conditions at one time. The current study was designed to determine the change in the arterial to end–tidal PCO_2 difference (ΔPCO_2) over a given period of time in children with congenital heart disease (CHD).

Methods

With approval from the hospital ethics committee, 26 patients >11 months in age and >6 kg in weight were studied. All patients were scheduled for corrective or palliative cardiac surgery.

Infants and children were classified according to their cardiopulmonary diagnosis as determined from physical, echocardiographic and/or angiographic examinations. These children were classified on the basis of their pulmonary blood flow (PBF) as: acyanotic with normal cardiac anatomy (control, n = 2); acyanotic with increased PBF (shunting-acyanotic, n = 10); cyanotic with decreased PBF (shunting-cyanotic, n = 6); and cyanotic with normal or increased PBF (mixing-cyanotic, n = 8) (Figure).

All children were studied at normothermia in the supine horizontal position after induction of anaesthesia and intubation. Distal $P_{ET}CO_2$ was sampled continuously using a puritan-Bennett/Datex model 253 infrared analyzer calibrated prior to each use. Simultaneous $P_{ET}CO_2$ recordings and $PaCO_2$ measurements were obtained during five events: (1) placement of arterial line (control), (2) patient preparation (time 1), (3)

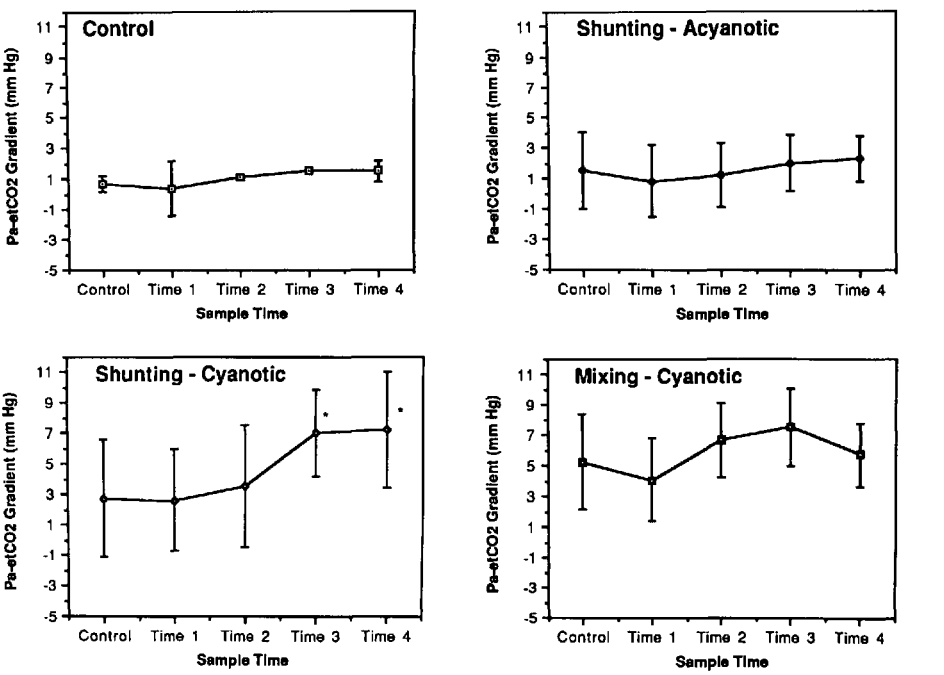

FIGURE *Statistically significant compared with control value.

post-sternotomy (time 2), (4) post-heparin administration (time 3) and (5) aortic cannulation (time 4).

Statistical significance was determined using one-way and repeated ANOVA and the Tukey test for multiple comparison $P < 0.05$.

Results

There was no significant difference in the distribution of ages among the four groups. The weight in the control group was significantly greater than in the other 3 groups. The graphs depict the ΔPCO_2 over time for each group. At the times designated as events 3 and 4, ΔPCO_2 in the children with shunting-cyanotic lesions was significantly different compared with control (event 1).

Discussion

These data suggest that although $P_{ET}CO_2$ measurements are reliable as a monitor of change of $PaCO_2$ in patients with acyanotic shunting (increased PBF) and mixing (normal or increased PBF) lesions, $P_{ET}CO_2$ is inappropriate as a monitor of change of $PaCO_2$ in children with cyanotic shunting (decreased PBF) lesions.

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Nonpulsatile cardiopulmonary bypass decreases cerebreal metabolic rate by fuctional cerebral capillary closure

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Nonpulsatile cardiopulmonary bypass (CPB) has been shown to reduce cerebral metabolism in both animals[1] and man.[2,3] The aetiology of this metabolic reduction is unclear but it may reflect either decreased synaptic transmission or other mechanisms, e.g., capillary closure.[1] Decreased synaptic transmission would reduce the total cerebral metabolic rate for oxygen ($CMRO_2$) without affecting the metabolic requirements for neuronal integrity (i.e., basal cerebral oxygen consumption, $BCMRO_2$), thus increasing the ratio $BCMRO_2/CMRO_2$. Capillary closure would reduce both total $CMRO_2$ and $BCMRO_2$ but should preserve their proportional ratio. By estimating $BCMRO_2$ using deep thiopentone anaesthesia,[4] and comparing the ratio $BCMRO_2/CMRO_2$ in the presence or absence of normothermic CPB, this distinction was made.

Methods

Following institutional approval and after obtaining written informed consent, 17 patients 32 ± 6 yrs undergoing accessory pathway cryoablation surgery[3] were assigned to either control group (n = 8) or normothermic CPB group (n = 9). Cerebral blood flow (CBF) was measured using a ^{133}Xe clearance technique, and insertion of a catheter into the jugular bulb enabled sampling of effluent cerebral venous blood for calculation of $CMRO_2$.[2,3] Cerebral perfusion pressure (CPP) was calculated as the difference between mean arterial pressure and jugular venous pressure, and nasopharyngeal temperature (NPT) was used to estimate brain temperature. For $BCMRO_2$ determination, thiopentone was administered in sufficient dosage to produce a burst/suppression EEG pattern (duration of burst <1/3 isoelectric duration) using a 10-channel EEG. Anaesthesia was induced and maintained with sufentanil 20 $\mu g \cdot kg^{-1}$. Following sternotomy, control CBF and $CMRO_2$ measurements were made in both groups. In the control group, thiopentone was administered and CBF and $BCMRO_2$ measurements were made. In the CPB group, after heparin 400 $iu \cdot kg^{-1}$, nonpulsatile normothermic CPB was established at a flow rate of 2.2 to 2.5 $L \cdot min^{-1} \cdot m^{-2}$, using a Cobe CML® membrane oxygenator and arterial line filter. During CPB, repeat CBF and $CMRO_2$ measurements were made, followed by thiopentone administration for CBF and $BCMRO_2$ measurements. An unpaired t test was used to compare control CBF and $CMRO_2$ measurements. The effect of nonpulsatile CPB was assessed by comparing the ratio $BCMRO_2/CMRO_2$ in control and CPB groups. Alpha <0.05 was significant.

Results

Prior to CPB there was no significant difference in CBF, $CMRO_2$, NPT, $PaCO_2$, CPP or haemoglobin concentration between groups. There was no significant difference in CPP or $PaCO_2$ between either group during the $BCMRO_2$ determination. With institution of CPB, both CBF and $CMRO_2$ were significantly reduced (CBF 28 ± 4 vs 37 ± 8 $ml \cdot 100\ gm^{-1} \cdot min^{-1}$; $CMRO_2$ 1.31 ± 0.2 vs 2.29 ± 0.3 $ml \cdot 100\ gm^{-1\ min-1}$), and $BCMRO_2$ was significantly lower in the CPB group vs the control group (0.90 ± 0.2 vs 1.62 ± 0.9 $ml \cdot 100\ gm^{-1} \cdot min^{-1}$). The ratio $BCMRO_2/CMRO_2$ was unchanged in the control group (74.6 per cent) vs the CPB group (69 per cent).

Discussion

The initial CBF and $CMRO_2$ were similar in both groups demonstrating comparability of the sample populations. The significant reduction in CBF and $CMRO_2$ with onset of nonpulsatile CPB is consistent with what has been previously demonstrated, and the similarity of the ratio $BCMRO_2/CMRO_2$ in the two groups suggests that it is capillary closure rather than cerebral depression that accounts for the reduced metabolic activity observed. Since this reverses after weaning from CPB,[2,3] it likely represents functional capillary closure rather than cerebral microembolization,[1] and may be remediable with pulsatile CPB.

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Immune dysfunction after pediatric open heart surgery

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The effects of cardiac surgery on cellular and humoral immunity in children is unknown. This study was undertaken to evualuate cellular and humoral immune function following cardiac surgery.

Methods

Institutional approval and informed parental consent were obtained for 24 patients (3 months to 12 years) undergoing cardiac surgery for repair of congenital cardiac defects. All patients were anaesthetized with halothane and oxygen and maintained with fentanyl (10–40 $\mu g \cdot kg^{-1}$) and pancuronium (0.15 $mg \cdot kg^{-1}$). Patients were studied before commencement of cardiac surgery and one hour and 24 hours postoperatively for blastogenic response (BR) of the lymphocyte to various mitogens and antigens, T cell subsets (CD3, CD4, CD8) and serum levels of complement (C3, C4) as well as immunoglobulins (IgG, IgM, IgA). Intraoperative events and postoperative severity of illness (PRISM) score[1] were assessed.

Results

Patient ages ranged from 3 mo to 12 yrs. Five patients had trisomy 21. Five children had closed procedures and 19 had open heart surgery. Partial thymectomy was also performed in 5 patients. Compared with preop values, significant suppression ($P < 0.05$, Student's t test) of C3, C4, Ig, IgM and of BR to tetanus toxoid was observed one hour post-op. C3 and C4 levels remained depressed and Ig levels and BR recovered on first post-op day. Closed heart procedures were associated with little change in immunity. Bypass snd cross-clamp time, degree of cooling, surgery and anaesthetic time, blood loss and postoperative severity of illness did not correlate with immune suppression. Partial thymectomy and trisomy 21 did not affect changes in immunity following surgery. There was one case of postoperative pneumonia with bacteremia, and two cases of prolonged unexplained fevers. Immune suppression in these patients was similar to that in patients without infection.

Discussion

Studies have shown that acute tissue injury by trauma or surgery causes suppression of immune functions. Humoral immunity is impaired due to depression of circulating B cells. The different components of the phagocytic system are depressed. However, the most consistent impairment of the immune system is manifested in the cellular immune system. Studies carried out on healthy adults who underwent elective surgery were found to have depression of the total lymphocyte B and T cell counts, of skin test reactivity, and of the *in vitro* proliferative response of lymphocytes to mitogens. The immunosuppressive effect of anaesthesia and surgery lasted from three to five days for most variables except for skin test responses, which returned to normal two to three weeks postoperatively.[2]

Cardiopulmonary bypass also has significant immunosuppressant effects. The rapid movement of immune cells and proteins through the cardiopulmonary pump causes cellular destruction complement activation which may contribute to depressed immunity.

We have demonstrated in this study that both the humoral and the cellular immune systems are suppressed after paediatric open heart surgery. The role of this immune suppression in postoperative morbidity is yet to be determined.

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Source of plasma histamine during paediatric cardiopulmonary bypass

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Histamine is a biogenic amine implicated in many physiological and pathological processes. The cardiovascular effects of histamine include vasodilatation, pulmonary vasoconstriction, cardiac dysrhythmias and increased capillary permeability. During and following paediatric cardiopulmonary bypass (CPB) these are events which may be detrimental to patient stability. Elevated histamine levels have been reported during cardiopulmonary bypass[1] but the source of histamine is unclear. Damage to hasophils in the pump has been postulated, also allergic reactions to anaesthetic drugs and protamine. This study postulates the lungs as a source of histamine release during the initial phases of reperfusion.

Methods

Five children undergoing cardiopulmonary bypass for a variety of procedures for correction of congenital heart disease were studied (age range: 3.5–8 years). Patients on drugs known to affect histamine release were excluded. All children recieved a standard pre-medication of Injection Pethidine Compound 0.07 $ml \cdot kg^{-1}$ with atropine 0.2–0.3 mg if weight >15 kg or papaveretum 0.4–0.5 $mg \cdot kg^{-1}$ with hyoscine 0.008 $mg \cdot kg^{-1}$, one hour prior to surgery. Anaesthesia was induced with cyclopropane and oxygen or thiopentone, and relaxation achieved with pancuronium. After intubation and the placement of arterial and CVP lines an initial baseline blood sample was taken. Subsequent samples were taken during surgery after any event, e.g., heparin, start of bypass. All samples were taken from the right atrial (RA) CVP line until a left atrial (LA) line could be inserted by the surgeons prior to coming off bypass. Parallel samples were then taken from RA and LA and again one and five minutes after inflation of the lungs. All samples were taken into EDTA on ice and spun as soon as possible in a cold centrifuge (2000 rpm for 10 min). The plasma layer was then removed and the samples frozen at −20° C until assayed. A radioenzymatic assay technique was used.[2]

TABLE Plasma histamine levels ($ng \cdot ml^{-1}$) pre- and post-reventilation

		Ventilation	
Patient	*Pre-reventilation*	*+1 min*	*+5 min*
1 RA	1.34	0.78	0.59
LA	1.05	1.09	1.56
2 RA	0.02	0.33	0.45
LA	0.02	–	1.90
3 RA	1.20	0.63	1.34
LA	0.65	0.64	2.08
4 RA	1.24	1.02	0.02
LA	–	–	0.09
5 RA	1.28	1.94	1.23
LA	1.03	–	1.60

Results

Two subjects had slightly elevated histamine levels (1.39 and 1.13 $ng \cdot ml^{-1}$) after induction of anaesthesia but these returned to normal prior to initiation of bypass. Elevated histamine levels (>1 $ng \cdot ml^{-1}$) occurred at the start of CPB in one patient. RA and LA levels were comparable before reventilation in all subjects (Table). The actual RA level was elevated in two subjects. After reventilation LA levels were higher than RA levels in three subjects. The LA level rose in one child after coming off bypass.

Discussion

This study demonstrates a difference between RA and LA histamine levels after reventilation of the lungs in some children. These findings suggest that histamine is liberated in the pulmonary vasculature at the time of reventilation and consequent reperfusion. Histamine thus may play a role in intraoperative dysrhythmias and hypotension, and in children with pulmonary hypertension may be implicated in increasing vascular reactivity perioperatively. The identification of a possible source of histamine release during CPB allows for the possiblity of effective therapeutic intervention.

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Dopamine induced renal vasodilation: Interactions with AMP and SNP

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Reduction in afterload can favourably influence myocardial oxygen supply demand balance and increase cardiac output in hypertension and cardiac failure. Adenosine monophosphate (AMP), an endogenous nucleotide, is an effective arterial vasodilator and in combination with dopamine (DA) causes a more profound increase in cardiac output than DA alone or a DA sodium nitroprusside (SNP) combination. Adenosine receptor stimulation has, however, been associated with renal vasoconstriction. We have studied the effects of SNP and AMP on renal blood flow in the dog and their influence on DA-induced renal vasodilation.

Methods

Eight mongrel dogs were anaesthetized with pentobarbital (30 $mg \cdot kg^{-1}$), their tracheas were intubated and their lungs ventilated. Anaesthesia was maintained by a constant infusion of pentobarbital (3 $mg \cdot kg^{-1} \cdot hr^{-1}$) and fentanyl (20 $\mu g \cdot kg^{-1} \cdot hr^{-1}$). Arterial blood gases and end–tidal CO_2 were monitored and normality maintained. Arterial pressure (femoral artery), pulmonary artery and central venous pressures (Swan Ganz) and EKG were monitored continuously. Cardiac output was determined by thermodilution (Edwards Cardiac Output Computer). Renal blood flow was measured by an electromagnetic flow probe (Statham SP2022) placed on the left renal artery. After a 60-minute stabilization period, control values were obtained and AMP (0.2, 0.5, 1.0, 2.5 $mg \cdot kg^{-1} \cdot min^{-1}$) and SNP (2, 5, 10, 25 $mg \cdot kg^{-1} \cdot min^{-1}$) were infused alone and in combination with DA (5 $\mu g \cdot kg^{-1} \cdot min^{-1}$). Parameters were recorded after ten minutes at each level of drug infusion.

Results

AMP and SNP reduced arterial pressure in a dose-dependent fashion. Both drugs, alone and in combination, increased heart rate and cardiac index but AMP increased cardiac index significantly more than SNP. AMP caused a biphasic alteration in renal blood flow, an initial transient (30 sec) reduction in flow followed by a return to control values. At infusion rates that produced an equivalent fall in systemic vascular resistance index, renal vascular resistance index was equally reduced by both drugs. DA induced renal vasodilation was not antagonized by AMP or SNP.

Discussion

DA at doses of 5 $\mu g \cdot kg^{-1} \cdot min^{-1}$ or less increases renal blood flow by stimulation of DA_1 receptors found on the renal vasculature.[1] Adenosine (A_2) receptor stimulation causes systemic vasodilation but initial renal vasoconstriction.[2] Our data indicate that the beneficial effects of DA on the renal vasculature persist during AMP-induced systemic vasodilation. SNP has little effect on RBF, an expected result, given the maintenance of blood pressure within the autoregulatory range. Further studies are required to determine intrarenal distribution of blood flow and the effects on renal function of the above drug combinations.

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Alfentanil pharmacokinetics in patients undergoing abdominal aortic surgery

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Narcotic-based anaesthesia may reduce the incidence of postoperative complications in patients undergoing abdominal or thoracoabdominal aortic surgery.[1] However, fentanyl and sufentanil are eliminated very slowly in these patients. In general surgery patients, alfentanil is eliminated faster than fentanyl and sufentanil.[4] Therefore, we undertook this investigation to determine the pharmacokinetics of alfentanil in patients undergoing abdominal aortic surgery.

Methods

After approval from the faculty human studies committee, informed consent was obtained from patients scheduled for elective abdominal aortic surgery. Morphine 0.15 $mg \cdot kg^{-1}$ IM and scopolamine 0.006 $mg \cdot kg^{-1}$ IM were given preoperatively. Anaesthesia was induced with alfentanil 175 $\mu g \cdot kg^{-1}$ IV, given by infusion over 3.5 min. Metocurine-pancuronium (4:1) 0.0675 $ml \cdot kg^{-1}$ was given concurrently. After tracheal intubation, nitrous oxide 70 per cent (inspired) was begun. Prior to the start of surgery, the nitrous oxide was discontinued and a second dose of alfentanil, 125 $\mu g \cdot kg^{-1}$, was given over 2.5 min. No other anaesthetic agents were given until either heart rate or mean arterial pressure increased to 120 per cent of the values prior to incision. At that time diazepam, morphine, isoflurane, and/or nitrous oxide were administered. Intraoperatively, crystalloid was given to maintain pulmonary artery wedge pressure near the preinduction value, and packed red blood cells were transfused as needed. Vasoactive drugs were given at the discretion of the attending anaesthetist. Starting 30 sec after the end of the first infusion, arterial blood samples were drawn at increasing intervals over a 24-hr period. The serum was separated and stored at −20° C. Serum alfentanil concentrations were determined by gas–liquid chromatography using fentanyl as the internal standard. Two- and three-compartment models, allowing for two infusions, were fit to the concentration versus time date by nonlinear regression. For each patient, the appropriate model was chosen,[5] and pharmacokinetic variables were calculated using standard formulae.[6]

Results

Five male patients having a mean (± SD) age of 67.1 ± 5.6 years and a mean weight of 84.5 ± 8.4 kg were studied. The volume of the central compartment was 0.062 ± 0.015 $L \cdot kg^{-1}$, the volume of distribution at steady state was 0.78 ± 0.40 $L \cdot kg^{-1}$, and total drug clearance was 8.3 ± 1.1 $ml \cdot min^{-1} \cdot kg^{-1}$. The rapid and slow distribution half-times were 1.8 ± 0.3 and 30.1 ± 7.8 min, respectively, and the elimination half-time was 4.1 ± 3.2 hr.

Discussion

In general surgery patients, mean elimination half-times of alfentanil of 1–1.5 hr have been reported.[4] The mean clearance in our patients, 8.3 $ml \cdot min^{-1} \cdot kg^{-1}$, is slightly higher than previously reported values. In spite of this, the elimination half-time in our patients, 4.1 ± 3.2 h, is longer than in general surgery patients because of a larger volume of distribution. The mean elimination half-time of alfentanil patients undergoing abdominal aortic surgery is much shorter than that reported for fentanyl or sufentanil in comparable patients.[2,3] All the patients required additional anaesthetic agents within 1 hr of the start of surgery, confirming that alfentanil should be given by continuous infusion. Further studies are indicated to determine if intraoperative infusions of alfentanil provide the benefits of more potent opioids,[1] while allowing more rapid recovery.

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The effect of mixtures of pancuronium and vecuronium on heart rate during anaesthesia for coronary artery bypass surgery

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Pancuronium is widely used in cardiac anaesthesia because its vagolytic properties counteract the bradycardia associated with high-dose opiate anaesthesia. Thomson *et al.* have shown that pancuronium in combination with fentanyl may result in tachycardia and ischaemia in patients undergoing coronary artery surgery (CAS).[1] The newer agents sufentanil and vecuronium are gaining in popularity; however, concerns have been expressed about this combination leading to bradycardia and hypotension with resultant ischaemia.[2] The purpose of this study was to determine if a mixture of pancuronium and vecuronium could produce a stable heart rate on induction of anaesthesia with sufentanil for CAS.

Methods

Seventeen patients for elective CAS were studied. Premedication consisted of diazepam, morphine and scopolamine. Routine invasive monitoring lines were inserted. Induction of anaesthesia was with sufentanil 5 $\mu g \cdot kg^{-1}$ given over 3 min with one of the following mixtures of muscle relaxants: Group I, vecuronium 0.1 $mg \cdot kg^{-1}$; Group II, pancuronium 0.1 $mg \cdot kg^{-1}$; Group III, pancuronium 0.01 $mg \cdot kg^{-1}$ + vecuronium 0.09 $mg \cdot kg^{-1}$;

TABLE Heart rate ± SEM

Group	WA	BA	IND	INT1	INT10	INC	STE
1	66 ± 3	51 ± 4	50 ± 7	61 ± 6	50 ± 5	49 ± 4	48 ± 3
2	64 ± 6	56 ± 6	69 ± 7	74 ± 10*	68 ± 9	68 ± 8	60 ± 7
3	67 ± 4	57 ± 3	53 ± 3	57 ± 1	49 ± 2	49 ± 1	49 ± 1
4	69 ± 4	62 ± 5	54 ± 7	57 ± 6	57 ± 6	53 ± 5	56 ± 7

WA = ward; BA = baseline; IND = 1 min post-induction;
INT 1 = 1 min post-intubation; INT 10 = 10 min post-intubation;
INC = 1 min post-skin incision; STE = 1 min post-sternotomy.
*P <0.05 compared to baseline measurement.

Group IV, Pancuronium 0.02 $mg \cdot kg^{-1}$ + vecuronium 0.08 $mg \cdot kg^{-1}$.

The relaxant combinations were prepared by the OR pharmacist in identical blinded 20 ml syringes containing the induction dose. Twenty per cent of the muscle relaxant dose was administered 60 sec prior to injection of sufentanil. The balance of the muscle relaxant was injected after loss of consciousness. Haemodynamic profiles were taken pre-induction, post-induction, 1 min post-intubation, 10 min post-intubation, 1 min post skin incision, and 1 min post-sternotomy. Ward heart rates were the average prior to premedication obtained from the nursing notes. A 20 per cent change in blood pressure was treated with enflurane or phenylephrine and heart rates greater than 90 bpm were treated with propranolol. Data were analyzed with one-way ANOVA with Tukey testing for significant differences. Chi-square testing was used for proportions. A P value of <0.05 was considered significant. Partial results of an on-going study were analyzed for this report. Preoperative beta-blockade, age and intraoperative heart rate, cardiac index and beta-blockade use were reviewed.

Results

There were five patients in Group I, three in Group II, five in Group III and four in Group IV. There were no differences in the mean ages or frequency of preoperative beta-blockade between groups. There were no significant differences in heart rates between groups (Table) although there was a trend ($0.1 > p > 0.05$) to higher heart rates post-induction in Group II. At intubation the heart rate was significantly higher than at baseline in Group II. There were no differences in intraoperative beta-blocker use or in the cardiac indices.

Discussion

This study shows again that pancuronium is associated with an increase in heat rate which is accentuated at intubation. In a study examining the heart rate responses to pancuronium, Miller *et al.* showed that a dose of approximately 0.03 $mg \cdot kg^{-1}$ of pancuronium caused an increase in heart rate when given during halothane anaesthesia and he suggested that this cardiovascular effect was independent of the dose administered. In this study 0.01 and 0.02 $mg \cdot kg^{-1}$ of pancuronium combined with sufentanil and vecuronium did not significantly alter the heart rate, whereas 0.1 $mg \cdot kg^{-1}$ did. In the search for a stable induction sequence, particularly in the non beta-blocked patient, an induction which produces minimal changes in heart rate and systolic BP is highly desirable. In this study no severe bradycardias were seen with sufentanil-vecuronium, although they have been reported.[4] The combination of sufentanil with vecuronium 0.08 $mg \cdot kg^{-1}$ and pancuronium 0.02 $mg \cdot kg^{-1}$ produced a very stable heart rate throughout induction and intubation. This combination can be recommended and warrants further study.

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Saline filled cuffs help prevent polyvinylchloride laser induced endotracheal tube fires

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Tracheal tube fires are the commonest catastrophic event occurring during CO_2 laser surgery on the airway. While the shafts of combustible tracheal tubes can be protected, the cuff remains vulnerable to the effects of the laser. It has been recommended that tracheal tube cuffs be filled with saline during laser surgery to prevent their combustion.[1] We determined if laser contact with the cuff could progress to tracheal tube explosion and whether filling the tracheal tube cuff with saline would reduce these risks.

Materials and Methods

A LaserSonics CO_2 laser in the continuous mode, was adjusted to a power setting of 5 W for part 1 and 40 W in part 2. The cuffs of 8.0 mm ID PVC tracheal tubes (Mallinckrodt Hi-Lo, St. Louis, MO) were inserted into the necks of Pyrex flasks. Five litres of O_2 flowed into the tracheal tubes until the cuffs were inflated. In part 1, the times to loss of airway pressure were noted while in part 2, times to tracheal tube explosion, if any, were recorded. If no ignition occurred after 60s, the laser was discontinued. Five trials of air and saline filled cuffs were studied in each part.

Results

The Table shows the times to cuff perforation and circuit deflation of both air and saline filled cuffs.

In part 1, saline filled cuffs exposed to 5 W continuous laser radiation perforated as quickly as did air-filled ones. However, owing to the greater density and viscosity of water, leakage from the saline-filled cuffs was slower and allowed a longer interval

TABLE Times to cuff perforation and circuit deflation (s)

Cuff	*n*	*Perforation (mean ± SD)*	*Deflation (mean ± SD)*
Air	5	1.10 ± 0.83 s	2.59 ± 1.97 s*
Saline	5	4.21 ± 3.91 s	104.6 ± 67.5 s*

*P = 0.029 (significant difference), paired Student's t test.

before cuff leakage caused circuit decompression. No combustion occurred.

In part 2, during all five trials using the air-filled cuffs, a tracheal tube explosion occurred in less than 1 sec. The water-filled cuffs were efficacious at preventing laser-induced tracheal tube explosions in all but one trial, during which the tube ignited in 5.19 sec. The Mann-Whitney U Test was used to compare the incidence of flammability in the two groups of tracheal tubes. It revealed a statistical significant difference at $P < 0.05$.

Discussion

The shafts of tracheal tubes can be protected from the CO_2 laser by foil wrapping with the correct metallic tape.[2] The cuffs of tracheal tubes remain vulnerable to the effects of the laser beam which may be directed at them during laryngological surgery.[1] Cuff perforation by the CO_2 laser was not inhibited by saline filling; however, the saline filled cuffs were slower to deflate. The use of saline-filled cuffs prevented tracheal tube explosion in most cases and is recommended. Tracheal tube cuffs should also be protected with wet pledgets.

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A random double-blind comparison of Rantidine and Famotidine for acid aspiration prophylaxis in morbidly obese patients

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During induction of general anaesthesia, morbidly obese patients are at risk of acid aspiration.[1] Therefore, it is common practice to premedicate these patients with H_2 antagonists. Studies comparing cimetidine and ranitidine favour ranitidine for paucity of side-effects and drug interactions, as well as its longer duration of action.[2] It has also been shown that metoclopramide offers no additional protection.[2] The purpose of this study was to compare the efficacy of ranitidine with famotidine, a new H_2 antagonist, for prophylaxis of acid aspiration in morbidly obese patients.

TABLE

	Famotidine	*Ranitidine*
Sex	9 female/1 male	9 female/1 male
Age (yr)	32 ± 10	41 ± 5*
Weight (kg)	131 ± 19	129 ± 2
Height (kg)	165 ± 7	165 ± 6
BMI ($kg \cdot m^{-2}$)	49 ± 7	48 ± 7
Time fasting (min)	687 ± 141	747 ± 106
Time from premedication (min)	90 ± 0	96 ± 20
Gastric pH	6.36 ± 2.24	6.80 ± 1.24
Gastric volume (ml)	22 ± 30	20 ± 22
Volume >25 ml (# pts)	2	4
pH <2.5 (# pts)	1	0
At risk (# pts)	1	0

* Statistically different from famotidine $P < 0.05$. Values are mean ± SD.

Methods

After institutional ethics approval and informed written consent, 20 morbidly obese patients undergoing surgery for gastric stapling were enrolled in this double-blind study. Subjects were randomly assigned to receive either famotidine 20 mg, or ranitidine 100 mg IV, 90 minutes prior to surgery. No other premedication was given. Patients were fasting for a minimum of 8 hr prior to the induction of anaesthesia. The duration of fasting and the time elapsed between the administration of the study drug and the time of intubation were recorded. Anaesthesia was induced with thiopentone and succinylcholine, given in a rapid sequence fashion. Intubation was performed while cricoid pressure was applied. After intubation an 18 Fr. oral gastric tube was inserted. To ensure complete emptying, the stomach was manually compressed by the surgeon. Within ten minutes after sample collection, volume and pH were measured using a calibrated syringe and Corning digital pH meter. Statistical assessment of the data was performed using a Student's t test and chi square analysis for parametric and nonparametric data respectively.

Results

We studied 20 subjects, ten per group, who were similar with respect to sex, height, weight, body mass index, time fasting and time elapsed from test drug administration until gastric sampling (see Table). Despite the randomized, double-blind nature of the study, there was a statistically significant difference in the average age of the two groups. It is unlikely that this represents a clinically important difference. Famotidine and ranitidine were similarly effective in reducing gastric volume and pH. In one subject from each group no gastric sample could be aspirated and surgical palpation of the stomach confirmed that it was empty. Two patients in the famotidine group and four in the ranitidine group had gastric volumes >25 ml. Using standard criteria to identify patients at risk of acid aspiration, which require the presence of both gastric volume of >25 ml and pH of <2.5, then only one patient remained at risk. In this patient (from the famotidine group) gastric volume was 100 ml and pH was 1.57.

Discussion

We conclude that ranitidine and famotidine are similarly very

effective in reducing gastric pH and volume. However, one patient did remain at risk of acid aspiration. Moreover, although pH is felt to be the more critical of the two factors it is still noteworthy that six of the 20 patients had residual gastric volumes of >25 ml. Finally, it is unsafe to assume that H_2 antagonists will *always* be successful in abolishing the risk of acid aspiration. In this patient population, we therefore advocate the continued use of rapid sequence induction, with applicaiton of cricoid pressure, *in addition to* premedication with an H_2 antagonist.

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Hazards of CO_2 laser reflection from laser-resistant endotracheal tubes

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In an effort to prevent laser-induced tracheal tube fires, foil-wrapped rubber or polyvinylchloride or special metallic tracheal tubes have been used. However, these tubes may reflect the laser's energy with potential risk to the patient. We have sought to determine the likelihood of indirect damage by CO_2 laser radiation reflected from either a specialized metallic tracheal tube, or from metal foil coverings used to protect conventional, flammable, endotracheal tubes.

Materials and Methods

A LaserSonics (Santa Clara, CA) model 880 CO_2 laser in the continuous mode was used with a Zeiss Universal S2 operating microscope and 400 mm objective. The laser's output was adjusted to 40 W and 0.68 mm spot diameter. Four tracheal tubes were evaluated: Rusch (W. Germany) red rubber (RR) 8.0 mm ID tracheal tubes were wrapped with aluminum (Al) adhesive foil tape (#425, 3M Corp., St. Paul, MN, USA) and with copper (Cu) adhesive foil tape (Venture Tape Co., Rockland, MA, USA). The other tubes studied were a Mallinckrodt (St. Louis, MO) Laser-Flex steel metallic tube, and a 7.0 mm ID polyvinylchloride (PVC) tracheal tube, covered with a Laser-Guard® (American Corp., Mystic, CT, USA) covering. This product consisted of an adhesive, corrugated silver (Ag) foil bonded to a thin, absorbent sponge layer, which was saturated with water. A ring stand was used to hold the straightened tracheal tubes vertically. They were centred within cardboard tubes of diameter 45 mm and length 115 mm. The laser was aimed to reflect from the tracheal surfaces at a 45 degree angle onto the cardboard. All trials were conducted in room air. Ten trials on each tube were done. The times to a burn perforating the cardboard were recorded. One-way ANOVA was used to determine statistically significant differences between mean times.

Results

Reflection from the Al and Cu foil-wrapped tubes caused combustion in 1.41 ± 0.54 (mean ± SD) and 1.73 ± 0.93 sec, respectively. The Laser-Guard Ag covering caused combustion after 3.70 ± 2.18 sec, a significantly longer interval than that of the Al ($P < 0.005$) or that of the Cu ($P < 0.02$). The Laser-Flex tube caused combustion after 9.26 ± 3.4 sec, a significantly greater interval than the Laser-Guard covering ($P < 0.003$), the Cu ($P < 1.5 \times 10^{-5}$), or the Al ($P < 6.2 \times 10^{-6}$).

Discussion

The reflectivity of laser light from a smooth, conducting surface is a complex physical phenomenon. It has been stated[1] that for an incident beam of intensity I_i, the reflected intensity is $I_r = I_i - I_a$, where transmission of the beam through the conductor is negligible, and where I_a is the amount of beam absorbance in the conductor. Thus increased absorbance of the beam energy will decrease the energy reflected. Here the Laser-Guard (Ag foil) and Laser-Flex surfaces were apparently superior in absorbing beam energy. Silver has a higher thermal and electrical conductivity than other metals, and the steel tube of the Laser-Flex is thicker than the Al or Cu foils, hence it has greater thermal capacity. It must be emphasized that unintended laser damage to tissues by reflection as shown in this experiment is possible when metallic endotracheal tubes or foil surfaces are used to prevent direct laser-induced endotracheal tube combustion.

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Environmental heat exchange measured with heat flux transducers

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Hypothermia, core temperature <35° C, remains a common complication of major surgery. To investigate this problem we have directly measured the heat loss from volunteers exposed in a measured thermal environment.

Method

Measurements

Seven volunteers lay on a water recirculating thermal mattress (CSZ Blanketrol II) which was set to 30° C and then raised to 33, 37 and 40° C. Heat Flux Transducers (HFT) (Thermonetics, San Diego, Calif.), a modern development of thermocouple technology, were used to measure heat exchange. Three HFTs were distributed in a triangle on the volunteer's exposed chest and three on the back in contact with the thermal mattress. The HFT output was averaged over one minute and recorded every minute. The measurements of the thermal environment were: air velocity (v) in metres · second^{-1} ($m \cdot s^{-1}$) – measured with a calibrated omnidirectional hot-wire anemometer; air temperature (Ta) – measured with a calibrated thermocouple shielded

from radiation; mean radiant temperature (Tmr) – calculated from the internal temperature of a 15 cm black copper globe (Tg), where $Tmr = Tg + 2.2\sqrt{v}(Tg - Ta)$.[1] Skin temperatures, at the centre of the HFT distribution, were measured on the chest (Ts), on the back (Tb) and at the mattress (Tm). Air velocity was varied between 0.12 ± 0.005 (SD) and $1.56 \pm 0.003\ m \cdot s^{-1}$ by a 24″ diameter fan directed along the long axis of the body. Heat exchange was taken as the average output of each group of 3 HFTs. Temperatures were recorded every five minutes and air velocity every ten minutes. All experimental runs lasted 30 minutes and began when temperatures were stable within ± 0.2° C and HFT readings within ± 10 per cent.

Calculations

Standard equations were used to calculate heat exchange.[2]

Heat loss, radiation

$Qr = \sigma(Ks^4 - Kmr^4)\ [W/m^2]$ (σ = Stefan-Boltzmann constant; K = temperature in Kelvin). This equation can be simplified and expressed in °C, without the power function, as Qr = Hr(Ts − Tmr), where Hr = first power combined radiation coefficient.

Heat loss, convection

$Qc = Hc\sqrt{v}(Ts - Ta)\ [W/m^2]$ (Hc = coefficient of forced convection).

Heat exchange, conduction

Qk = Hk(Tb − Tm) (Hk = coefficient of conductance). On the back, heat exchange was by conduction (Qk). On the chest, total heat loss (Qt) was the sum of heat loss by radiation and convection, Qt = Qr + Qc, Kmr and Qr were calculated, so Qc = Qt − Qr. *Hr* was calculated as Qr/(Ts − Tmr); *Hc* as the slope of Qc/(Ts − Ta) versus $\sqrt{v}$; *Hk* as the slope of Qk versus (Tb − Tm). *Hrc*, the combined coefficient of heat loss by radiation and convection, when $v < 0.2$ m/s, was calculated as Qt/(Ts − Ta).

Results

$Hc = 8.65 \pm 0.25\sqrt{v}\ W \cdot m^{-2} \cdot °C$, n = 30, r = 0.988. The regression line was forced through the origin. $Hr = 6.2 \pm 0.18\ W \cdot m^{-2} \cdot °C$, n = 110. $Hk = 40.98 \pm 1.86\ W \cdot m^{-2} \cdot °C$, n = 38, r = 0.965, when (Tb − Tm) = +2.7 to −1.4° C. The regression line was forced through the origin. $Hrc = 9.87 \pm 1.5\ W \cdot m^{-2} \cdot °C$, n = 14.

Discussion

The values quoted in the literature for the coefficients Hc, Hr and Hrc are: $Hc = 8.3\sqrt{v}$; Hr = 6.7; Hrc = 10.2.[1-3] The close agreement between these values and ours suggests that our methods of measurement and analysis are accurate and reliable. No values of Hk for the thermal mattress have been published previously.

The clinical significance of our results can be illustrated in two ways. (1) Metabolic heat production under general anaesthesia is approximately $40\ W \cdot m^{-2}$. Since Hrc is $10\ W \cdot m^{-2} \cdot °C$, a temperature gradient between the patient, or his outer coverings, and the environment of more than 4°C will cause more heat to be lost than is produced – so that hypothermia is inevitable. The usual OR temperature gradient is at least 10° C. (This imbalance between heat production and loss can be prevented by providing adequate insulation [2 clo].) (2) The thermal mattress which we tested supplied $41\ W \cdot m^{-2} \cdot °C$. Used with attention to the covered body surface area and temperature gradient, this particular model is capable of effectively doubling the patient's heat production.

The direct measurement of heat exchange with heat flux transducers, when applied to patients undergoing surgery, will allow a better appreciation of the mechanisms and magnitude of the heat loss which produces hypothermia.

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A national survey of tertiary hospital preanaesthetic clinics

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The trend toward day surgery programs in Canada has been developing widely in recent years. The causes are multifactorial but include the fiscal restrictions applied in most provinces. Delivery of anaesthetic services to high-risk patients is now part of this trend. Thus, appropriate standards of care require preanaesthetic clinics (PAC's) to screen such patients and prepare them for anaesthesia and surgery. To help us develop such a program we conducted a cross-country survey of day surgery PAC's. The results of our findings are reported here.

Methods

A Sixteen Question Survey was circulated to Departments of Anaesthesia across Canada. All the hospitals surveyed nationally were tertiary care teaching hospitals with an average of 700 beds.

Basic demographic data regarding the hospital and the number of patients anaesthetized in 1982 and 1987 as in-patients or day surgical patients were requested. Information on PAC's and their administration was sought. Finally respondents were asked to predict the future development of day surgery and PAC's at their institutions.

Results

Replies were received from 10 of the 12 centres surveyed (83%). Of the hospitals surveyed four (40 per cent) currently have PAC's that operate on a regular basis. All these clinics are currently funded through fee-for-service income. In three centres, there are daily clinics; in all but one anaesthetists see consultations referred by physicians. Only one (McMaster) routinely reviews *all* day surgery patients and sees patients in consultation. A nurse practitioner reviews patients' charts and refers high-risk patients to an anaesthetist attending in the clinic.

The mean number of operative procedures in nine of the reviewed hospitals rose from 12,600 in 1982 to 15,400 in 1987

(mean 18 per cent). In 1982 day surgery patients constituted 15 per cent of this meaned total (Range 0–30 per cent) compared with 26 per cent (Range 1–50 per cent) in 1987. Those anaesthesia departments surveyed predicted a rise in the day surgery load to 46 per cent (Range 30–50 per cent) by 1990.

While only four of the hospitals currently have PAC's, four others are planning to develop clinics for the assessment of patients for day surgery. These latter four clinics are proposed as screening clinics run by nurse practitioners with problem patients referred to an anaesthetist (similar to the practice in McMaster).

Discussion

All institutions have seen an increase in their operative case load over the past six years. They see this continuing into the near future. However, all are experiencing a restriction in the availability of acute care beds. As a result more and more patients previously operated upon as in-patients are undergoing day surgical or same-day admission procedures. The figures in this study are similar to those in the USA where 18 per cent (1985) of surgery was outpatient and predicted to rise to 50–60 per cent.[1] In addition savings can be realized through lower rates of preoperative testing and the elimination of overnight stays.[2]

The respondents were uniform in their predictions regarding this changing pattern of practice; that current methods of processing patients for day surgery are deficient; and that new methods and standards need to be developed. McMaster Medical Centre has developed one model. Nine respondents state that they are in the process of developing a similar system for assessing patients prior to undergoing day surgical procedures.

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The effect of liability on the provision of anaesthetic care

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As part of the federal-provincial-territorial review on liability and compensation issues in health care, a survey of anaesthetists was undertaken to determine the effect of liability concerns on the practice of anaesthesia in Canada. A sample was drawn from a list generated in the 1986 Canadian Medical Association Manpower Study and included those practitioners who were engaged in full-time practice and spent time in direct patient care. Due to the small number of anaesthetists in some areas of Canada, the respondents were sampled in four regions: east, Quebec, Ontario, and west. The final stratified sample consisted of 649 physicians which was 41 per cent of the CMA list (n = 1558 for physicians claiming anaesthesia as part of their practice). The response rate to the mailed questionnaire was 81.5 per cent. A small number were subsequently excluded because they no longer practise anaesthesia or have retired, leaving an overall response rate of 73.3 per cent or 476 usable returns. Physicians were sent the questionnaire in the spring of 1988 followed by a reminder card and two subsequent mailings. The questionnaire consisted of 21 items developed in consultation with four anaesthetists asking the respondents' opinions on various aspects of how liability and other factors were affecting their practice in recent years.

The respondents

Of the respondents, 15.3 per cent were from the eastern region; from Quebec, 23.3 per cent; 30.7 per cent from Ontario; and 31.7 per cent from the west. School of graduation, duration in medical practice, solo versus group practice and length of post-graduate training were all documented.

Awareness of Liability Issues: the newsletter from the Canadian Medical Protective Association was the most frequently cited source of information with regard to liability issues, 92.9 per cent, and by far the most influential, 39.1 per cent. Only 18.7 per cent of anaesthetists had any personal involvement with liability, though this involvement was more frequent in the east, and increased with duration in practice.

Practice pattern

Most anaesthetists, 91.7 per cent, reported no change in the portion of their practice in general anaesthesia, but did show a decrease or exclusion from their practice of obstetrical anaesthesia or the administration of anaesthetics to children under two years of age. The most frequently chosen reason for this change was liability concerns (42 per cent). Physicians reported that they had made changes in their practice pattern within a specific type of anaesthetic practice during the past five years. About 41 per cent had changed their general pattern, 75 per cent of the respondents had made at least one change to their practice, including 65 per cent who had made specific drug changes. The reasons most commonly given for these changes were concerns about litigation and Guidelines of Practice of Anaesthesia as recommended by the Canadian Anaesthetists' Society.

Style of practice

A series of questions dealt with changes in style of practice, including use of monitoring, laboratory tests and documentation. Of the respondents, 93.8 per cent indicated they had increased the monitoring of patients during the last five years. Thirty per cent reported ordering more laboratory tests, *x*-rays and other investigations. Seventy-five per cent of respondents answered yes to the question "Have you increased documentation of what you have done or discussed on patient records during the past five years?" The most common reasons given for increased monitoring were the availability of monitors, but again, concerns about litigation, complexity of medicine, professional standards – were all factors. Spending more time with patients discussing the risks and benefits of treatment was reported by 63 per cent of respondents. Minor reasons cited for this were patient demand and suggestions from Continuing Medical Education. The most compelling concern was litigation.

Medical-legal concerns

We asked a series of questions in an attempt to assess the attitudes of anaesthetists with regard to medical-legal concerns. We scored the results on a 1 to 5 scale (strongly agree to strongly disagree). The means of these scores were then listed and tabulated. Results were also analysed by years in practice. Overall, physicians tended to agree that the physician-patient relationship has suffered in recent years. They felt that patients were more likely to sue their doctors than they were five years ago. They thought that patients did not understand the risks involved with procedures even when they were fairly explained, and that they had unrealistic expectations about modern medicine. There was also a trend towards a dissatisfaction with the practice of anaesthesia, especially in those with longer durations of practice, who felt that anaesthetic practice was more stressful and less satisfying in recent years.

Summary

Liability issues have had a profound effect on the practice of anaesthesia in the past five years. Liability concerns were rated as the first or second reason for making major changes in anaesthetic practice with perceived hassles of liability even more disconcerting than the increased cost of malpractice insurance. In general, Canadian anaesthetists are greatly concerned with medical legal issues, have changed their anaesthetic practice and moved away from areas of concern (obstetrical anaesthesia and neonatal anaesthesia) are monitoring their patients more closely, have changed their drug practices, are ordering more laboratory tests and are providing better documentation then they did five years ago. The attitudes of the Canadian anaesthetists have changed. Most report more hassles, reduced satisfaction and reduced satisfaction with their practice especially those with a longer duration of practice. The most common theme in practice change is the increased threat and hassle of medical-legal liability.

There can be no doubt that anaesthesia practice has improved in Canada, but how much of this improvement is because of medical-legal concerns, and how much has been due to the maturity and increased excellence of a vigorous specialty is not answered by the survey.

Effects of chlorpromazine on $[Ca^{2+}]_i$ in skeletal muscle

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The neuroleptic malignant syndrome (NMS) is an uncommon, life-threatening disorder associated with the use of neuroleptic agents. Among the neuroleptic agents most often used are haloperidol and chlorpromazine. We have studied the effects of chlorpromazine on intracellular free calcium concentrations ($[Ca^{2+}]_i$) by means of calcium selective microelectrodes in frog muscle fibres. Lumbricalis muscle bundles isolated from Leptodactylus insularis were used experimentally. The muscle fibres were mounted horizontally on an experimental chamber between a glass arm attached to a force transducer (Cambridge 200) and a stainless steel hook fixed to the bottom of the chamber. Calcium microelectrodes were prepared and calibrated as described previously (López *et al.* Biophys J 1983; 43: 1. The experiments were carried out at room temperature. At low chlorpromazine concentration (10^{-8} – 10^{-6} M), it induced an increment in the $[Ca^{2+}]_i$, which was related to drug concentration present in the bath. From a resting value of 0.10 ± 0.01 μM (n = 38), $[Ca^{2+}]_i$ was increased to 0.37 ± 0.02 μM (n = 10) to 0.60 ± 0.02 (n = 18), and 0.76 ± 0.04 (n = 16) in the presence of chlorpromazine 10^{-8}, 10^{-7}, and 10^{-6} M respectively. At higher concentrations, it produced a slow and irreversible contracture which was associated to the increment in $[Ca^{2+}]_i$. The $[Ca^{2+}]_i$ in the presence of 10^{-5} and 10^{-4} M chlorpromazine was 7.26 ± 0.55 μM (n = 8) and 8.68 ± 0.33 μM (n = 10) respectively. The addition of dantrolene (10^{-5} M) blocked the increment of $[Ca^{2+}]_i$ associated to the chlorpromazine effect, as well as the muscle contracture. In this study we have found that chlorpromazine induced an increase in $[Ca^{2+}]_i$ in amphibian muscle fibres, which was dosedependent (10^{-8} – 10^{-6} M). At higher concentrations (10^{-5} – 10^{-4} M) the increment in $[Ca^{2+}]_i$ was associated to a slow and irreversible contracture. Dantrolene was able to block the increment $[Ca^{2+}]_i$ in and the muscle contracture observed in the presence of chlorpromazine. The dantrolene effects might be mediated by its inhibitory action on calcium release. We have reported that high concentrations of

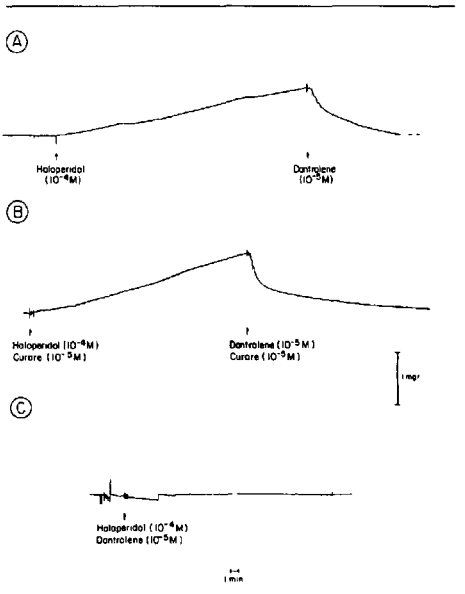

FIGURE A and B: Time course of the muscle contracture induced by haloperidol under different experimental conditions. Effects of dantrolene. C: Inhibitory effects of dantrolene on the muscle contracture induced by haloperidol.

chlorpromazine inhibit the Ca^{2+} pump of sarcoplasmic reticulum vesicles (López *et al.* Acta Cient Venez 1988; 43: 210. This effect may explain in part the increment in $[Ca^{2+}]_i$ observed in the presence of chorpromazine.

Supported by Grants from CONICIT of Venezuela (S1-1277) and the Muscular Dystrophy Association.

Clinical evaluation of the relationship of train-of-four stimulation and double burst stimulation

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When using non-depolarizing neuromuscular blockers, it is often difficult to identify fade manually when train-of-four (TOF) ratio (i.e., the ratio of the fourth twitch height to the first twitch height) is greater than 0.4.[1] Recently, double-burst stimulation (DBS) (two short tetanic stimulations that are seen and felt as two muscular contractions), has been suggested as more suitable to identify fade manual.[2] This study was designed to evaluate the relationship between TOF and DBS and to determine the interval required for the neuromuscular junction to recover after DBS stimulation.

Methods

We studied eleven adults ASA physical status I or II undergoing elective surgery. Anaesthesia was induced with thiopentone 3–5 $mg \cdot kg^{-1}$ and maintained with nitrous oxide 70 per cent and isoflurane (up to one per cent end-tidal) in oxygen. The ulnar nerve was stimulated and the adductor pollicis response measured using a force displacement transducer. Atracurium 0.5 $mg \cdot kg^{-1}$ was used for neuromuscular blockade. The TOF (2 Hz for 2 sec) stimulation was applied at 12 intervals and interrupted every 2 min to allow DBS stimulation (two 50 Hz, 60 ms trains each separated by 750 ms). Reapplication of TOF took place 6, 12, 18, 24 or 30 sec after DBS, by random allocation.

Results

The control DBS tension (±SEM) was 2.7 ± 0.14 times as high as the TOF control. The time from injection of atracurium to reappearance of the first discernible response was 38.4 (±1.7) min for TOF and 36.2 ± 2.1 min for DBS ($P = 0.01$). The time to reappearance of the fourth twitch in TOF was 51.2 ± 2.0 min, which was slightly longer than the second DBS response (DBS_2) (48.6 ± 2.3 min) ($P = 0.006$). The height of DBS, relative to control was depressed to a slightly greater extent than T_1/control (Figure 1). The relationship of the DBS ratio (DBS_2/DBS_1) and the TOF ratio was close to the line of identity (Figure 2). The response to TOF stimulation applied after DBS was depressed if the interval was 6 sec, but not if it was 12–30 sec.

Conclusions

This study showed that: (1) the depression of the first DBS response usually exceeds that of T_1; (2) DBS ratio parallels TOF ratio; (3) at least 12 sec must elapse after DBS for the neuromuscular junction to recover to its pre-DBS state; and (4) the response to DBS is stronger than that of TOF stimulation. Although statistically significant, the slightly earlier appearance of DBS_1 and DBS_2 compared with T_1 and T_4 respectively is of no clinical importance.

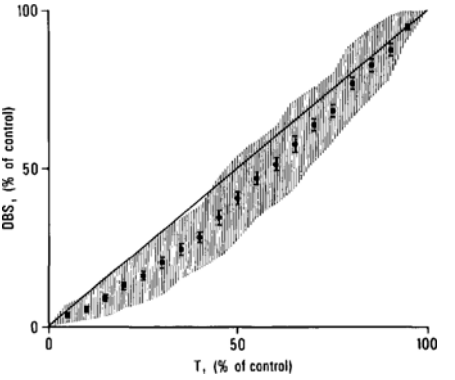

FIGURE 1 The relationships of DBS_1, and T_1 (±SEM). The shaded zone shows the 95 per cent confidence limits.

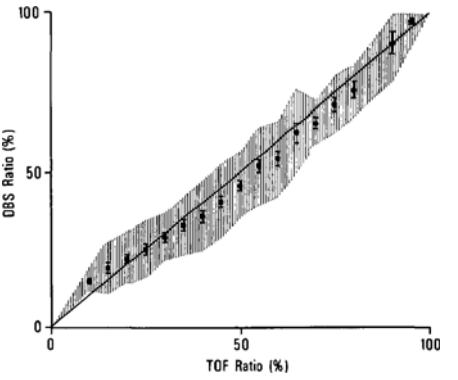

FIGURE 2 The relationship of DBS ratio and TOF ratio. The shaded zone shows the 95 per cent confidence limits.

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Pharmacokinetics and pharmacodynamics of atracurium in morbidly obese subjects

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Body composition is altered in morbidly obese individuals and this may alter the pharmacokinetics of drugs. However, plasma levels of neuromuscular relaxants (pharmacokinetics) and the relationship between concentration and neuromuscular block (pharmacodynamics) have not been obtained in obese patients. The purpose of this study was to determine the pharmacokinetics and pharmacodynamics of atracurium in morbidly obese patients.

Methods

The protocol was approved by the Hospital Ethics Committee. Nine morbidly obese patients scheduled for gastroplasty (weight >45 kg above ideal) and nine subjects with normal body habitus (weight within 20 per cent of ideal) were included in the study after informed consent was obtained. Anaesthesia was induced with thiopentone, 3–5 $mg \cdot kg^{-1}$, fentanyl 2–5 $\mu g \cdot kg^{-1}$, and succinylcholine, 1 $mg \cdot kg^{-1}$, and maintained with nitrous oxide, 60 per cent, and isoflurane 0.5 per cent end-tidal in oxygen. Train-of-four stimulation was applied to the ulnar nerve and the force of contraction of the adductor pollicis muscle measured. After recovery from succinylcholine blockade, atracurium, 0.2 $mg \cdot kg^{-1}$, was given. Plasma samples were drawn at 0, 0.5, 1, 1.5, 2, 3, 5, 7, 10, 15, 20, 30, 45, 60, 90 and 120 minutes, and analyzed for plasma atracurium levels by a HPLC assay. A non-compartmental analysis was performed. Results are presented as means ± SEM. Comparisons were made using the Student's t test and a P value less than 0.05 was considered to indicate a statistically significant difference.

Results

Mean weight was 129 ± 11 kg in the obese group and 60 ± 3 kg in controls. The plasma concentrations in obese individuals were greater at all times than in controls. Mean residence time (MRT) was not significantly different between the groups, but both volume of distribution at steady state (VdSS) and clearance were less in the obese subjects (Table I). Although onset of neuromuscular blockade was faster, its duration was not significantly longer in obese individuals (Table II). Plasma concentrations corresponding to 50 per cent recovery (Cp50) were 52 per cent greater in obese patients (Table II).

TABLE I Pharmacokinetic characteristics (mean ± SEM)

	VdSS ($ml \cdot kg^{-1}$)	*Clearance* ($ml \cdot kg^{-1} \cdot min^{-1}$)	*MRT* (*min*)
Obese	101 ± 6	4.92 ± 0.24	20.5 ± 0.8
Control	190 ± 26	9.09 ± 0.84	20.4 ± 0.8
	P < 0.01	P < 0.001	NS

TABLE II Pharmacodynamic characteristics (mean ± SEM)

	Time of 50% block (*min*)	*Time to 50% recovery* (*min*)	*Cp50* (*ng/ml*)
Obese	1.04 ± 0.12	33.6 ± 2.8	262 ± 22
Control	1.75 ± 0.25	31.8 ± 3.0	172 ± 22
	P < 0.02	NS	P < 0.01

Discussion

Neuromuscular relaxants such as atracurium are ionized compounds whose volume of distribution approximates extracellular fluid volume (ECF). The smaller ECF volume per kg body weight in obese patients probably accounts for their smaller volume of distribution. However, obese individuals require a larger concentration of atracurium for the same neuromuscular blockade than lean individuals. This effect tends to counteract the alterations produced by changes in volume of distribution. As a result, obese individuals require comparable doses of atracurium, on a $mg \cdot kg^{-1}$ basis, as subjects with normal body weight.

Tactile evaluation of the response to train-of-four and double burst stimulation

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During recovery from neuromuscular blockade, it is often difficult to identify fade manually.[1] Recent studies have indicated that it was easier to feel fade in response to double a burst stimulation (DBS) (two 50 Hz, 60 ms trains separated by 750 ms) than to train-of-four (TOF) stimulation.[2,3] This study was designed to compare the tactile evaluation of fade in response to DBS and TOF stimulation.

Methods

We studied 11 ASA physical status I and II adults undergoing elective surgery. Anaesthesia was induced with thiopentone 3–5 $mg \cdot kg^{-1}$ and maintained with nitrous oxide 70 per cent and isoflurane (up to one per cent end-tidal) in oxygen. The ulnar nerve of both arms was stimulated and the adductor pollicis response to TOF stimulation (2 Hz for 2 sec at 12 sec intervals) on one arm was measured using a force displacement transducer. On the other arm the presence or absence of fade in response to DBS and TOF stimulation was evaluated manually by 15 anaesthetists who use nerve stimulators regularly. The recorded TOF ratios were kept unknown to the observers. Atracurium 0.3–0.5 $mg \cdot kg^{-1}$ was used for neuromuscular blockade. The chi squared test was applied for statistical comparison. $P < 0.05$ was considered significant.

Results

There were nine females and two males. The mean age ± SD was 49.5 ± 13.9 years and mean weight was 65.4 ± 12.7 kg. The DBS and TOF responses were evaluated 122 times in these 11 patients. The presence of fade was missed frequently with manual evaluation of TOF, but the detection rate was increased significantly by DBS (Table). For TOF ratio less than 70 per cent, the presence of fade remained undetected in 71 per cent of instances with TOF and only 26 per cent with DBS.

TABLE

Measured TOF	*Detection rate with TOF*		*Detection rate with DBS*		*P*
0.11–0.20	5/5	100%	5/5	100%	NS
0.21–0.30	7/14	50%	13/14	93%	0.02
0.31–0.40	4/17	24%	12/17	71%	0.01
0.41–0.50	5/14	36%	12/14	86%	0.01
0.51–0.60	3/23	13%	16/23	70%	0.001
0.61–0.70	2/18	11%	9/18	50%	0.02
0.71–0.80	0/13	0	7/13	54%	0.005
0.81–0.90	0/10	0	3/10	30%	NS

Conclusion

This study showed that: (1) the tactile evaluation of TOF ratio was associated with a high percentage of failure in identifying TOF fade; (2) there was a significant improvement in the detection of fade with DBS between TOF ratios of 0.21–0.80. It appears that DBS provides a more reliable manual identification of residual curarization than does TOF.

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Effects of EU-4093 on calcium transport by sarcoplasmic reticulum

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Malignant hyperthermia (MH) is a genetic disorder involving abnormal intracellular calcium movement in skeletal muscle cells in response to certain anaesthetic drugs such as halothane and/or depolarizing muscle relaxants, type succinylcholine. EU-4093 is a direct muscle relaxant which has been successfully used to prevent and treat this syndrome. The purposes of this study were: (1) to determine the effects of EU-4093 on calcium uptake by the sarcoplasmic reticulum in vesicles isolated from control and MH susceptible swine and (2) to determine the effects of this muscle relaxant on the Ca^{2+}-Mg^{2+} ATPase activity. The experiments were carried out in 6 MH susceptible crossbred swine (Poland China – Pietrain) and four nonsusceptible Yorkshire swine. Susceptibility to MH was confirmed by challenge with halothane (two per cent). Six weeks after the anaesthesia challenge, the nonsusceptible and MH susceptible swine were anaesthetized with intravenous thiopentone, tracheas intubated and lungs ventilated with oxygen, and then the back muscles were quickly excised and placed in ice for further procedures. The sarcoplasmic reticulum fraction was immediately prepared following the method described by Martonosi and Feretos (J Biol Chem 1964; 239: 648). At the end of the isolation procedure, aliquots of 100 µl of the preparation were resuspended in 0.3 M sucrose and stored at −70° C at a final protein concentration of about 5 mg · kg^{-1}. ^{45}Ca uptake by the sarcoplasmic reticulum vesicles was measured in the absence and in the presence of EU-4093 following the experimental protocol used by Meissner and Fleischer (Biochim Biophys Acta 1971; 241: 356. (Ca^{2+} – Mg^{2+}) ATPase activity was measured in the presence and absence of EU-4093 1 mM. The calcium uptake was 0.257 ± 0.02 (µmoles $Ca^{2+} \cdot mg^{-1}$ prot. min) in control muscle swine and 0.227 ± 0.01 (µmoles $Ca^{2+} \cdot mg^{-1}$ prot. min) in MH susceptible muscle. No difference was observed between these two groups of swine. The incubation of SR vesicles for five minutes previous to addition of ATP in EU-4093 up to 10^{-5} M did not modify the capacity of calcium uptake by SR vesicles measured at two, five and ten minutes in control and MH susceptible muscles. At concentrations higher than 10^{-5} M, the effect of EU-4093 was more marked in the SR vesicles isolated from MH^2 susceptible swine than in nonsusceptible swine. EU-4093 increases the activity of the (Ca^{2+} – Mg^{2+}) ATPase in both groups of SR vesicles (Figure). The effect was more evident in MH susceptible SR vesicles than in those isolated from nonsusceptible swine. These results suggest that the prophylactic and therapeutic effects of EU-4093 in MH susceptible swine might be mediated by two different mechanisms

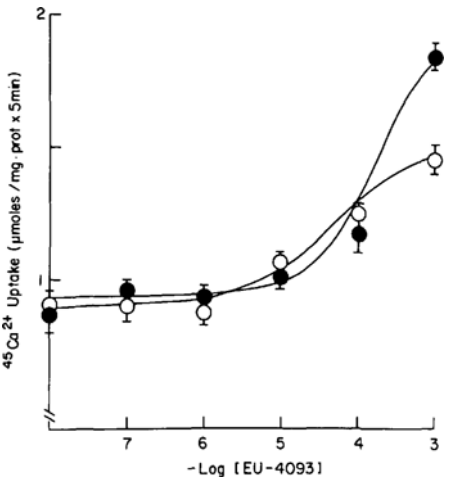

FIGURE Effects of EU-4093 on calcium uptake by sarcoplasmic reticulum vesicles isolated from MH-susceptible (●) and non-susceptible swine (○).

depending on the dose used: (1) an inhibition of calcium release from the SR (Sánchez *et al.* Biophys J 1988; 48: 286a, and/or (2) an increase in the rate and capacity of the SR to transport calcium.

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Benzodiazepine induced inhibition of calcium uptake into astrocytes

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Recent research has demonstrated several "mechanisms" of anaesthesia. Despite our long-term enthusiasm with the Meyer-Overton hypothesis on the role of lipid solubility, increasing data suggest that membrane proteins, which probably include ion carriers or channels, are affected by anaesthetics. Two cations of major importance for neuronal excitability are potassium (K^+) and calcium (Ca^{2+}). It has become evident that the concentrations of these two ions in the interstitial fluid of the brain are regulated by an interaction between neurons and astrocytes. Thus, excited neurons release potassium, and potassium ions are to a large extent either re-accumulated into astrocytes or redistributed via a syncytium of astrocytes with a high potassium permeability (the spatial buffer). At the same time the extracellular calcium concentration decreases, probably through cellular uptake. The calcium ion is of primary importance for regulation and function of intracellular messengers, of ion channels and of cell viability. Elevations of the extracellular potassium concentration, corresponding to those occurring as a result of normal neuronal excitation and/or seizure activity, cause an increase in uptake of calcium ions into astrocytes. This probably contributes to the decline in extracellular calcium. The finding that dihydropyridine nimodipine at low concentations (IC_{50} 2.5 nM) abolishes K^+-induced stimulation of calcium uptake in primary cultures of astrocytes[1] indicates that the uptake occurs through the voltage-sensitive, dihydropyridine-inhibited L-channel. In contrast the drug had very little effect on calcium uptake in the absence of excess K^+.

Since indirect evidence demonstrates that benzodiazepines interact with the L-channel in astrocytes[2] we have now tested the ability of the water-soluble benzodiazepine, midazolam, on K^+ induced uptake of calcium into primary cultures of mouse astrocytes. The cultures were grown for at least four weeks in MEM tissue culture medium which, from the age of two weeks, contained 0.25 mM dibutyryl cyclic AMP. ^{45}Ca influx into the cells was studied by exposing the cells to this isotype at time 0, with the addition of either additional medium or a concentrated KCl solution (to a final concentration of 55 mM) after exactly 30 seconds and termination of the uptake after 60 seconds. Uptake rates ± SEM (standard error of the mean) and the number of experiments (parentheses) are shown in Table.

Midazolam (Mid) at a concentration of 10 μM abolished K^+ stimulated Ca^{2+} uptake but had little effect in the absence of excess K^+. This mechanism may play a major role in the sedative and anaesthetic activity of this benzodiazepine and further work is presently underway to determine the dose-response curve.

TABLE Ca^{2+} uptake into primary cultures of astrocytes

Control	*High K^+*	*Midazolam (mid)*	*Mid + high K^+*
15.59 ± 0.50 (18)	19.36 ± 1.44 (15)	15.67 ± 1.29 (7)	15.00 ± 1.86 (5)

It can be seen that elevated K^+ stimulated Ca^{2+} uptake by about 25 per cent. Thus midazolam seems to act as an antagonist of voltage dependent calcium L-channels. It will be exciting to look at the effect of other anaesthetics.

References

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Mental recovery after general anaesthesia or spinal anaesthesia with intravenous sedation

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A significant mental impairment of cognitive function occurred perioperatively following general anaesthesia (GA) compared with spinal anaesthesia (SA),[1] but the majority of the patients in the SA group received no intraoperative sedation. The purpose of this study was to compare mental recovery in the elderly after GA or SA with supplemental intravenous sedation.

Methods

The protocol was approved by the Human Ethics Committee, and informed consent was obtained. Forty-four patients, age 60 and over, scheduled for transurethral resection of prostate were randomized either to GA or SA. No premedication was given. GA was induced with a sleep dose of thiopentone 2–5 $mg \cdot kg^{-1}$ and fentanyl 1–2 $\mu g \cdot kg^{-1}$. Pre-curarization by 3 mg d-tubocurarine was followed by muscle relaxation, with 1.5 $mg \cdot kg^{-1}$ suxamethonium. The trachea was intubated. Anaesthesia was maintained with nitrous oxide, oxygen, vecuronium, fentanyl, and isoflurane. SA was done at L3–4, L4–5 interspace with a 22- or 25-gauge spinal needle. Tetracaine or xylocaine was used. Supplemental intravenous sedation, diazepam, droperidol or fentanyl was given as needed to ensure a relaxed patient. Psychological assessment included preoperative cognitive screening by Mini-Mental State test (MMS) and standardized geriatric mental status examination. MMS examination was administered pre-op, six hours (h) after surgery and on one, three, five days and one month post-op. Statistical

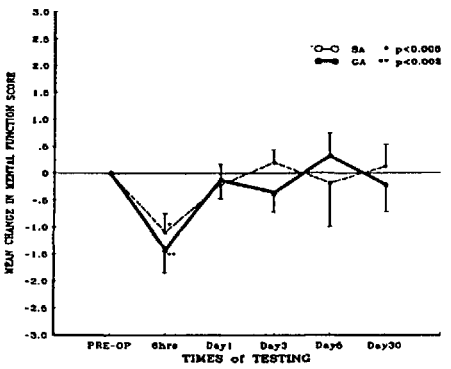

FIGURE Mean change in mental function score in patients having GA (—) versus spinal anaesthesia (---).

significance between the two groups was analyzed by the two-sided Student's t test, and analysis of variance, or the Chi-square test. Change in MMS score in the GA or SA group in the post-op period was analyzed by repeated measures analysis of variance, with contrast at each specific interval.

Results

There was no statistically significant difference between the GA group and the SA group with respect to age, ASA status and duration of surgery. There was no significant intergroup difference in the MMS score between the GA and SA group pre-op, 6 hr, 1, 3, 5 and 30 days post-op. MMS scores decreased significantly in the overall postoperative period in both the GA ($P < 0.02$) and in the SA group ($P < 0.03$) (MANOVA). In the GA group, the significant decrease in MMS score occurred at 6 hr postoperatively ($P < 0.002$), whereas in the SA group, MMS score decreased significantly at 6 hr ($P < 0.005$) (Figure). The amount of general anaesthesia required is shown in the Table. In the SA group with sedation, ten patients required IV fentanyl, three received IV diazepam, seven received a combination of IV fentanyl and diazepam, and two, both IV fentanyl and droperidol.

TABLE Intraoperative Data (mean ± SE)

General anaesthesia		*Spinal anaesthesia*		
Thiopentone	264.2 ± 11.7 mg	Tetracaine	10.8 ± 0.3 mg	n = 4
Succinylcholine	109.1 ± 3.8 mg	Xylocaine	73.6 ± 3.2 mg	n = 18
Fentanyl	97.2 ± 5.5 mcg			
		Intraoperative sedation		
		Fentanyl	50.0 ± 7.4 mcg	n = 10
		Valium	5.8 ÷ 2.2 mg	n = 3
		Fentanyl	46.4 ± 3.6 mcg;	
		Valium	3.0 ± 0.3 mg	n = 7
		Fentanyl	50.0 ± 0 mcg;	
		Droperidol	1.5 ± 1.0 mg	n = 2

Discussion

Significant mental impairment occurred at 6 hr post-op in the GA group, and SA group. This is in contrast to the previous study that mental recovery was better perioperatively with SA as compared to GA. This difference in results could be accounted for by supplemental intraoperative sedation in the SA group in this study with an adverse effect on perioperative cognitive function.

Reference

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Dissociation of sensory block distribution in the suprapopliteal approach for sciatic nerve block

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Sciatic nerve gives rise to five cutaneous nerves. They exist at various depths in the substance of its two components, namely tibial (T) and common peroneal (CP) nerves. This work was undertaken to study the onset of block at each cutaneous nerve distribution after needle encountering either T or CP nerves.

Technique

Patient was placed in the prone or lateral decubitus position. The needle was introduced at the apex of the popliteal fossa, which was identified by asking patient to flex the knee against resistance to tense muscles which formed the triangular boundary of the fossa. This point was 8–15 cm above knee crease. The needle was directed 30–45 upwards and slightly laterally.

Method

30 ASA physical status I–II patients for ankle and foot surgery given mepivacaine 1.5 per cent as 6.0 $mg \cdot kg^{-1}$. A peripheral nerve stimulator was used to elicit motor response from either T or CP nerves. Needle prick test was used to verify time to onset of sensory block at distribution of sural S, plantar P, lateral cutaneous IC, superficial peroneal SP, and deep peroneal DP nerves.

Results

The Table shows time (min) to onset of sensory block following successful needle first encounter with tibial or common peroneal nerves. Results are expressed as mean ± SEM. Student's t test was used for significance of difference.

Discussion

Time onset of block at cutaneous nerve distribution was significantly different with respect to branches of tibial nerve component of sciatic nerve. It was shorter when needle first encountered tibial nerve. No significant difference was found in time of onset of block of common peroneal nerve distribution

TABLE

		Tibial		*Common peroneal*		
First encounter		*S*	*P*	*LC*	*SP*	*DP*
Tibial nerve						
N (12)	$\bar{X}$	3.29*	5.86*	4.14	5.57	8.14
	SEM	0.19	1.00	0.14	0.30	0.26
Common peroneal nerve						
N (16)	$\bar{X}$	5.38*	8.50*	3.75	5.38	7.88
	SEM	0.26	0.19	0.16	0.50	0.55

*P = 0.02

irrespective of needle encountering either components of sciatic nerve. The shorter onset of S and P nerves is due to needle proximity in the tibial nerve encounter. As common peroneal nerve is smaller in size than tibial nerve, it is conceivable that its encounter occurs at its lateral side allowing longer time for local anaesthetic to bathe tibial nerve.

Conclusion

Dissociation of time onset of sensory block occurs with prolongation when common peroneal nerve is encountered.

Patient reaction to conscious tracheal intubation

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Tracheal intubation in the conscious patient is avoided by many anaesthetists prior to the induction of general anaesthesia because it is felt to be too unpleasant for the patient.[1] Yet there are a number of clinical situations in which awake intubation is the safest option.[2] Patient reaction to awake intubation has not yet been reported.

Methods

All patients undergoing awake intubation by any route over a six-month period were identified and interviewed postoperatively by an individual unaware of the techniques and methods of tracheal intubation. Patients were required to consent to the interview and the study had the approval of the Ethics Committee. Interviewed patients were asked if they remembered the intubation. If the answer was affirmative, they were also asked if the procedure was painful. The anaesthetic records of these patients were retrospectively reviewed for urgency of the procedure and intubation technique by an individual blinded to the interview results. Patients were divided into two groups, elective or emergency as graded by each patient's anaesthetist at the time of surgery. The frequency of recall of intubation was calculated for each group. The effect of oral intubation technique, such as direct laryngoscopy or fibreoptic bronchoscopy, was also assessed with respect to the frequency of recall. Data was placed in two by two contingency tables and compared using Chi square analysis with $P < 0.05$ considered statistically significant.

TABLE Recall of oral intubation by technique

	Laryngoscopic intubation		*Bronchoscopic intubation*	
Recall	*No*	*Yes*	*No*	*Yes*
Emergent	5	6	6	11
Elective	15	8	28	15
Total	20	14	34	26

Results

One hundred and eight patients underwent awake intubation in a six-month period. Ninety-nine patients were interviewed postoperatively while nine were lost to follow-up. Of the elective patients (n = 68) 25 (36.7 per cent) had recall of tracheal intubation while in the emergency patients (n = 31) 18 (58.1 per cent) remembered their intubation. These proportions were significantly different ($P < 0.05$). Ninety-four patients were intubated awake orally while five patients underwent nasotracheal intubation. The patients intubated via the nasal route were eliminated from further analysis because of the small number involved. Frequency of recall with different oral intubation techniques was then compared. When a larynsoscopic method was utilized, 14 of 34 patients (41.2 per cent) had recall. If a fibreoptic technique was employed, 26 of 60 patients (48.3 per cent) remembered their intubation. These groups were not significantly different. Furthermore, no differences were seen in intubation technique when the patients were further subdivided into emergency or elective surgery (Table). Only four patients reported that their intubations were painful. Patients reporting pain were seen in both emergency and elective groups and with both intubation techniques.

Discussion

In total, 43.4 per cent of patients remembered their awake intubation. Yet few patients felt that the procedure was painful. Recall of tracheal intubation occurred less frequently in an elective situation. Likely explanations include better premedication, more time taken to ensure adequate patient sedation and greater care taken to ensure proper topical anaesthesia of the upper airway. The technique of oral intubation made little difference on the incidence of recall, again suggesting that other factors such as premedication, sedation and topical anaesthesia play a more important role. In the future, the use of sedative agents with greater amnestic properties may reduce the incidence of recall.

References

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Conscious sedation with Midazolam or Diazemuls in cataract surgery

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The use of supplemental intravenous sedative drugs during local anaesthesia can enhance patient comfort and increase acceptance of these techniques. Midazolam is a new short-acting water-soluble benzodiazepine with anxiolytic and amnesic properties.[1] Diazemuls is an injectable emulsion of diazepam causing less pain at the site of injection. This study was designed to compare the safety and effectiveness of intravenous midazolam and diazemuls as sedative supplements in patients undergoing cataract surgery.

Methods

The protocol was approved by the Hospital Ethical Committee. Informed consent was obtained from 60 physical status ASA I or II outpatients 55 years of age or older undergoing cataract operation. Patients received no premedication. They were monitored by electrocardiogram, automatic blood pressure and oximeter. All patients received supplemental oxygen via aerosol masks. Respiration was monitored by a 16-gauge angiocath located at the patient's nostril and connected to a mass spectrometer. All patients received 0.5 $\mu g \cdot kg^{-1}$ fentanyl IV and then received either midazolam or diazemuls randomly. Midazolam was given at an initial dose of 0.015 $mg \cdot kg^{-1}$. Diazemuls were given at an initial dose of 0.06 $mg \cdot kg^{-1}$. Additional doses of 25 per cent of the initial dose were given until the desired level of sedation was reached which was defined as the stage at which the patient was comfortable and relaxed, and able to lie still for the operation.

Retrobulbar block was performed. All data were collected by an investigator who was blinded to the type of IV medication given. Vital signs were documented. Trieger and digit symbol substitution tests were used to measure the patient's time to recovery. They were done preoperatively, and at 30, 60, 90, 120, and 180 minutes postoperatively. Anterograde amnesia was tested by showing the patient a picture of a familiar object 2 min after the end of injection of the study drug. One and 24 hours after the procedure, the patient was asked if he/she remembered the object. Local tolerance to injection was recorded at the same time periods. The data were analyzed by a two-way analysis of variance (ANOVA), student's t test, and Chi-square analysis where appropriate. $P < 0.05$ was considered significant.

Results

There was no significant difference in age, weight, sex, ASA physical status or duration of surgery between the midazolam and diazemuls groups. The midazolam group received a mean dose of 1.17 ± 0.3 mg IV total. The diazemuls group received 4.50 ± 1.7 mg IV total. Patients in the midazolam group had significantly better sedation at 5 and 10 min after injection than diazemul group. One patient in the midazolam group developed apnoea while four patients in the diazemuls group developed apnoea. The number of dots and the distance missed in the trieger test when compared with the preoperative baseline values were significantly higher at 30 to 180 minutes postoperatively in the midazolam group and significantly higher at only 30 minutes postoperatively in the diazemuls group. The score in the digit symbol substitution tests was significantly decreased at 30 to 90 minutes in the midazolam group, whereas in the diazemul group the score was significantly decreased at 30 minutes only. Between-group comparison showed that diazemuls group had a significantly better score from 60 to 120 minutes (Figure). There was no significant difference in the percentage of patients having anterograde amnesia in both groups. Five patients in the diazemuls group had mild tenderness at the intravenous site 24 hours postoperatively, while none in the midazolam group had any problem ($P < 0.01$).

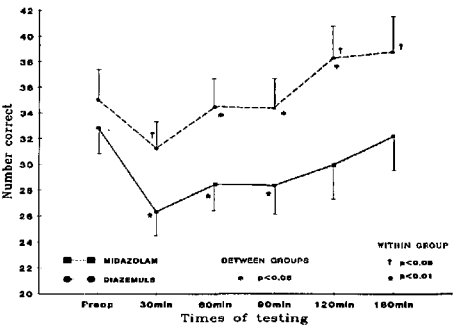

FIGURE Preoperative and postoperative scores in digit symbol substitution tests.

Discussion

The number of patients with tenderness at the injection site is lower in the midazolam group compared with the diazemuls group. Patients in the midazolam group had significantly better sedation than diazemuls group, but more patients in the diazemuls group developed episodes of apnoea. However, psychomotor recovery is better in diazemuls group compared with midazolam group.

Reference

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Analgesic effect of intrapleural Bupivacaine following thoracotomy

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Intrapleural bupivacaine use for post-thoracotomy pain gives variable degree of relief.[1,2] Our study examined the analgesic effect of intrapleural bupivacaine; the optimal number and location of catheter placement; the extent of systemic absorption and pleural fluid drainage of bupivacaine.

	Catheter No.	Catheter Location	Bupivacaine 0.5%
Group DE N=7	Double	Peripheral = catheter tips at axillary line	+ Epineph. 1/200,000
Group DP N=6	Double	Peripheral	Plain
Group SE N=7	Single	Central = catheter tip at para-vertebral space	+ Epineph. 1/200,000

FIGURE

Methods

Twenty patients consented to participate in the study as approved by the Human Research Committee. Thoracotomies were performed under general anaesthesia for open lung biopsy (one), wedge resection (three), lobectomy (15) and pneumonectomy (one). Intraoperative narcotic administration was not restricted. Before wound closure and under direct vision, the surgeon sutured one or two epidural catheter(s) to the posterior parietal pleura above the incision site. Patients were randomly assigned to three groups (Figure).

All patients were awake, extubated, lying supine and the chest tubes were *not* clamped at the time of intrapleural injection of 100 mg of 0.5 per cent bupivacaine ± epinephrine: 10 ml into each of the two catheters or 20 ml into one catheter. Top-up doses of 100 mg bupivacaine were given every 4-hr upon demand (maximum six doses in 24 hr). To treat inadequate analgesia, patients could receive morphine 0.06 $mg \cdot kg^{-1}$ IV in the recovery room and 0.1 $mg \cdot kg^{-1}$ IV on the ward upon request.

Arterial blood samples were obtained in 17 patients at 0, 1, 3, 5, 10, 15, 20, 25, 30, 45, 60, 120, 180 and 240 min after the initial injection. Pleural effusate samples were collected at 240 min in 13 patients. Whole blood and pleural effusate samples were frozen at −20° C until bupivacaine determination by gas chromatography. Verbal analogue pain score (0 – no pain; 10 – maximal pain) and sensory anaesthesia to pinprick on anterior chest wall were assessed at 30, 60, 90 and 240 min. Data were analyzed by ANOVA and t test and $P < 0.05$ was significant.

Results

Twenty-four hour morphine requirement in group DE and DP was much lower than group SE ($P < 0.03$, see Table). Lower 4 hr pain score in group DE and DP was not statistically significant. Sensory anaesthesia was detected in 15/20 patients. Peak whole blood bupivacaine level (C_{max}) was highest in group DP (no epinephrine) but did not reach statistical significance because of high degree of concentration variability. The time to peak blood level (T_{max}), C_{max}, sensory level and the amount of bupivacaine wasted in pleural effusate did not influence pain score or morphine requirement.

Discussion

We found that intrapleural bupivacaine provides variable pain relief following thoracotomy. Superior analgesia obtained in patients with two catheters located peripherally at axillary line may be due to optimal local anaesthetic spreading. C_{max} is within toxic range in all patients after the first dose. Uptake of intrapleural bupivacaine after thoracotomy does not follow any pharmacokinetic profile due to erratic systemic absorption.

TABLE

	Group DE	*Group DP*	*Group SE*
Pain score 4 hr	4.5 ± 1.13	4.08 ± 0.98	6.29 ± 0.71
Morphine (mg) 8 hr	11.86 ± 5.02	12.17 ± 5.31	18 ± 2.54
Morphine (mg) 24 hr	19.14 ± 7.24*	18 ± 4.44*	42.71 ± 5.37
Morphine (mg) Intraop	34.14 ± 3.33	54 ± 8.36†	28 ± 2.47
C_{max} ($\mu g \cdot ml^{-1}$)	0.21 ± 0.07	0.79 ± 0.25	0.29 ± 0.12
T_{max} (min)	4.67 ± 2.73	9 ± 3.53	3.43 ± 1.23
4 hr Pleural fluid Bupivacaine (mg)	33.82 ± 18.65	39.98 ± 13.25	34.98 ± 11.42
4 hr Pleural fluid volume (ml)	172.5 ± 20.26	197.83 ± 42.36	140 ± 33.58

Values are means ± SE; *$P < 0.03$ compared to group SE.
†$P < 0.02$ compared to group DE and SE.

References

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Comparison of postoperative analgesia: bupivacaine by instillation vs. ilionguinal/iliohypogastric nerve block

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Inguinal hernia repair is frequently performed in paediatric outpatients. Various regional anaesthetic techniques have been employed for postoperative analgesia in these children. This study compares the postoperative pain relief provided by simple instillation of bupivacaine into the hernia wound with that provided by ilioinguinal/iliohypogastric (IG/IH) nerve block.

Methods

Institutional approval and informed parental consent were obtained for 60 ASA physical status I or II children (ages two to ten years) undergoing inguinal hernia repair on an ambulatory basis. Anaesthesia was induced and maintained with N_2O/O_2/halothane administered via face mask in all cases. After ligation of the hernia sac, patients received instillation block or IG/IH nerve block in a randomized fashion using bupivacaine 0.25 per cent. For the instillation block, 0.25 $ml \cdot kg^{-1}$ of bupivacaine was instilled into the wound as an irrigating solution, and left for two minutes. This was repeated prior to skin closure. The IG/IH nerve block was performed through the lateral edge of the wound at the end of the surgical procedure

TABLE

	IG/IH (n = 30)	*Instillation (n = 30)*
Age (months)	68.6 ± 34.6	68.1 ± 30.7
Wt (kg)	21.9 ± 9.9	21.4 ± 7.4
Duration of surgery (min)	26.5 ± 8.4	25.6 ± 10.0
Duration of anaesthesia (min)	54.8 ± 11.9	52.5 ± 11.5
Time to reach score of 10 in PARR	18.3 ± 7.4	22.3 ± 9.1
Time to discharge (min)	143.9 ± 56.3	130.7 ± 49.4
Number of patients requiring fentanyl	1	1
Number of patients requiring oral analgesics	24	20

Mean ± SD

using 0.25 ml · kg^{-1} 0.25 per cent bupivacaine. Upon arrival in the Post-Anaesthetic Recovery Room (PARR) pain was assessed by a research associate blinded to the type of regional anaesthetic, using a previously described objective pain scale. Pain and/or discomfort were equated with posturing, agitation, crying, blood pressure elevation or verbalization on a scale of 0–2 for each of the five categories. Intravenous fentanyl 1–2 μg · kg^{-1} was administered to any patient who achieved a pain score of six or more on two successive five-minute observations. Patient recovery was assessed and recorded using Aldrete scoring criteria. The time when all discharge criteria were met was also recorded. Data were compared using Fisher's exact test and Student's t test.

Results

Patients in both groups were comparable with regards to age, weight, and the duration of both surgery and anaesthesia (Table). There was no statistically significant difference between the groups with regard to their postoperative pain scores, the need for analgesia, the time to reach a recovery score of 10 or the time to discharge from the hospital.

Discussion

Standard approaches ot the treatment of postoperative pain following hernia repair include the use of IV narcotics as well as regional blocks. Narcotics are associated with an increased incidence of emesis and somnolence, both of which may delay a return to normal activity and hence delay discharge from hospital. Although regional blocks are easy to perform in children, they still require some degree of training. This study demonstrates that simple instillation of bupivacaine into a wound provides postoperative pain relief following hernia repair equal to that provided by intraoperative ilioinguinal/iliohypogastric nerve blocks.

Analgesic effects of epidural nalbuphine in post-thoracotomy patients

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Lumbar epidural morphine provides effective analgesia for post-thoracotomy patients, but clinically significant respiratory depression may occur. Nalbuphine, a kappa receptor agonist and mu receptor antagonist, demonstrates a ceiling effect for respiratory depression, but may not provide adequate analgesia when administered parenterally. This study compares the analgesic and respiratory effects of epidural nalbuphine with epidural morphine.

Methods

After informed consent, 15 ASA physical status I–II patients undergoing thoracotomy were studied. The study was randomized and double-blinded. Patients were monitored the night before surgery. Arterial blood gases (ABGs) were sampled via an arterial line awake and then at 2 hr intervals while asleep. Patients were continuously monitored with respiratory inductance plethysmography (RIP) and pulse oximetry. Episodes of apnoea (AP, tidal volume <100 mls for >15 sec) and slow respiratory rate (SRR, any five-minute interval with a mean respiratory rate <10) were recorded. No narcotics were given preoperatively. A lumbar epidural catheter was inserted prior to surgery and placement verified with two per cent lidocaine. Thiopentone and pancuronium were given for induction of anaesthesia, and patients received oxygen and isoflurane or halothane for maintenance. All patients were extubated at the conclusion of surgery.

Patients were assigned to one of three groups (M – morphine 5 mg · 20 ml^{-1}, N10 – nalbuphine 10 mg · 20 ml^{-1}, N20 – nalbuphine 20 mg · 20 ml^{-1}). The first dose was given approximately two hours prior to the estimated time of completion of surgery. Subsequent doses were given for inadequate analgesia at intervals of not less than 30 min. Inability to provide adequate analgesia after three doses resulted in withdrawal from the study. Postoperatively patients were continuously monitored with RIP and pulse oximetry. Visual analogue pain (VAS) and somnolence scores were measured immediately before a repeat dose of study drug, then at 15, 30, 45, and 60 min and hourly after the dose. ABGs were taken prior to a repeat dose, at 30 min, and hourly thereafter. Patients not withdrawn from the study were monitored for 18–20 hours postoperatively. Groups were compared using a 2 by 3 Chi square analysis.

Results

Groups were similar with respect to age, sex, weight, procedures undertaken, and ASA status. Six patients received morphine, four received nalbuphine 10 mg and five received nalbuphine 20 mg.

Preoperative monitoring: There were no significant differences between groups and no patient demonstrated CO_2 retension while awake. Three patients had maximum detected $PaCO_2$'s of 47–50 mmHg. Eleven patients had one to 66 apnoeic episodes of 15–20 sec during sleep. Two patients had

TABLE Patients in each group successfully completing study or withdrawn because of inadequate analgesia ($P < 0.02$)

Group	*M*	*N10*	*N20*
Completed	6	2	0
Withdrawn	0	2	5

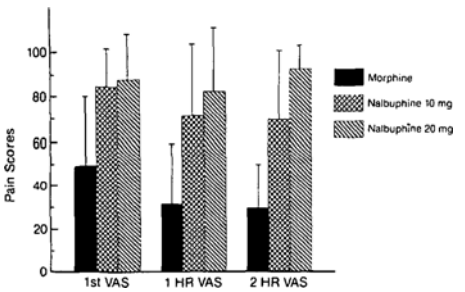

FIGURE 1 Pain scores ± S.D. on arrival in the RR and one hour and two hours postoperatively.

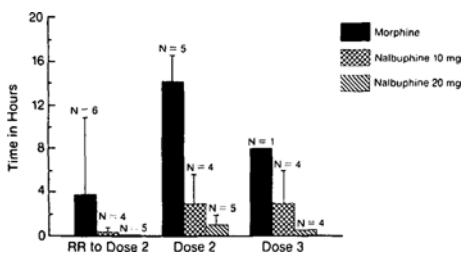

FIGURE 2 Duration of adequate analgesia ± S.D. RR to Dose 2 is the time from arrival in RR to administration of second dose.

saturations of less than 90 per cent (86 and 88) during these events. No periods of SRR were detected.

Postoperative monitoring: With the exception of one patient in Group M, all patients required additional study drug during the first two postoperative hours. Group M patients received an average of 2.3 doses and all had adequate analgesia after the second dose (VAS < 2). In contrast, two of four patients in Group N10 and all patients in Group N20 were withdrawn from the study in the first three postoperative hours because of inadequate analgesia ($P < 0.02$, Table). The VAS on admission to recovery room and at one and two hours postoperatively are shown in Figure 1. The duration of adequate analgesia following each dose is shown in Figure 2. Average hourly pain scores and $PaCO_2$'s for Group M patients are shown in Figure 3. The mean $PaCO_2$ was in the 45–50 range throughout the postoperative

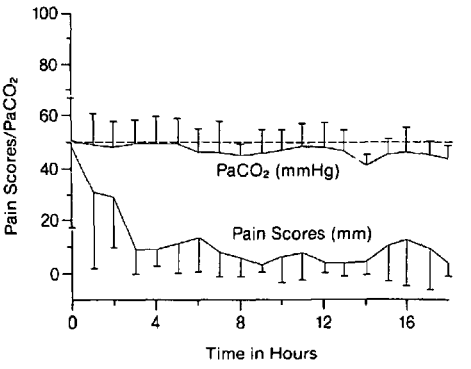

FIGURE 3 Pain scores and $PaCO_2$ ± S.D. in Group M patients.

study period. One Group M patient was not monitored with RIP due to equipment problems. Two of five Group M patients had apnoeas (234 and 80) and SRR (44 and 32) which peaked in frequency approximately seven hours following the second dose of morphine. No significant relationship between episodes of apnoea, SRR, or hourly respiratory rate with $PaCO_2$ was seen. Two Group M patients had persistent marked elevations of $PaCO_2$ (55–65 range, $P > 0.05$). In one patient this occurred after a single dose.

Discussion

Lumbar epidural nalbuphine did not provide adequate analgesia for post-thoracotomy patients. Lumbar epidural morphine provided excellent analgesia, but was associated with significant CO_2 retention in two of six patients.

Reversal by isoproterenol of bupivacaine-induced electrophysiologic disturbances in the isolated rabbit heart

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The anaesthetic agent bupivacaine may cause major disturbances of cardiac rhythm when given at high dose in animals[1] or humans. The mechanisms underlying these arrhythmias are not well established and therapy is empiric. Previous data in our laboratory suggest that the main effect of bupivacaine is a dose-dependent depression of conduction. The purpose of this study was to determine whether this depression of conduction could be reduced by isoproterenol, a cathecolamine with predominant beta-adrenergic stimulating properties.

Methods

In eight rabbit heart preparations (Langendorff model), we continuously recorded the standard electrocardiogram (ECG) as

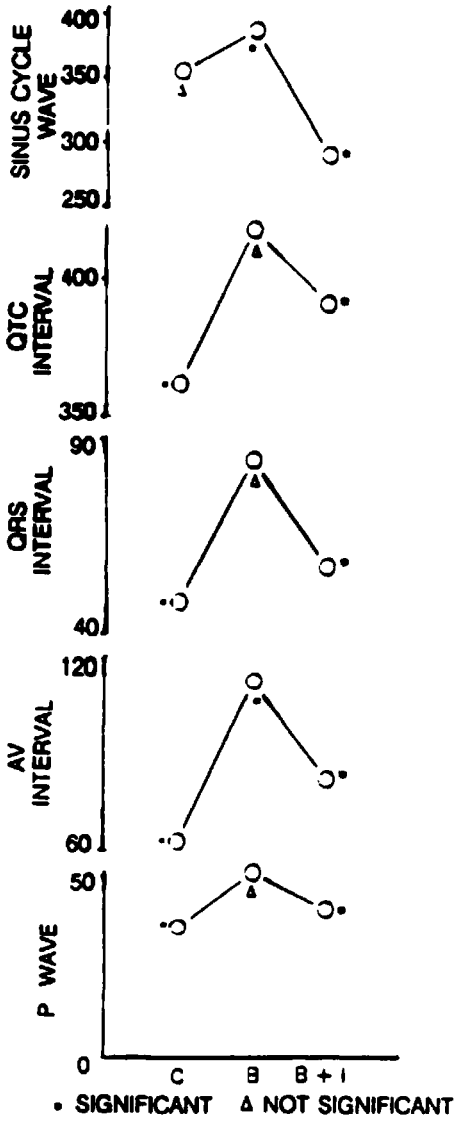

FIGURE 1

well as local electrograms from the epicardium of both atria and ventricles and an intracardiac recording of the atrioventricular junction. Programmed electrical stimulation consisting of rapid and premature pacing of the right atrium and left ventricle were performed in order to measure specific electrophysiologic parameters.

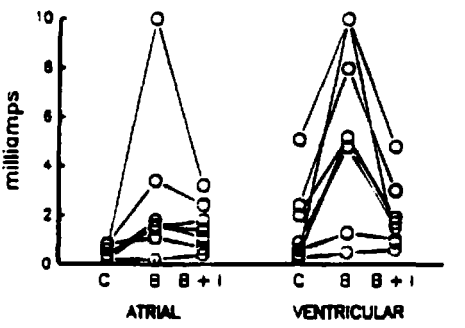

FIGURE 2 Thresholds.

In each individual preparation, data were obtained (1) in the basal control state (C); (2) during perfusion of bupivacaine, $\mu g \cdot ml^{-1}$ at a fixed rate determined by basal coronary flow (B); and (3) after the addition of isoproterenol, 1–2 $\mu g \cdot ml^{-1}$, adjusted so that spontaneous sinus rhythm rate increased by no more than 35 per cent (B + I). Statistical analysis was done using a one way ANOVA with the Tukey multiple comparison test. $P < 0.05$ was considered significant.

Results

All values in milliseconds except where indicated, * (asterisk) denotes a significant change compared with C.

ECG measurements

Duration of P wave (C = 36, B = 51* , B + I = 41), QRS complex (C = 48, B = 84*, B + I = 57) and QT interval (C = 216, B = 259*, B + I = 211) were increased by B but reverted to baseline values after B + I (Figure 1).

Sinus node

Sinus cycle length (C = 355, B = 382, B + I = 290*) was unaffected by B but lowered by B + I while sinus node recovery time (C = 36, B = 52, B + I = 38) was not significantly changed.

Atrioventricular conduction

Atrium to ventricle interval (C = 63, B = 114*, B + I + 83), anterograde (C + 161, B = 260*, B = I = 150) and retrograde (C = 194, B = 268*, B + I = 176) Wenckebach point, anterograde (C = 114, B = 155*, B + I = 123) and retrograde (C = 195, B = 205, B + I = 186) refractory periods of the atrioventricular junction were all increased by B and consistently reverted to normal or near normal baseline values after B + I (Figure 2).

Myocardium

Similarly, B + I reversed the B-induced increase of pacing

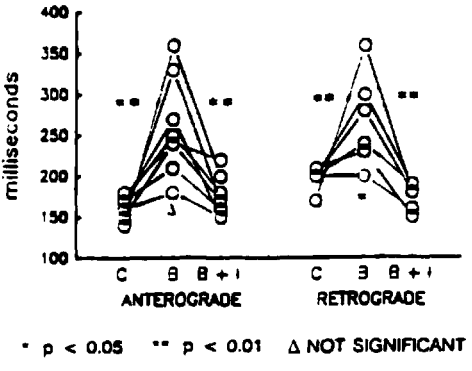

FIGURE 3 Wenckebach.

thresholds of atrium (C = 0.48 mA, B = 2.68 mA, B + I = 1.49 mA) and ventricle (C = 1.51 mM, B = 5.61 mA*, B + I = 1.93 mA) and refractory periods of atrium (C = 114, B = 155*, B + I = 123) and ventricle (C = 183, B = 220*, B + I = 165) (Figure 3).

Conclusion

The bupivacaine-induced depression of conduction is abolished by isoproterenol, at the expense of a moderate increase in normal automaticity. These data suggest that beta-agonists should be the treatment for bupivacaine-induced dysrhythmias.

Reference

1 *Rosen M, Thingpen J, Shnider S et al.* Bupivacaine-induced cardiotoxicity in hypoxic and acidotic sheep. Anesth Analg 1985; 64: 1089–96.

Changes in cardiac output during spinal anaesthesia with sedation

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A recent review of data from Caplan[1] showed that sudden, unexpected deaths may occasionally occur during spinal anaesthesia in healthy patients. The authors suggested that a complex chain of events involving loss of consciousness, hypoxaemia, decreased venous return, decreased cardiac output and hypotension may have led to cardiac arrest. All the patients reviewed had received IV sedatives, often both diazepam and fentanyl. We have therefore recorded continuous cardiac output measurements during spinal anaesthesia in patients sedated with either diazepam (seven subjects) or alfentanil (three subjects).

Methods

The study received approval by the Hospital Ethics Committee and each patient gave informed consent. No premedication was used. On arrival in the OR, in addition to the usual monitors (ECG, NIBP and O_2Stat), Non-invasive Continuous Cardiac Output Monitoring using thoracic bioimpedance (NCCOM), (Bomed Medical Manufacturing Ltd) was started. This monitor measures pulsatile variations in the electrical impedance of the thoracic contents and derives stroke volume, heart rate and computes cardiac output. Average data for 12 acceptable cardiac beats were transmitted to a microcomputer which was used to display and record the data. Spinal anaesthesia was induced in the sitting position using 12–20 mg of tetracaine in seven per cent dextrose. Subjects were then placed supine and the recordings were continued for 10–15 minutes. Ringer's Lactate 500-1000 ml and ephedrine were used to maintain blood pressure at pre-anaesthetic levels. Supplemental oxygen was given whenever peripheral O_2 saturation fell below 95 per cent. Twelve to fifteen minutes after tetracaine was administered, either diazepam or alfentanil was given in increments to a total of 0.15 $mg \cdot kg^{-1}$ or 4 $\mu g \cdot kg^{-1}$ respectively. Monitoring was continued until the end of surgery. Values obtained during four different periods: "baseline sitting," "baseline supine," "during spinal anaesthesia" and "during spinal anaesthesia with sedation" were edited to remove artifacts due to movement and electrocautery. The mean value of ten readings were averaged and compared with the value obtained prior to induction of anaesthesia in the sitting position. Differences between mean values were compared using Student's t test.

Results

The mean cardiac output for patients who received alfentanil ranged between 4.73 $L \cdot min^{-1}$ and 5.94 $L \cdot min^{-1}$ for the four periods. There was no statistical difference among the four periods. For the patients who received diazepam, the mean cardiac outputs for the four periods were respectively 5.75 $L \cdot min^{-1}$, 6.06 $L \cdot min^{-1}$, 5.94 $L \cdot min^{-1}$ and 4.85 $L \cdot min^{-1}$. The cardiac output during the "spinal anaesthesia with sedation" period was lower than the first three preceding periods ($P < 0.05$). Percentage of changes of the cardiac output and the heart rate were calculated and plotted against time. This is shown in

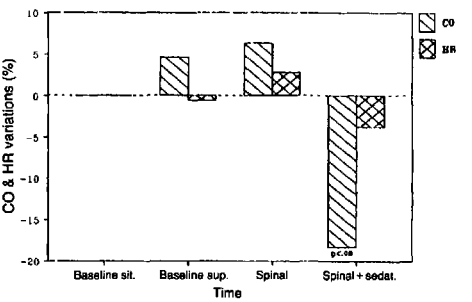

FIGURE CO and HR variations (%) during spinal anaesthesia with diazepam sedation.

the Figure. Blood pressure and O_2 saturation remained within normal limits throughout the study for both groups.

Conclusion

Our data suggest that spinal anaesthesia associated with diazepam sedation may result in a decrease in the cardiac output, not associated with a drop in blood pressure or in O_2 saturation. Further studies with larger groups will have to be carried out to confirm and explain these findings.

Reference

1 *Caplan RA et al.* Unexpected cardiac arrest during spinal anesthesia: a closed claims analysis of predisposing factors. Anesthesiology 1988; 68: 5–11.

An evaluation of the efficacy of methods to treat postoperative pain

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The purpose of this study was to evaluate the efficacy of present methods of postoperative pain relief in paediatric patients.

At the present time there is a variety of methods used to provide pain relief at this institution. Some anaesthetists use intraoperative narcotics and others do not. Frequently patients arrive in the postanaesthetic recovery room (PAR) with varying degrees of pain relief. The attending anaesthetist orders an analgesic and a route of administration that he or she deems appropriate. It was our opinion that there was inadequate pain relief achieved in some of the patients in the PAR.

Methods

The study was prospective and did not require institutional approval as there was no adjustment or modification of any present acceptable techniques for postoperative pain relief. We studied 100 patients, ASA physical status I or II, undergoing orthopaedic, plastic and general lower abdominal surgical procedures. The staff was not informed that this study was being conducted and the authors' cases were excluded from the study.

On admission to the PAR each patient was evaluated by one of the authors to determine the severity of their pain using the Objective Pain-Discomfort Scale (OPDS).[1] The OPDS has been shown to be a valid instrument in the very young and unverbal child and is as useful as a linear analogue scale for older children.

Each patient was evaluated and scored on admission to the PAR and subsequently at 10, 20, 30 and 60 minutes in the PAR. In addition, supplementary data for each patient included use of volatile agent, intraoperative narcotics including type of drug and total dose administered. The time, type, dose and rate of administration of analgesics used in the PAR were also recorded. Results were tabulated and chi-square analysis for independent variables was used. Statistical significance ($P < 0.05$) was determined.

Results

The mean (± SD) age and weight of the children were 9.75 ± 5.10 years and 3.02 ± 18.43 kg, respectively. Patients who had received a pure volatile anaesthetic technique showed a statistically significant difference ($P < 0.05$) in postoperative pain compared with patients who had received a balanced or narcotic anaesthetic technique. No patient who received regional anaesthesia as part of the anaesthetic required postoperative analgesia.

Discussion

There has been a significant amount of concern by both anaesthetist and others that postoperative pain in the paediatric patient is poorly controlled.[2–4] In addition, anaesthetists themselves do not use any form of analgesia routinely for the management of postoperative pain particularly in neonates or infants.[5]

The results of our study would seem to corroborate the experience of others.

As we now have a documented baseline regarding the adequacy of postoperative pain relief in children, further education *vis à vis* the need for and advantages of postoperative pain relief will be carried out with the staff. Further studies will be necessary to determine protocols for adequate analgesic administration.

References

1 *Broadman L, Rice LJ, Hannallah R.* Testing the validity of an effective pain scale for infants and children. Anesthesiology 1988; 69: A770.
2 *Mather C, Mechic J.* The incidence of postoperative pain in children. Pain 1983; 15: 271–82.
3 *Eland JM, Anderson JF.* The experience of pain in children. *In*: Vacox (Ed.). A Source Book for Nurses and Other Health Professionals. Little, Brown and Co., Boston, 1977, pp. 452–73.
4 *Dilworth NM.* Children in pain: an underprivileged group. J Paed Surg 1988; 23: 103–4.
5 *Purcell-Jones G, Dormad F.* Paediatric anaesthetists' perceptions of neonatal and infant pain. Pain 1988; 33: 181–7.

Intravenous regional anaesthesia with 2-chlopoprocaine does not cause clinically significant thrombophlebitis

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Chloroprocaine (CP) has been suggested as an ideal agent for intravenous regional anaesthesia (IVRA) because its rapid hydrolysis in blood by pseudocholinesterase results in a lower incidence of minor central nervous system (CNS) side effects (9.3 per cent vs 30–50 per cent for lidocaine).[1] However, its use in IVRA has been criticized because of a fear of thrombophlebitis (TP)[1] despite demonstration of its efficacy for IVRA.[1,2] This study was designed to determine prospectively the frequency of clinically significant TP with CP use in a randomized, double-blind comparison with lidocaine.

Methods

In a study approved by the Ethics Committee, 104 patients scheduled for elective or emergency procedures on an upper or lower extremity were randomly allocated to receive IVRA with

TABLE I

	N	Age yrs	Height cm	Weight kg	M:F	ASA class I	II	III
CP	53	38.9 ± 2.5*	175.6 ± 2.1*	70.0 ± 1.9	0.9:1	46	5	2
XYL	50	45.0 ± 2.6	166.2 ± 1.4	70.9 ± 1.9	0.8:1	35	11	3

Values ± SEM. NS Non-Significant.
*P ≤ 0.05.

TABLE II

	TP	Drug failure	Technical failure	CNS symptom
CP	0	1	1	14
XYL	0	4	4	7

either one per cent CP or 0.5 per cent xylocaine (XYL). Demographic data related to our patient population is found in Table I. The anaesthetists performing the procedure were asked to use 60 ml for a lower limb and 50 ml for an upper limb. Symptoms of CNS dysfunction were elicited first by asking the patient to report any unusual sensations on cuff deflation and then by specific questioning. Intravenous sedation was permitted. Thrombophlebitis was defined as any area that was tender, discoloured, itchy or painful with or without a cord-like mass. The patient was told that an independent nurse researcher would telephone to ask about the presence or absence of TP. Data was analyzed using t tests and Chi-squared test with Yates' correction. Statistical significance was defined as a P value ≤ 0.05.

Results

IVRA was highly successful in both the CP and XYL groups. There were five drug failures (one CP and four XYL). All other failures were considered technical (four XYL and one CP), and were usually related to tourniquet malfunction. The frequency of CNS side-effects was 28 per cent for CP and 16 per cent for XYL. There were no cases of TP in either group, as determined by either the telephone survey or direct follow-up. Those individuals seen because of symptoms were found to have simple bruises or swelling related to the operative site (Table II).

Discussion

This study demonstrates that CP is both safe and effective in IVRA. We were unable to demonstrate any clinically significant episodes of TP in either the CP group or the XYL group. The investigators who conducted the original studies reported an eight per cent incidence of TP with CP use in IVRA. They neither studied the frequency of TP prospectively nor defined what they meant by TP. We were unable to demonstrate any superiority of CP relative to XYL with respect to the frequency of CNS side effects. This may be attributed to the large average dose of CP used in this study (7.8 mg · kg^{-1}) compared with that used by previous investigators (3 mg · kg^{-1}). We conclude that the incidence of clinically significant TP in association with IVRA with a commerical preparation of CP is remarkably low and that CP is therefore a safe drug for use in IVRA. In view of the potential advantages inherent in the use of chloroprocaine its use in IVRA should be re-evaluated.

References

1 *Harris W, Slater, Bell M.* Regional anesthesia by the intravenous route. JAMA 1965; 194: 105–8.
2 *Palar TAR, Gerber HR.* Intravenous regional anesthesia for operations in the lower limb. Reg Anesth 1982; 7: 29–32.

Traitement symptomatique de l'arachnoïdite et du syndrome post discoidectomie au moyen d'une epidural permanente. Comparaison de trois protocoles d'injection

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L'arachnoïdite chronique et le syndrome post discoïdectomie constituent un éventail important de patients fréquentant les cliniques de douleurs. Parmi ces patients, un certain nombre répondent bien aux épidurales, mais il n'est pas clair dans la littérature si c'est l'interruption des influx nociceptifs liée à l'administration de l'anesthésique local ou l'anti-inflammatoire cortisoné ou encore le bloc sympathique, qui contribue à les soulager.

Méthode

Nous avons choisi parmi nos patients souffrant d'arachnoïdite et de syndrome post discoïdectomie 14 patients qui obtenaient après une épidurale cortisonée un soulagement dont la durée variait de trois semaines à trois mois, et après consentement informé, nous avons installé sous anesthésie générale un port-a-cath épidural (12 lombaires à L1-L2 et deux au niveau cervical à C7-T1). Au niveau lombaire nous avons installé un cathéter INFUSAID relié à un port-a-cath veineux dont la capsule reposait sur le gril costal droit.

Au niveau cervical, nous avons installé un cathéter intraspinal (Pharmacia) dans l'espace épidural, laissant la capsule reposer sous la clavicule droite. Chaque patient servant comme son propre contrôle, nous avons injecté, avec des précautions d'asepsie chirurgicale, selon les protocoles suivants:

A chaque semaine durant 3 semaines

Bupivicaine 0.25%	15 ml	protocole #1
Brétylium 100 mg ± H_2O	13 ml	protocole #2
Bupivicaine 0.25% +	14 ml	
Dépo-médrol 20 mg	0.5 ml	protocole #3

A chaque 3 semaines durant 2 périodes de 3 semaines

Bupivicaine 0.25%	15 ml	protocole #4
Brétylium 100 mg + H_2O	13 ml	protocole #5
Bupivicaine 0.25% +	14 ml	
Dépo-médrol 20 mg	0.5 ml	protocole #6

La perméabilité du système était garantie par 3 ml d'héparine-lock. L'étude a duré 27 semaines pour chaque patient; ces derniers décrivaient à l'échelle d'analogie visuelle l'intensité de

la douleur et compilaient une échelle de fonctionnalité (marche, sommeil, station debout, médication narcotique).

Deux cathéters ont dû être retirés à cause d'infection (staphylococques dorés), ces cas ont été traités par antibiothérapie IV durant 15 jours. Aucun abcès épidural n'a cependant été mis en évidence à la résonance magnétique.

Résultats

Le protocole #1 (Bupivicaine 15 ml à chaque semaine) s'est révélé supérieur statistiquement et cliniquement aux autres protocoles (diminution de la douleur d'au moins 75 pour cent au VAS, amélioration de fonctionnalité de 50 pour cent). L'addition de Brétylium, donc le bloc sympathique seul, ou l'addition d'un anti-inflammatoire n'a pas ajouté au confort des patients.

Aucune anomalie neurologique supplémentaire n'a été notée. Des épidurographies sériées faite chez chaque patient n'ont pas montré de dégradation de l'arachnoïdite.

La consommation de narcotique a diminué ou cessé chez la totalité des patients.

Conclusion

Chez des patients choisis porteurs de ces syndromes et répondant bien aux épidurales, ce genre d'approche semble sécuritaire et efficace.

Premedication with metoprolol – A transoesophageal echocardiographic study

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Patients receiving calcium entry blocking drugs (CEB) prior to cardiac surgery have been shown to have a higher incidence of perioperative myocardial ischaemia than those receiving beta adrenergic blocking drugs (BB).[1] No randomized study, however, has been performed. This prospective randomized double-blind study was undertaken to determine the effects of BB as an adjunct to CEB when administered as a premedication prior to coronary artery bypass grafting (CABG).

Methods

Informed consent was obtained from ten patients receiving calcium channel blockers scheduled for CABG. Patients were randomly assigned in a double-blind fashion to receive either Metoprolol, 100 mg the night before the operation and 100 mg 1½ hours prior to surgery, or two doses of a placebo. All cardiac medications were continued up to the time of surgery. A standard high-dose fentanyl anaesthetic technique was used.

All patients were monitored for 24 hours beginning 90 min prior to surgery using an ambulatory ECG monitor, recording modified leads AVF and V5. Arterial and pulmonary artery pressures were monitored intraoperatively. After intubation, a transoesophageal echocardiography probe was positioned to obtain a cross-sectional view of the left ventricle at the level of the papillary muscles. Heart rate and blood pressure were maintained within 20 per cent of normal. Haemodynamic profiles and cardiac output were obtained prior to induction and at 1 min post-induction, intubation, skin incision, sternotomy, aortic cannulation, bypass, protamine injection, sternal wiring and skin closure. Echocardiographic studies were done during surgery after intubation. Blinded analysis of the ST segments on the Holter record done independently by two investigators were used to document myocardial ischaemia. Regional wall motion abnormality, end–diastolic and end–systolic diameters (EDD and ESD), per cent fractional shortening (FS) were also documented by two investigators independently. Standard criteria for ST change and wall motion abnormalities were used in the interpretation of data. Statistical analysis was done using the Student's t test and Chi square where appropriate.

TABLE

	Metoprolol (n = 5)	*Placebo (n = 5)*
Heart rate	60.4 ± 10.6	81.0 ± 13.9*
Inotrope	No	No
Pacemaker	Yes: 2 No: 3	Yes: 2 No: 3
Wall motion abn.	Yes: 0 No: 5	Yes: 2 No: 3
ST elevation	Yes: 1 No: 4	Yes: 0 No: 5

*$P < 0.03$ post-intubation.

Results

There were no significant differences in age, sex, weight, the New York Heart Association classification and duration of aortic cross-clamp between the two groups. Heart rate was significantly higher in the placebo group versus the metoprolol group at 1 min post-intubation. Mean arterial pressures and pulmonary capillary wedge pressures did not differ significantly between the two groups. None of the patients required intraoperative calcium chloride or dopamine. Two out of five patients in each group required pacemaker assistance on weaning off bypass (Table).

There were no significant differences in the frequency of perioperative ectopic beats. None of the patients showed ECG evidence of prebypass ischaemia. One patient in the metoprolol group developed significant ST elevation of 2 mm in both leads AVF and V5 for 30 min post-bypass with EKG and CPK-MB evidence of perioperative myocardial infarction. However, no intraoperative wall motion abnormality was detected in this patient. A transthoracic echocardiogram done postoperatively showed an antero-apical infarct.

Transoesophageal echocardiographic findings showed no significant differences between the two groups in their EDD, ESD or FS. New wall motion abnormalities were noted in two patients in the placebo group, one during the pre-bypass period and the other post-bypass.

Discussion

In this preliminary study, there was no observable difference in the need for inotropic or pacemaker support nor was there a decrease in the echocardiographically assessed ventricular function between the two groups. A large sample size will be required to confirm the possible cardiac protective effect of

metoprolol as a premedication in patients who are not on beta adrenergic blockade prior to CABG.

Reference

1 *Chung F et al.* Calcium channel blockade does not offer adequate protection from perioperative myocardial ischemia. Anesthesiology 1988; 69: 3: 343–7.

Effect of cardiopulmonary bypass with a membrane oxygenator on plasma nitroglycerin levels

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Patients undergoing coronary artery bypass grafting (CABG) have a perioperative risk of developing myocardial ischaemia and infarction. Intravenous nitroglycerin (GTN) has been used to control perioperative ischaemia and hypertension, and is also used prophylactically during CABG surgery. Cardiopulmonary bypass (CPB) has been shown to affect the pharmacokinetics of some drugs. In one report serum GTN levels decreased during CPB using a bubble oxygenator.[1] The purpose of this study was to measure plasma GTN in patients having CABG with continuous IV GTN to determine if infusion rates need to be altered when using a membrane oxygenator.

Methods

After ethics committee approval and informed consent, four premedicated ASA physical status III patients aged 45–70 years scheduled for CABG surgery were studied. After application of monitors and insertion of venous, arterial and pulmonary catheters under local anaesthesia, IV, GTN 0.5 $\mu g \cdot kg^{-1} \cdot min^{-1}$ was infused via polyethylene non-GTN adsorbing tubing into a central line throughout the operation. Ten minutes later, anaesthesia was induced and maintained with fentanyl, and relaxation was obtained with pancuronium. Arterial blood samples for GTN analysis were taken before, during and after CPB (Cobe CML membrane oxygenator). The blood samples were drawn into iced, non-adsorbing syringes, placed in heparinized tubes, and centrifuged at 4°C; the plasma was separated and frozen. Analysis of GTN and its metabolites was done by gas–liquid chromatography.

Results

The Table shows that the average pre-bypass plasma GTN concentration was 8.35 $ng \cdot ml^{-1}$. During early CPB, the level decreased to 5.89 $ng \cdot ml^{-1}$ and then it increased in three patients to above pre-bypass levels. After bypass, GTN concentrations decreased to an average of 6.82 $ng \cdot ml^{-1}$.

TABLE Plasma GTN concentration – $ng \cdot ml^{-1}$

		Bypass time			
Patient	*Prebypass*	*10 min*	*30 min*	*60 min*	*Post bypass*
1	5.36	4.04	5.31	4.69	4.20
2	8.60	8.60	14.60	16.40	9.10
3	6.33	4.13	10.90	8.28	5.22
4	13.10	6.79	10.70	11.70	8.74
Average	8.35	5.89	10.38	10.27	6.82

Discussion

In the only previous report of GTN blood levels during CPB, a bubble oxygenator was implicated in causing a significant decrease in GTN.[1] In the present study, using a membrane oxygenator, a small decrease in plasma GTN occurred initially on CPB, but levels were still in the therapeutic range for the treatment of heart failure. This suggests some minor adsorption of GTN by the apparatus. During later stages of bypass, the average plasma GTN levels increased suggesting a change in clearance induced by factors such as hypothermia, haemodilution, altered hepatic blood flow and/or lung isolation. Following bypass, the GTN levels decreased but were still in the therapeutic range.

In summary, 0.5 $\mu g \cdot kg^{-1} \cdot min^{-1}$ IV GTN resulted in plasma GTN levels which were in the therapeutic range, and this was maintained when a membrane oxygenator (Cobe CML) was used during CPB.

Reference

1 *Dasta FJ et al.* Influence of cardiopulmonary bypass on nitroglycerin clearance. J Clin Pharmacol 1986; 26: 165–8.

Continuous alfentanil infusion for abdominal aortic surgery

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A variable rate infusion of (ALF) alfentanil has been shown to provide effective anaesthesia for varying surgical stimuli during general surgery. We hypothesized that this technique would also be useful for abdominal aortic surgery (AAS).

Methods

Eighteen patients undergoing elective AAS entered this trial after given written informed consent to the protocol approved by the Hospital Ethics Committee. ASA physical status IV or V patients and those greater than 75 years of age were excluded. Preoperatively, patients received lorazepam 0.04 $mg \cdot kg^{-1}$ and either their usual dose of beta-blocker or metoprolol 100 mg PO. A loading dose of ALF 50 $\mu g \cdot kg^{-1}$ was administered over 60 seconds, during which pancuronium 0.15 $mg \cdot kg^{-1}$ was infused, immediately followed by thiopentone 3.0 $mg \cdot kg^{-1}$. Following intubation, anaesthesia was maintained with 66 per cent N_2O and infusion of ALF adjusted to maintain systolic blood pressure and heart rate within 20 per cent of each patient's baseline value. The infusion was terminated at the end of surgery. Haemodynamic measurements were taken at the following times: awake (BL_1), post-induction (IND), post-intubation (INT), before and after skin incision (BL_2 and INC, respectively), before and after

TABLE Haemodynamic responses to anaesthetic and surgical interventions (Mean ± SEM)

	BL_1	IND	INT	BL_2	INC
HR (BPM)	67 ± 3	65 ± 2	68 ± 3	62 ± 2	68 ± 2*
MAP mmHg	111 ± 5	82 ± 3*	83 ± 5	83 ± 4*	104 ± 4*
CVP mmHg	9 ± 1	8 ± 1	8 ± 1	9 ± 1	11 ± 1*
PCWP mmHg	13 ± 1	11 ± 1*	10 ± 1	12 ± 1	15 ± 1*
CI $L \cdot min^{-1} \cdot m^{-2}$	3.0 ± 1.3	2.9 ± 1.7	3.0 ± 1.3	2.9 ± 1.3	2.9 ± 7

	BL_3	XCL	BL_4	DEC
HR (BPM)	69 ± 2	70 ± 2	64 ± 2	66 ± 2*
MAP mmHg	94 ± 4	101 ± 5*	95 ± 4	83 ± 3*
CVP mmHg	10 ± 1	10 ± 1	10 ± 1	10 ± 1
PCWP mmHg	13 ± 1	14 ± 1	12 ± 1	12 ± 1
CI $L \cdot min^{-1} \cdot m^{-2}$	3.1 ± 1.7	2.8 ± 1.6*	2.7 ± 1.9	2.9 ± 1.7

*Change significant ($P < 0.05$) between asterisk value and preceeding baseline BL (1–4) value.

aortic cross-clamping (BL_3 and XCL, respectively), and before and after declamping (BL_4 and DEC, respectively). A 24-hour Holter analysis (Marquette 8000) of leads II and V_5 was performed to quantitate perioperative myocardial ischaemia (PMI). Results were analyzed using repeated measures analysis of variance, and paired Student's t tests to assess the change ($P < 0.05$) caused by IND, INT, INC, XCL and DEC compared to the corresponding, preceding BL_{1-4} value (Table).

Results

The ALF infusion rate varied from 0.5–2.0 $\mu g \cdot kg^{-1} \cdot min^{-1}$, with an average dose of 14,250 ± 5,620 $\mu g \cdot kg^{-1}$ for surgery lasting 155 ± 38 minutes. This average dose includes small (7.5 $\mu g \cdot kg^{-1}$) boluses of ALF administered, according to the protocol, each time the infusion rate was increased (range of 1–4 boluses/patient). No patient required supplemental anaesthetic agents or vasodilators during surgery, including at the time of XCL. A transient decrease ($P < 0.01$) in mean arterial pressure (MAP) occurred during IND, with a reduction in PCWP ($P < 0.05$), but no change in HR, CVP or cardiac index (CI) was observed. No haemodynamic variable changed during INT. Although HR, MAP, PCWP and CI increased ($P < 0.05$) during INC, these responses were rapidly controlled by ALF. As expected, XCL caused a small increase in MAP, and DEC decreased MAP. No patient developed PMI during surgery, but five of the 13 Holter analyses (38 per cent) demonstrated PMI in the postoperative period, although no patient had a myocardial infarct. The average length of postoperative ventilation was 21 ± 9 hours and six patients (33 per cent) were extubated on the day of surgery. No patient had awareness of intraoperative events, and there were no deaths.

Discussion

In contrast to our previous finding that high-dose fentanyl and sufentanil require routine use of small doses of nitroglycerin and/or isoflurane to control haemodynamic responses during AAS[1] a variable rate ALF infusion, with N_2O, can rapidly control hypertension and tachycardia without the need of supplemental agents. The significant incidence of postoperative PMI seen with our more sensitive monitoring system is in keeping with this patient population at risk for coronary artery disease. Interestingly, none of the 13 Holters demonstrated PMI intraoperatively during anaesthesia with the ALF infusion. We conclude that a variable rate infusion of ALF provides good haemodynamic control without the use of supplemental agents during AAS, and this technique may facilitate early extubation postoperatively.

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Esmolol for control of haemodynamic responses during anaesthetic induction

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Induction of anaesthesia frequently results in marked increases in heart rate. We hypothesized that esmolol, a new cardioselective, short-acting beta-blocker, would be useful to attenuate the tachycardic reflex if administered as a bolus prior to induction of anaesthesia. We designed a double-blind, randomized placebo-controlled study in a patient population with risk factors for coronary artery disease in order to evaluate this hypothesis.

Methods

Thirty patients undergoing elective peripheral vascular surgery entered the study and gave written informed consent to the protocol approved by the Hospital Ethics Committee. Excluded were patients taking verapamil, beta blockers, or those in whom beta blockers would have been contraindicated. Patients were premedicated with diazepam 0.15 $mg \cdot kg^{-1}$ 90 minutes preoperatively. Following defasciculation, fentanyl 2 $\mu g \cdot kg^{-1}$ was given and the patients were pre-oxygenated. A coded, labelled syringe was then given over 30 seconds, and contained either placebo (P), esmolol 1.5 $mg \cdot kg^{-1}$ ($ESM_{1.5}$ or esmolol 3.0 $mg \cdot kg^{-1}$ ($ESM_{3.0}$), according to the randomization schedule. This was immediately followed by thiopentone 3.0 $mg \cdot kg^{-1}$ and succinylcholine 1.5 $mg \cdot kg^{-1}$ each given over 15 seconds. The patients' tracheas were intubated 60 seconds later, and then their lungs ventilated with nitrous oxide/oxygen in a 2:1 ratio. Measurements were taken at baseline (BL), 30 seconds following induction of anaesthesia (IND) and two minutes following intubation (INT). Cardiac index (CI) and ejection fraction (EF) were measured noninvasively by a transthoracic bioimpedance monitor (Bo-Med). Results were analyzed using repeated measures analysis of variance and least squares adjusted means (Table).

TABLE Haemodynamic responses to induction and intubation (means ± SD)

	BL	*IND*	*INT*
HR (BPM)			
P	70 ± 8	68 ± 8	86 ± 11*
$ESM_{1.5}$	71 ± 15	72 ± 11	82 ± 14
$ESM_{3.0}$	69 ± 5	69 ± 9	74 ± 7
MAP (mmHg)			
P	104 ± 17	103 ± 17	117 ± 23
$ESM_{1.5}$	105 ± 9	95 ± 13	106 ± 31
$ESM_{3.0}$	103 ± 11	83 ± 13*†	107 ± 20
CI ($L \cdot min^{-1} \cdot m^{-2}$)			
P	2.9 ± .8	2.7 ± .8	2.6 ± .6
$ESM_{1.5}$	2.8 ± .3	2.5 ± .2	2.5 ± .3
$ESM_{3.0}$	3.0 ± .5	3.0 ± .7	2.2 ± 4*
EF (%)			
P	57 ± 8	57 ± 7	50 ± 7*
$ESM_{1.5}$	54 ± 6	50 ± 7	50 ± 7
$ESM_{3.0}$	55 ± 7	51 ± 7*	45 ± 7*
RPP ($\times 10^3$)			
P	11.1 ± 2.7	10.4 ± 2.6	13.5 ± 3.8
$ESM_{1.5}$	11.9 ± 3.1	9.6 ± 2.3	10.2 ± 6.2
$ESM_{3.0}$	11.4 ± 2.7	7.1 ± 2.9	9.2 ± 3.8†

*Different from BL.
†Different from P.

Results

There were no significant differences between groups with respect to age, ASA classification, or preoperative blood pressure. Induction caused a significant reduction of mean arterial pressure (MAP) with $ESM_{3.0}$, but not with P or $ESM_{1.5}$. Heart rate (HR), CI and EF were not altered during IND in any group, but the rate–pressure product (RPP) tended to decrease with $ESM_{1.5}$, and to a greater extent with $ESM_{3.0}$. Intubation produced a significant increase ($P < 0.01$) in HR in the PLAC group, but HR did not change with either $ESM_{1.5}$ or $ESM_{3.0}$. The MAP also tended to increase in the PLAC group, but was unchanged compared to BL with either $ESM_{1.5}$ or $ESM_{3.0}$. Although $ESM_{3.0}$ resulted in significantly lower RPP compared to PLAC following intubation ($P < 0.01$), the CI and EF decreased significantly ($P < 0.04$) compared to baseline with $ESM_{3.0}$. The CI and EF were not depressed with $ESM_{1.5}$. No patient developed ischaemic electrocardiographic changes (lead V_5).

Discussion

The cardioselectivity, rapid onset, and short duration of action (half-life of nine minutes) of ESM[1] make this drug well suited to attenuate hyperdynamic responses during anaesthetic induction. $ESM_{1.5}$ prevented any change in HR or MAP during intubation, without altering CI or EF. $ESM_{3.0}$ resulted in the lowest RPP, but induced a transient, but significant fall in MAP during IND, and a decrease in CI and EF following INT. We conclude that esmolol 1.5 $mg \cdot kg^{-1}$ is safe and effective in controlling cardiovascular responses during anaesthetic induction.

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Esmolol is efficient in controlling post intubation tachycardia and hypertension

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Esmolol is a short-acting beta blocker, which may be useful in blunting the sympathetic response following endotracheal intubation. The purpose of this study is to compare the effects of two doses of esmolol (100 mg and 200 mg) and placebo on haemodynamics, following intubation.

Methods

Approval for the study was obtained from the Hospital Ethics Committee, and informed consent was obtained from each patient. Patients were excluded if they had contraindications to the use of beta blockers. Forty-eight ASA physical status I and II patients scheduled for hysterectomy were included in the study. Diazepam 5–10 mg was given orally 1½ hours preoperatively. Three baseline values were obtained for heart rate and blood pressure. Prior to induction of anaesthesia with vecuronium 1 mg, thiopentone 3–5 $mg \cdot kg^{-1}$ and succinylcholine 1.5 $mg \cdot kg^{-1}$, a 20 ml solution containing either 0, 100 mg or 200 mg was given intravenously, in double-blind fashion. Pulse and blood pressure readings were obtained at one-minute intervals. After intubation, if blood pressure or heart rate exceeded 20 per cent of baseline values, if systolic blood pressure was greater than 140 mmHg, or if heart rate was greater than 90 min^{-1}, 100 mg was given intravenously, and repeated once more if haemodynamic measurements still exceeded aforementioned limits. Maintenance anaesthesia consisted of 50 per cent nitrous oxide, enflurane 1–1.5 per cent and vecuronium 0.8 $mg \cdot kg^{-1}$. Patients were monitored with ECG, automated blood pressure cuff, and Holter monitor. All data were analyzed by analysis of covariance. A P value of less than 0.5 was considered significant.

Results

No differences in age, weight and height were seen in the three groups. Heart rate: the post-intubation heart rates following 100 mg and 200 mg of esmolol were significantly less than placebo, immediately after intubation and at 0.5, 1.5 and 2.5 minutes, though not different from each other (Figure 1). Periods of intraoperative tachycardia were effectively controlled by 100 mg of esmolol (Figure 2). Blood pressure: post-intubation systolic blood pressure following 200 mg of esmolol was significantly less than placebo immediately post-induction and at 0.5 and 1.5 minutes. Following 100 mg of esmolol, systolic blood pressure was statistically lower than placebo only at 0.5 minutes (Figure 3). Periods of intraoperative systolic hypertension were effectively controlled by 100 mg esmolol (Figure 4). Post-intubation mean and diastolic blood pressures following 100 mg and 200 mg of esmolol were significantly less than placebo at 0.5 minutes and no differences were seen between the

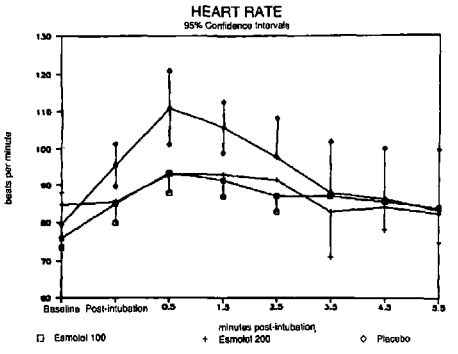

FIGURE 1

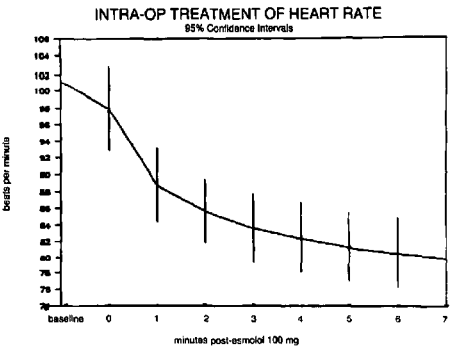

FIGURE 2

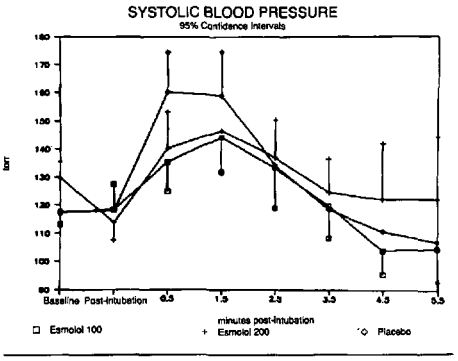

FIGURE 3

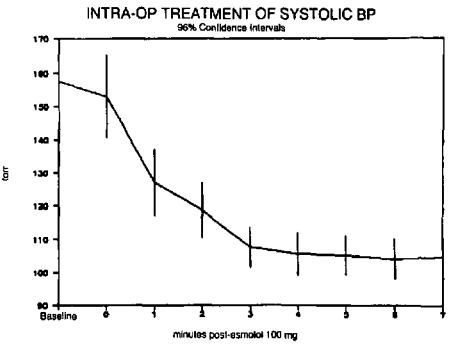

FIGURE 4

two doses of esmolol. No episodes of hypotension, bradycardia or other arrhythmias were seen in any of the patients.

Discussion

Esmolol 100 mg effectively controlled the post-intubation hypertension and tachycardia seen with placebo, although the effect was short-lived. Episodes of intraoperative hypertension and tachycardia were also controlled. Esmolol 200 mg was equally effective in the immediate post-intubation period and was found to be superior to the 100 mg dose in controlling systolic blood pressure for a longer period of time. No side effects could be attributed to esmolol.

Attenuation of the heart rate response to intubation by bolus doses of Esmolol

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Thiopentone is the most popular agent for anaesthetic induction in patients without cardiovascular compromise. Despite this, a thiopentone induction can be associated with hypotension and reflex tachycardia, followed by hypertension and further tachycardia at intubation. Patients with coronary artery disease (CAD) taking beta adrenergic antagonists chronically or as a single oral dose prior to induction have an attenuated heart rate response to intubation associated with a reduced incidence of ischaemia.[1,2] The new ultra short-acting beta adrenergic antagonist esmolol when given by infusion also attenuates haemodynamic responses to intubation;[3] however, an infusion is cumbersome at the time of induction. This investigation was performed to assess the effectiveness of a single dose of esmolol in attenuating the haemodynamic response to intubation after a thiopentone-based induction sequence, in patients at risk of CAD.

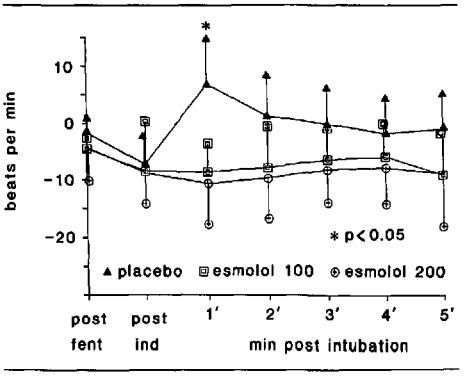

FIGURE Change in heart rate (±95% confidence limit)

Methods

With Ethics Committee approval and after informed consent, 20 patients with known or suspected (risk factors) CAD presenting for surgical procedures requiring intubation were studied. Premedication was with diazepam 0.15 mg · kg^{-1} PO, glycopyrrolate 3 μg · kg^{-1} and morphine 0.075 mg · kg^{-1} IM 90 min before surgery. On arrival in the operating suite a continuously recording monitor of leads II and V5 of the EKG was attached (QMED), and either an arterial cannula inserted or an automated blood pressure cuff attached (Dinamap). The operating room pharmacist supplied the anaesthetist with a blinded syringe containing either saline (placebo), esmolol 100 mg or esmolol 200 mg. After baseline recordings of heart rate (HR), systolic and diastolic blood pressures (SBP, DBP) d-tubocurarine 0.04 mg · kg^{-1} and fentanyl 2 μg · kg^{-1} were given. Three minutes later thiopentone 3–5 mg · kg^{-1} was given over 30 sec followed by succinylcholine 1.5 mg · kg^{-1} over 10 sec, then the study drug over 15 sec. Intubation was performed 90 sec after the study drug and anaesthesia maintained with N_2O/O_2 and enflurane. HR, SBP and DBP were recorded at 1 min intervals for 15 min after intubation. Data were analysed using analysis of covariance, with a significance level of $P < 0.05$.

Results

There were seven patients in the placebo group, seven patients received esmolol 100 mg and six esmolol 200 mg. Changes in HR from baseline are shown in the Figure. At 1 min after intubation HR had increased by a mean of 7 bpm in the placebo group compared with a mean decrease of 10 bpm in both esmolol groups ($P < 0.01$). The latter groups were not different from one another. There were no significant differences in SBP at any time between groups. The SBP fell 31 ± 4 mmHg (mean ± SEM of the 20 patients) below baseline after thiopentone, was 52 ± 6 mmHg below baseline before intubation, and rose to 1 ± 8 mmHg above baseline 1 min after intubation. There were no episodes of myocardial ischaemia.

Discussion

This study shows that esmolol 100 mg prevents the tachycardia associated with intubation after thiopentone. There was no advantage in using esmolol 200 mg. Prevention of tachycardia may prevent ischaemia in patients with CAD,[1,2] and 100 mg esmolol appears to be a valuable and convenient adjunct to anaesthetic induction in this patient population.

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Esmolol reduces nitroprusside-induced tachycardia after abdominal aortic surgery

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Myocardial ischaemia in patients undergoing aortic reconstructive surgery (ARS) may occur in patients with pre-existing coronary artery disease, and can be associated with perioperative hypertension and tachycardia.[1] Postoperative hypertension can be controlled with sodium nitroprusside (SNP) but this often produces reflex tachycardia. Previously we found that although the short-acting beta-blocker esmolol (ESM) was ineffective as the sole agent in controlling postoperative hypertension,[2] it modified the tachycardia associated with SNP. We wished to determine the efficacy of esmolol vs placebo in controlling SNP associated tachycardia following ARS.

Methods

With Ethics Committee approval and informed consent, 17 patients scheduled for ARS were studied. Patients with asthma, COPD, cardiac failure or those taking chronic beta blockers were excluded. All patients received a standardized premedication and anaesthetic. Postoperatively, SNP was started when systolic blood pressure (SBP) >140 mmHg. If the heart rate (HR) then increased to >80 bpm, the patient was randomized to receive either esmolol or placebo in a double-blind fashion. The study drug was given to efficacy or termination of the titration period by increasing rates of infusion during three titration stages. A bolus of 25 mg of the study drug was given over 30 sec at the start of each titration stage, followed by an infusion of 8 mg · min^{-1}, increasing to 16 mg · min^{-1} and then 24 mg · min^{-1} at 5 min intervals until efficacy was reached (defined as a >10 per cent decrease in HR). The rate of infusion at which efficacy was reached was maintained for up to 4 hrs (maintenance). If efficacy was not reached by the end of the third stage, the infusion was maintained for a further 30 mins then discontinued. The SNP infusion was kept constant during the titration stages,

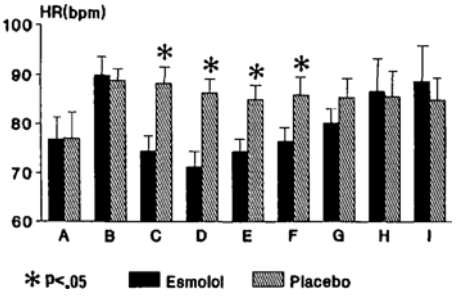

FIGURE Heart rates at study intervals (mean ± SEM). A = PreSNP; B = PreESM; C = At maintenance (M); D = M + 15 min; E = end of ESM inf + 5 min (E); F, G, H, I = E + 15, 30, 45, 60 min.

TABLE Nipride infusion requirements $\mu g \cdot kg^{-1} \cdot min^{-1}$

	Placebo	*Esmolol*
Pre-esmolol	1.62 ± 0.5	1.64 ± 0.4 (NS)
Pre-maintenance	1.65 ± 0.05	1.62 ± 0.8 (NS)
Maintenance +15 min	1.56 ± 0.5	1.76 ± 0.3 (NS)

otherwise it was titrated to keep SBP between 130–140 mmHg. HR and SBP were recorded before the start of the SNP infusion, before the start of the titration stages, at 1 min intervals during titration and for the first 15 min of maintenance, or for 15 min after the third titration stage, at the end of the study drug infusion, and at 5, 15, 30, 45 and 60 min post infusion. Haemodynamic profiles were measured at preSNP, preESM, maintenance + 15 min or maximum infusion rate + 15 min, on discontinuation of the infusion of esmolol and at 60 min post-infusion. Data were analyzed with ANOVA for repeated measurements.

Results

Eight patients received esmolol (Group E) and nine placebo (Group P). All patients in Group E but none in Group P reached efficacy. The mean time to efficacy in Group E was 4 min (range 2–7 min). Significant differences in HR are shown in the Figure. SNP requirements were unchanged in Group P but decreased in Group E during the first 15 min of maintenance by a mean of 50 per cent from preESM (Table). By this time SNP was removed entirely in three patients in Group E compared with no patients in Group P. The SBP was significantly lower in the esmolol group at the beginning of maintenance period. There were no other significant differences in any haemodynamic variables between the two groups.

Discussion

Esmolol was effective in reducing the tachycardia associated with SNP therapy. No difference in CO was demonstrated between the groups suggesting no negative inotropic effect in this patient population. Furthermore the rate of SNP infusion was reduced by 50 per cent only in the esmolol group. The combination of esmolol and SNP appears to be an effective way of treating postoperative hypertension following ARS especially in patients where tachycardia already is present, or where reflex tachycardia associated with SNP therapy is undesirable.

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Circulatory effects of isoflurane following graded versus abrupt increases in concentration

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The haemodynamic effects of potent inhalational anaesthetics are traditionally studied at steady state end tidal concentrations.[1,2] It is assumed that anaesthetic effects are dose-related and independent of method or rate of administration. This assumption was challenged using an acutely instrumented dog model which compared abrupt versus graded increases in isoflurane concentration.

Methods

Mongrel dogs were basally anaesthetized with morphine 3 $mg \cdot kg^{-1}$ and chloralose 100 $mg \cdot kg^{-1}$, tracheas intubated and lungs ventilated. Choralose infusion was maintained at 20 $mg \cdot kg^{-1} \cdot hr^{-1}$. Haemodynamic monitoring consisted of heart rate (HR), mean arterial pressure (MAP), thermodilution cardiac output (CO), pulmonary arterial occlusion pressure (PAOP) and left ventricular dP/dt. Thoracotomy was performed to measure electromagnetic circumflex coronary artery blood flow (CBF_{circ}) and coronary sinus oxygen saturation ($CSO_{2\ SAT}$). Following chest closure, control measurements were made during the basal anaesthetic state. Each dog received isoflurane by two different methods, graded (G) or abrupt (A), in random order. By method G isoflurane concentration was increased by increments (0.4, 0.8, 1.2, 1.6, 2.0, 2.4 per cent end tidal) with a minimum 10-minute equilibration period at each concentration. By method A isoflurane was administered to 1.2 per cent end tidal for ten minutes and then 2.4 per cent end tidal for an additional ten minutes. Isoflurane was measured by continuous infrared analysis. Effects of methods G and A were compared at 1.2 and 2.4 per cent isoflurane. Data was analyzed with ANOVA and paired t tests ($P < 0.05$).

Results

Graded administration of isoflurane produced a significant increase in HR, CBF_{circ} and $CSO_{2\ SAT}$ with significant reductions in MAP, dP/dt and CVR_{circ}. CO decreased only at 2.4 per cent isoflurane. Abrupt administration of isoflurane to 1.2 per cent was associated with significantly greater HR and CBF_{circ} and lower CVR_{circ} compared with graded administration. The increase in CO was not significant ($P = 0.065$). MAP, dP/dt and

TABLE Results: mean ± SD

		1.2% Isoflurane	
N = 9	Control	G	A
HR min	72 ± 21	80 ± 18	93 ± 22*
MAP mmHg	110 ± 16	81 ± 17	82 ± 19
CO L·min^{-1}	2.96 ± 0.61	2.77 ± 0.60	3.16 ± 0.69
dP/dt mmHg·min^{-1}	3148 ± 850	2315 ± 361	2406 ± 449
CBF_{circ} ml·min^{-1}	43 ± 11	58 ± 20	73 ± 32*
CVR_{circ} dyne·sec·cm^{-5}	200 ± 45	114 ± 50	99 ± 52*
$CSO_{2\ SAT}$%	56.2 ± 6.9	70.6 ± 5.0	73.8 ± 8.0

	2.4% Isoflurane	
N = 9	G	A
HR min	103 ± 12	101 ± 15
MAP mmHg	55 ± 11	50 ± 8
CO L·min^{-1}	2.81 ± 0.78	2.79 ± 0.48
dP/dt mmHg·min^{-1}	1302 ± 212	1409 ± 281
CBF_{circ} ml·min^{-1}	58 ± 26	60 ± 25
CVR_{circ} dyne·sec·cm^{-5}	77 ± 40	64 ± 29
$CSO_{2\ SAT}$%	76.5 ± 9.7	78.7 ± 7.9

*Significant difference graded versus abrupt. $P < 0.05$.

$CSO_{2\ SAT}$ were similar with both methods. At 2.4 per cent isoflurane there were no differences between abrupt and graded administration (Table).

Summary

This study confirms the potent haemodynamic and coronary vascular effects of isoflurane.[1,2] Isoflurane vasodilated the coronary circulation as shown by both increased CBF_{circ} and $CSO_{2\ SAT}$. The effects of isoflurane differed between abrupt and graded administration. Isoflurane given abruptly to 1.2 per cent potentiated the increase in HR and CBF_{circ}, likely as a result of increased HR and MVO_2. The cause of this exaggerated tachycardia is not apparent from this study.

Future studies of isoflurane's circulatory effects should take into consideration the effect of rate of administration in addition to dose. Tachycardia and increased coronary blood flow are potentiated by abrupt administration. From a clinical point of view this may be important for the anaesthetic management of patients with coronary artery disease.

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The effect of isoflurane on recovery of stunned myocardium

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Reperfusion after a brief period of coronary artery occlusion results in delayed recovery of regional contractile function despite the absence of myocardial cell necrosis. This syndrome of stunned myocardium may occur in many diverse clinical situations in the patient with coronary artery disease. This study examines the effect of isoflurane administered prior to reperfusion on the functional recovery of systolic shortening in post-ischaemic myocardium in an open-chest dog model.

Methods

Six mongrel dogs (21–29 kg) were anaesthetized with intravenous sodium pentobarbitone (30 mg·kg^{-1}, bolus plus 2 mg·kg^{-1}·hr^{-1} infusion) and fentanyl (23 μg·kg^{-1} bolus plus 1 μg·kg^{-1}·hr^{-1} infusion). Through a left thoracotomy, pairs of piezoelectric crystals were implanted in the subendocardium in the area of the left anterior descending coronary artery (LAD) to be stunned, and in the distribution of the circumflex artery (CIRC). Systolic shortening (SS) was determined by the equation %SS = ((EDL-ESL)/EDL)100, where EDL equals end–diastolic length and ESL equals end–systolic length. All values are expressed as percentages of pre-ischaemic baseline measurements. To produce an area of stunned myocardium, the LAD distal to the first major diagonal branch was occluded for 15 minutes and then reperfused for three hours. In three dogs isoflurane was administered at a constant end–tidal concentration of 1.2 per cent for 20 minutes prior to and during occlusion, whereas the remaining three dogs underwent occlusion-reperfusion without isoflurane. Isoflurane was discontinued at the

TABLE Systolic shortening (%baseline)

		Occlusion (min)	Reperfusion (min)	
		15	15	30
CIRC	Control	84.0 ± 18.9	88.7 ± 16.0	106.5 ± 13.3
	Isoflurane	86.0 ± 18.3	92.2 ± 12.6	94.3 ± 11.7
LAD	Control	−12.9 ± 8.5*	33.1 ± 26.4*	48.6 ± 26.2*
	Isoflurane	+9.1 ± 8.1†	29.7 ± 18.7†	54.6 ± 19.9†

		Reperfusion (min)		
		60	120	180
CIRC	Control	121.8 ± 24.0	86.5 ± 28.3	101.4 ± 39.4
	Isoflurane	93.2 ± 16.3	83.2 ± 16.3	77.0 ± 18.6
LAD	Control	65.2 ± 15.2*	38.9 ± 43.9*	48.6 ± 42.9*
	Isoflurane	55.6 ± 20.6†	61.5 ± 11.3†	57.2 ± 11.5†

*Significant difference between LAD and CIRC in control dogs ($P < 0.05$); mean (SD).
†Significant difference between LAD and CIRC in isoflurane dogs ($P < 0.05$).
No significant differences between control and isoflurane dogs in CIRC or LAD ($P > 0.05$).

onset of reperfusion to study recovery of function in the absence of anaesthetic-induced depression of myocardial contractility. To control haemodynamic variables the left atrium was paced and the descending aorta was variably occluded with umbilical tape. Data were analyzed using repeated measures analysis of variance followed by Tukey's test for multiple comparisons where appropriate

Results

LAD occlusion produced significant decreases in systolic shortening in both groups in the LAD area only which persisted during reperfusion ("stunned myocardium"). The recovery of contractile function was not significantly different between those dogs having received isoflurane prior to reperfusion and those having received no inhalational agent. Haemodynamic changes between groups were minimized and the rate-pressure product used as an indirect measure of oxygen demand was not significantly different between groups at any point of measurement.

Discussion

These results do not demonstrate a protective effect of isoflurane on the development or recovery of post-ischaemic ventricular dysfunction in this model. This is in contrast to the recent report of Warltier *et al.*,[1] who studied conscious, chronically instrumented dogs with no basal anaesthetic, and made no attempt to control haemodynamic changes. Although isoflurane would appear not to have a protective effect in the absence of haemodynamic changes in this acute dog model, because of the small number of animals studied, further experiments are required to support these conclusions.

Acknowledgement

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Reference

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Isoflurane depresses vetricular function in stunned myocardium

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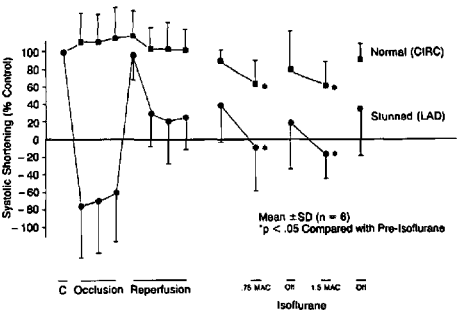
It is well recognized that short periods of coronary artery occlusion, while not associated with myocardial necrosis, can produce persistent ventricular dysfunction.[1] Since the effect of inhalational anaesthetics on this "stunned myocardium" is unknown, this study examined the effect of isoflurane, administered after reperfusion, on regional function and metabolism in the canine heart.

Methods

Six mongrel dogs (17–30 kg) were anaesthetized with intravenous sodium pentobarbital (bolus of 30 $mg \cdot kg^{-1}$ then 1 $mg \cdot kg^{-1} \cdot hr^{-1}$) and fentanyl citrate (bolus of 23 $\mu g \cdot kg^{-1}$ then 0.8 $\mu g \cdot kg^{-1} \cdot hr^{-1}$), tracheas intubated and lungs mechanically ventilated to maintain normocarbia. The heart was exposed through a left thoractomy, the left anterior descending (LAD) artery was dissected free distal to the first major diagonal branch and a snare loosely placed. Regional function was evaluated by measuring systolic shortening using ultrasonic crystals – one pair implanted in an area supplied by the LAD artery and a second pair in a "control" area supplied by the circumflex (CIRC) artery. Systolic shortening (SS) was determined by the equation %SS = ((EDL-ESL)/EDL) × 100 where EDL = end–diastolic length and ESL = end–systolic length. Values are expressed as a percentage of the baseline value. Heart rate was kept constant by atrial pacing and arterial pressure was held near control levels by variable cinching of the descending aorta. Venous blood samples for oxygen and lactate measurements were obtained through small gauge catheters inserted into the epicardial veins draining the LAD and CIRC regions. Following stabilization and baseline measurements, the LAD was occluded for 15 min and reperfused for 15 min. The effect of two doses of isoflurane (0.75 and 1.5 MAC) on stunned and normal myocardium was measured during the subsequent two hours of reperfusion in each animal. Data were analyzed using repeated measures analysis of variance and Duncan's multiple range test. $P < 0.05$ was considered significant.

Results

Occlusion of the LAD with subsequent reperfusion produced decreased systolic shortening (stunned myocardium) in the LAD area (Figure). The administration of isoflurane resulted in significant but comparable decreases in systolic shortening in both the stunned and normal regions of the heart. Lactate extraction was not significantly decreased with isoflurane in either area. Lactate production did not occur at any time during reperfusion or isoflurane administration. Oxygen extraction was not different between the two areas of the heart although the high



FIGURE

dose of isoflurane produced a significant decrease in oxygen extraction in the stunned area. Mean arterial blood pressure, heart rate and left ventricular end–diastolic pressure did not change significantly throughout the experiment.

Discussion

These results show that in dysfunctional or stunned myocardium, the subsequent administration of isoflurane produces further significant decreases in systolic shortening. Although this decrease in function is likely to be of greater consequence in an already compromised area of the heart, the changes are not qualitatively different from the decreases in function produced in normal areas of the myocardium.

Acknowledgement

Supported in part by the David S. Sheridan Canadian Research Award.

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Bolus doses of esmolol for the prevention of post-intubation hypertension and tachycardia

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Esmolol, an ultra short-acting (half-life of nine minutes) beta-blocking agent with cardioselectivity, has been shown to attenuate the sympathetic response to intubation when administered as an infusion prior to induction. This study was designed to determine the efficacy and safety of 100 mg and 200 mg esmolol vs placebo in preventing intubation-induced hypertension and tachycardia when given as bolus doses.

Methods

Thirty unpremedicated ASA physical status II or III patients were randomly assigned to receive, in a double-blind fashion, placebo (n = 10), esmolol 100 mg (n = 12), or esmolol 200 mg (n = 8) IV 90 seconds prior to intubation. Systolic and diastolic blood pressure and heart rate were recorded every minute for three minutes prior to induction and for 15 minutes after intubation. Lead II and modified V5 of the EKG were continuously recorded by Holter monitoring to detect ST evidence of ischaemia and arrhythmias during this period. The standardized induction sequence consisted of thiopentone 5 $mg \cdot kg^{-1}$, succinylcholine 1.5 $mg \cdot kg^{-1}$ followed by tracheal intubation within one minute. The lungs were ventilated with nitrous-oxide/oxygen alone ($3 + 2\ L \cdot min^{-1}$), and the patients were left undisturbed for the first five minutes post-intubation.

Results

There was no difference in demographic data or baseline haemodynamic values among groups. Mean maximum increases in heart rates and blood pressures were observed within two minutes post-intubation in all groups. Mean heart rates post-intubation were significantly lower ($P < 0.05$) in both esmolol groups vs placebo for the first three minutes post-intubation. Mean maximum heart rates post-intubation were 91 ± 11 bpm following esmolol 100 mg ($P < 0.01$ vs placebo), 88 ± 8 bpm following esmolol 200 mg ($P < 0.001$ vs placebo) and 107 ± 9 bpm following placebo. Mean blood pressures (systolic and diastolic) post-intubation did not differ among any groups. ST evidence of ischaemia was not detected in any patient. Significant ventricular arrhythmias occurred in six of ten patients following placebo vs two of 20 patients following esmolol ($P < 0.01$ by Fisher exact test). No statistically significant difference in any variable was detected between the 100 mg and 200 mg esmolol group.

Discussion

When given in bolus doses of 100 or 200 mg 90 seconds pre-intubation, esmolol attenuates but does not abolish the sympathetic response to intubation. Like others, we found that esmolol attenuates tachycardia but has less clinically significant effect on blood pressures. Optimum dosage and timing of bolus esmolol prophylaxis warrants further investigation.

References

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Resonance characteristics of pulmonary artery catheters: is shorter better?

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Although the clinical use of invasive pressure measurement catheters has become commonplace, a number of technical considerations are important in obtaining accurate recordings. Such catheter-transducer assemblies are generally well modelled as an "underdamped, second order dynamic system" defined by two variables: the resonant (natural) frequency and the damping coefficient.[1] The resonant frequency "refers to how rapidly the system oscillates" while the damping coefficient "refers to how quickly the system comes to rest." Studies by Gardner[1] and Hunziker[2] have emphasized the importance of high resonance frequencies in obtaining accurate recordings in such systems.

The objective of this study was to compare the resonance characteristics of 85 and 110 cm pulmonary artery catheters. Measurements were obtained by applying a variable frequency sine wave pneumatic input from a Bio-Tek model 601A blood pressure simulator to the catheters under test. As in Hunziker's

TABLE

	Abbott 85 cm	*Edwards 110 cm*
n	6	5
Mean resonant freq (Hz)	35.0	27.2
Standard deviation	7.02	4.33
Range (Hz)	26.7 – 42.6	22.2 – 31.4

study, a disposable Cobe pressure transducer was used. The excitation frequency which provided the maximum signal amplitude at the transducer output was taken as the resonant frequency.[1,2] Six Abbott 85 cm and five Edwards 110 cm pulmonary artery catheters were compared by t test. The results are given in the Table. The difference in mean resonance frequency is significant at the $P < 0.05$ level ($T = -2.17$, df = 9).

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 under-damped second order systems cannot be easily increased, while the damping coefficient can be increased to improve waveform fidelity by using a damping device such as an Accudynamic(R).[2,3] The results presented here suggest that the shorter 85 cm pulmonary artery catheters are superior to the 110 cm units studied from a resonance frequency perspective. At the clinical level, the use of the shorter 85 cm catheters would be expected to result in improved waveform fidelity in patients undergoing pulmonary artery catheterization.

References

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Increased secretion of artrial natriuretic factor (ANF) induced by a low dose of fentanyl in humans

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Plasma concentrations of ANF, a new hormone with vasodilator, hypotensive and natriuretic properties, were measured in three groups of normal subjects between the ages of 18 and 50 years. All were normotensive and pain-free. Measurements were made after 30 minutes at rest in the recumbent position (baseline) and at different intervals after an IV bolus of fentanyl 3 $\mu g \cdot kg^{-1}$ given in a single-blind fashion.

TABLE Effect of fentanyl on C-ANF (Group B, n = 10)

Time	*0'*	*5'*	*15'*	*30'*	*45'*
Mean	6.8	10.8	12.8	10.9	9.1
SD	4.9	9.7	11.5	7.3	4.8
% Control		151.4	181.4	172.8	157.2
SD (%)		52.1	87.4	82.8	102.3
P value		<0.05	<0.05	<0.05	NS

Group A (Short protocol, ten subjects)

C-terminal ANF (C-ANF) and N-terminal ANF (N-ANF) was measured at 0 and then at 5 and 15 minutes after a fast bolus (<15 seconds) of fentanyl (3 $\mu g \cdot kg^{-1}$). In the six females, C-ANF rose from 7.8 (±2.7) to 11.6 (±4.3) at 5' and 13.8 (±4.7) $pmol \cdot L^{-1}$ at 15'. In the four males, ANF was 7.7 (±3.4) at 0', 8.2 (±3.9) at 5' and 13.1 (±4.7) $pmol \cdot L^{-1}$ at 15'. These values represent a comprehensive rise of 30 per cent at 5' ($P < 0.01$) and 76 per cent at 15' ($P < 0.001$). The response was higher in the female group at 5' but identical to males at 15'.

Group B (Long protocol, 12 subjects)

C- and N-ANF, haematocrit (Hct), renin activity (PRA), aldosterone (ALDO), Norepinephrin (NE) and cyclic GMP (cGMP) have been measured at 0, 5, 15, 30, 60, 90 and 120' after a slow IV bolus of fentanyl (3 $\mu g \cdot kg^{-1}$) given over a period of one minute. Two subjects developed hypoxia at 15' and were eliminated. In two subjects (non-responders), ANF did not rise. In eight responders, C- and N-ANF rose and remained high for at least 30 minutes (Table).

In six subjects in whom C-ANF rose more than 100 per cent, cGMP increased from 50 to 100 per cent confirming biological activation of target cells. PRA rose at 15', ALDO varied without a definite trend and NE did not change.

Group C (Control group)

Six subjects have been studied as in group B but without any fentanyl injection.

In all groups, Hct, blood pressure and heart rate did not change significantly. O_2 by mask was given and SaO_2 monitored in group B and C. D5W-1/2 saline infusions were given at a total rate of 3.5 $ml \cdot kg^{-1} \cdot hr^{-1}$ which does not cause fluid overloading or atrial distension.

In the absence of other known stimulatory factors, it is concluded that ANF secretion can be stimulated by a low dose of fentanyl and that its plasma concentration remained high for at least 30 minutes.

With higher dosages of fentanyl or with other narcotics, as used during anaesthesia, the increased ANF release may contribute significantly to the described vasodilation, blood pressure stability and Na excretion changes seen with this type of anaesthesia.