Clinical Reports

Anaesthesia for coronary artery bypass surgery supplemented with subarachnoid bupivacaine and morphine: a report of 18 cases

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We report our experience with general anaesthesia (GA) supplemented with subarachnoid bupivacaine and morphine for coronary artery bypass surgery (CABG) in 18 patients. Fifteen patients were male, and mean age was 62 yr. Anaesthesia (GA) was induced with alfentanil $97 \pm 22 \mu\text{g} \cdot \text{kg}^{-1}$ and midazolam $0.04 \pm 0.02 \text{ mg} \cdot \text{kg}^{-1}$ supplemented with a muscle relaxant, and maintained with isoflurane (0.25–0.5%) in oxygen throughout surgery. Spinal anaesthesia (SA) was then performed at a lumbar level using hyperbaric bupivacaine (23–30 mg) and/or lidocaine (150 mg) with morphine (0.5–1 mg). Pooled data showed the following haemodynamic results ($P < 0.05$). Induction of GA produced a decrease in mean arterial pressure (MAP). Addition of SA produced a decrease in heart rate. Heart rate and MAP did not change with sternotomy. Phenylephrine support of arterial blood pressure was used at some time during operation in 17 patients. Supplementation of GA was minimal. Patients received 2.7 ± 0.7 coronary grafts. Operating room time was 3.9 ± 0.6 hr. Postoperative analgesic requirements were minimal, and in half of the patients tracheal extubation occurred on the day of surgery. Complications included one myocardial infarction, one re-sternotomy, a metabolic

encephalopathy in a dialysis-dependent patient, and one case of herpes labialis. No patient recalled intraoperative events. Combined GA with SA may be an effective technique for CABG surgery. Further study of the cardiovascular, neurological and metabolic effects of the technique is required.

Nous rapportons notre expérience avec l'anesthésie générale (AG) associée à une rachianesthésie (RA) à la bupivacaine et à la morphine réalisée chez 18 opérés pour pontages coronaires. Quinze des patients sont des hommes et l'âge moyen est de 62 ans. L'anesthésie générale est induite avec de l'alfentanil $97 \pm 22 \mu\text{g} \cdot \text{kg}^{-1}$, du midazolam $0,04 \pm 0,02 \text{ mg} \cdot \text{kg}^{-1}$ et un myorelaxant, et maintenue avec de l'isoflurane (0,25–0,5%) en oxygène. Après l'induction, une rachianesthésie lombaire est alors exécutée avec de la bupivacaine hyperbare (23–30 mg) avec ou sans lidocaïne (150 mg) et avec de la morphine (0,5–1 mg). Les données groupées révèlent les résultats hémodynamiques suivants ($P < 0,05$). L'induction de l'AG provoque une baisse de la pression artérielle moyenne (PAM). L'addition de la RA produit un ralentissement de la fréquence cardiaque (FC). La sternotomie ne modifie ni la FC ni la PAM. A un moment ou un autre de l'intervention, la pression artérielle a dû être soutenue chez 17 patients avec de la phényléphrine. Le besoin d'AG supplémentaire est minime. Les pontages aortocoronariens totalisent $2,7 \pm 0,7$ par patient. La durée moyenne des interventions est de $3,9 \pm 0,6$ h. Les besoins d'analgesie postopératoires sont minimes et la moitié des patients sont extubés le jour de la chirurgie. Les complications comprennent: un infarctus du myocarde, une reprise de sternotomie, une encéphalopathie métabolique et un herpès labial. Aucun des patients ne s'est remémoré d'événements peropératoires. L'AG combinée à la RA pourrait s'avérer une technique efficace pour la chirurgie de revascularisation myocardique.

Key words

ANAESTHESIA: cardiovascular;
ANAESTHETIC TECHNIQUES: spinal;
SURGERY, CARDIOVASCULAR: cardiopulmonary bypass.

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Des études plus poussées au regard des répercussions cardiovasculaires, neurologiques et métaboliques s'imposent.

An ideal anaesthetic agent for coronary artery bypass surgery (CABG) should provide: haemodynamic stability without myocardial depression or coronary vasoconstriction; ease of administration; lack of toxicity; elimination independent of the lung, liver, and kidney; rapid emergence with residual analgesia; and titratable effect.¹ In practice, no agent has all of these characteristics. High-dose opioid anaesthetics are commonly used in cardiac surgery due to the relative intraoperative haemodynamic stability.²⁻⁴ Nevertheless, problems with high-dose opioid techniques are well recognized and include hypertension and tachycardia related to sternotomy,^{5,6} awareness, and postoperative respiratory depression.

Foothills Hospital has a small cardiac surgery programme performing approximately 310 procedures per year. In 1993, only 15% of coronary procedures were performed on patients admitted electively. Many of the remainder were receiving heparin *iv* until the time of surgery. During that year, 52 patients received some form of spinal anaesthesia or analgesia. The main selection criterion for a spinal technique was absence of preoperative heparin infusion.

Following the approach of Fitzpatrick *et al.*,⁷ we have administered subarachnoid morphine to cardiac surgical patients in order to improve postoperative analgesia while decreasing perioperative *iv* opioid dose. Recently, this technique has been modified by the addition of large doses of subarachnoid bupivacaine (30 mg) to provide a high spinal anaesthetic (SA). The main objectives of this adaptation were to provide a stable intraoperative haemodynamic course, to decrease requirements for long-acting opioids, and potentially to obtain the beneficial effects of cardiac sympathectomy, which may include decreased myocardial oxygen consumption and enhanced blood flow to ischaemic myocardium.⁸⁻¹⁰ We have used sufentanil or the shorter-acting opioid, alfentanil to induce general anaesthesia (GA) in conjunction with SA. Since the effect of SA on haemodynamic stability throughout surgery may be more apparent following alfentanil, we report our experience with this technique in 18 patients.

Case reports

The hospital charts of all patients anaesthetized with this technique at Foothills Hospital from January to November 1992 were reviewed. Eighteen such patients were identified. These patients underwent elective or urgent CABG and were ASA III-IV. Numerical data are reported as mean $\pm$ standard deviation (SD). Fifteen patients were male, and the age was 62 ± 11 yr (range

39-79 yr). Recorded ejection fractions ranged from 30 to 73%. Antianginal therapy included β -adrenergic blockers (12 patients), calcium antagonists (11 patients), and nitrates (six patients). Six patients were receiving angiotensin converting enzyme antagonists. Preoperatively, risk was predicted according to the scoring system developed by Parsonnet, in which total score equates the percentage risk of perioperative mortality.¹¹ The mean Parsonnet score was 8 ± 5.4 (range 0 to 16).

Potential risks and benefits of spinal anaesthesia were explained to the patients who provided consent for the use of the technique. Regular antianginal medications were continued until surgery, and patients were not receiving heparin preoperatively. Premedication was with lorazepam 2-3 mg *po* (12 patients), diazepam 10 mg *po* with morphine 5-10 mg and scopolamine 0.4 mg *im* (four patients), or morphine/scopolamine (two patients). Routine monitoring was initiated before induction of GA and included pulmonary artery catheterization and two lead (II, V₅) electrocardiography with continuous ST-segment analysis. Anaesthesia was induced with alfentanil $97 \pm 22 \mu\text{g} \cdot \text{kg}^{-1}$ (range 50-130 $\mu\text{g} \cdot \text{kg}^{-1}$) and midazolam $0.04 \pm 0.02 \text{ mg} \cdot \text{kg}^{-1}$ (range 0-0.06 $\text{mg} \cdot \text{kg}^{-1}$), and supplemented with neuromuscular blocking agents (metocurine-pancuronium, pancuronium, vecuronium or a combination of these). After induction of GA, SA was administered at the L₃₋₄ or L₄₋₅ interspace using 25 ga (16 patients) or 22 ga (two patients) needles. Hyperbaric bupivacaine (23-30 mg, 15 patients), lidocaine (150 mg, one patient) or a combination (two patients), and unpreserved morphine (0.5-1.0 mg) were administered. Trendelenburg position was maintained for at least 10 min after administration of SA. Anaesthesia was continued with isoflurane 0.25-0.5% (vaporizer concentration) in oxygen throughout the surgical procedure. Hyperdynamic, hypodynamic, and myocardial ischaemic responses were treated with anaesthetic and vasoactive agents at the discretion of the anaesthetist.

Surgeons used cold blood cardioplegia without active systemic cooling on cardiopulmonary bypass (CPB). Patients received 2.7 ± 0.7 coronary grafts (range one to four). Operating room time was 3.9 ± 0.6 hr (range 3.1-5.3 hr). Time from induction of GA to sternotomy was 54 ± 8 min (range 40-70 min). Postoperatively, patients were transferred to intensive care (ICU) with the duration of controlled ventilation at the discretion of the intensivist.

Heart rate (HR), mean arterial pressure (MAP), cardiac index (CI) and pulmonary capillary wedge pressure (PCWP) for the following periods were taken from the anaesthetic records: before and after induction of GA, after induction of SA, immediately after sternotomy, and after weaning from CPB. Individual patient data and

FIGURE 1 Heart rate: individual patients ($n = 18$). Mean (SD). FIGURE 3 Cardiac index: individual patients ($n = 12$). Mean (SD). FIGURE 2 Mean arterial pressure: Individual patients ($n = 18$). Mean (SD). FIGURE 4 Pulmonary capillary wedge pressure: individual patients ($n = 13$). Mean (SD).

mean (SD) are presented in Figures 1-4 ($n = 18$ for HR and MAP; $n = 12$ for CI; $n = 13$ for PCWP). Pooled data were analyzed using Friedman repeated measures analysis of variance (ANOVA) on ranks, and are presented in the Table. Individual comparisons were made using Student-Neuman-Keuls test for multiple comparisons. Significance was accepted at $P < 0.05$. The ANOVA showed time period interactions ($P < 0.001$) for all haemodynamic variables. Induction of GA produced a decrease in MAP. Addition of SA produced a decrease in HR. Heart rate and MAP did not change

with sternotomy. All haemodynamic variables increased after CPB.

Several observations were made on the individual patient data. Heart rate decreased more than 20% from the previous interval in five patients after induction of GA, and in two patients after induction of SA. After sternotomy, two patients had a 20% decrease in HR and no patient had a 20% increase in HR. Mean arterial pressure decreased more than 20% in 11 patients after induction of GA, and in two patients after induction of SA. Mean

TABLE Pooled haemodynamic data

Variable	Pre-induction	Post-induction	Post-spinal	Post-sternotomy	Post-CPB
HR beats $\cdot$ min ⁻¹ 18 (n = 18)	67 $\pm$ 11	59 $\pm$ 9	52 $\pm$ 5*	52 $\pm$ 8*	67 $\pm$ 8
MAP mmHg (n = 18)	89 $\pm$ 13*	71 $\pm$ 9	69 $\pm$ 11	72 $\pm$ 9	74 $\pm$ 9†
CI L $\cdot$ min ⁻¹ $\cdot$ M ⁻² (n = 12)	2.4 $\pm$ 0.4	2.2 $\pm$ 0.3	2.2 $\pm$ 0.2		2.7 $\pm$ 0.5*
PCWP mmHg (n = 13)	12 $\pm$ 3	11 $\pm$ 3	13 $\pm$ 2		16 $\pm$ 3*

Mean values $\pm$ SD. ANOVA $P < 0.001$ for time period interactions for all variables.

Heart rate (HR) - * $P < 0.05$ vs all other times.

Mean arterial pressure (MAP) - * $P < 0.05$ vs all other times. † $P < 0.05$ vs post-spinal.

Cardiac index (CI) - * $P < 0.05$ vs all other times.

Pulmonary capillary wedge pressure (PCWP) - * $P < 0.05$ vs all other times.

arterial pressure increased more than 20% in two patients after induction of SA. Mean arterial pressure increased more than 20% in three patients after sternotomy, but in none of these three cases did this value exceed 85 mmHg.

No ST-segment changes >0.1 mV were noted before CPB. Five patients had ST-segment changes >0.1 mV (elevation in three and depression in two) after CPB.

Ten patients received supplemental alfentanil 32 ± 14 $\mu\text{g} \cdot \text{kg}^{-1}$, and 17 patients received supplemental midazolam 0.07 ± 0.04 $\text{mg} \cdot \text{kg}^{-1}$ throughout the operative period. Phenylephrine was given, by bolus or infusion, to seven patients after induction of GA, eight patients after induction of SA, 13 patients during CPB and seven patients after CPB. Phenylephrine was given to 17 patients at some point in the intraoperative period. Intraoperative fluid administration (anaesthesia, CPB, cardioplegia) was 6.3 ± 0.9 L (range 5.0–8.0 L) (78 ± 11 $\text{ml} \cdot \text{kg}^{-1}$). In ICU, time to awakening was 1.6 ± 1.1 hr (range 0–3.1 hr). The infusions of vasoactive agents used in ICU were nitroglycerin (15 patients, and routinely administered with internal mammary artery grafts), phenylephrine (nine patients), dopamine (eight patients), and sodium nitroprusside (four patients). Nine patients underwent tracheal extubation on the day of surgery, 6.3 ± 1.2 hr (range 4.4–9.9 hr) after surgery. The remainder had controlled ventilation overnight. (It was then usual practice to use controlled ventilation overnight for afternoon patients [6/18].) Five patients received no additional analgesia before extubation. Of the remainder, three patients received morphine or fentanyl infusions for overnight ventilation; the others received total doses of morphine 2–14 mg *iv* and/or fentanyl 100–500 μg *iv*. After extubation, most patients received acetaminophen with codeine *po* for analgesia before discharge from the ICU. Eleven patients were discharged from ICU on the first postoperative day, and seven patients on the second day.

Complications included: one perioperative myocardial infarction (creatinine kinase MB > 80 U $\cdot$ L⁻¹ and ECG

changes); one resternotomy for haemorrhage; a postoperative metabolic encephalopathy in a dialysis-dependent patient; and one case of herpes labialis. There were no other recognized neurological complications and no patient had recall of intraoperative events. All patients were discharged from hospital, 8.1 ± 1.9 d (range 6–15 d) after surgery.

Discussion

The retrospective nature of this report is an obvious weakness. Haemodynamic data were collected from anaesthetic records, where timing and accuracy of recording may be inconsistent. The criteria for intervention with vasoactive agents were at the discretion of individual anaesthetists. The usual practice with these patients is to tolerate mean arterial pressure in the range of 65–70 mmHg when myocardial ischaemia is absent on the ECG.

Induction of GA with alfentanil produced decreases in MAP in these patients who were usually lightly premedicated. These decreases were most frequently treated with small boluses of phenylephrine. Induction of SA produced little additional haemodynamic change. However, phenylephrine was used after SA in eight patients, and on CPB in 13 patients. This may have been due to both the sympathetic block and the isoflurane used for maintenance of GA. Hyperdynamic responses to sternotomy were limited and supplementation of GA was minimal. Postoperative analgesic requirements in the ICU were minimal.

Using alfentanil-oxygen anaesthesia for CABG, Robbins showed that total alfentanil doses of approximately 1000 $\mu\text{g} \cdot \text{kg}^{-1}$ were associated with hyperdynamic responses to surgical stimuli in 20 to 60% of patients.¹² Our total alfentanil doses were 10 to 13% of Robbins' doses, and 75 to 100% of this was given nearly one hour before sternotomy. Our isoflurane doses averaged <0.5 MAC. Therefore, we feel that it is very likely that spinal anaesthesia was primarily responsible for the minimal hyperdynamic responses in our patients.

Although commonly used for CABG, high-dose opioid techniques may be associated with hypertension, tachycardia and awareness.^{5,6,13,14} These techniques have made controlled ventilation for 12–24 hours following induction of anaesthesia a common routine.¹ While hypnotic and inhalational agents used to supplement opioids have reduced the incidence of these problems, supplements may result in loss of cardiovascular stability.³

Combined general and subarachnoid or epidural anaesthesia have been used to diminish these difficulties for a variety of major procedures including lung resection, repair of abdominal aortic aneurysm, and cardiac surgery.^{9,10,15–17} These techniques provide haemodynamic stability and reduce cardiovascular responses to surgical stimulation. There are also decreased requirements for supplementary inhalational or intravenous agents. Recently, augmentation of general anaesthesia with epidural anaesthesia and/or postoperative epidural analgesia has reduced overall morbidity and mortality in high-risk surgical patients¹⁵ and provided satisfactory postoperative pain control.^{10,18}

The minimal hyperdynamic response to surgery suggests that our technique achieves cardiac sympathectomy. If so, this may be an important advantage of the technique. In dogs, cardiac sympathetic blockade reduces the haemodynamic correlates of myocardial oxygen consumption, reduces myocardial ischaemia, improves ischaemic zone perfusion and reduces infarct size.⁸ In patients with severe coronary artery disease, sympathetic blockade of the heart increases the diameter of stenotic epicardial coronary artery segments without causing dilation of coronary arterioles or "steal."¹⁹ Thoracic epidural anaesthesia (TEA) can be used to provide pain relief in patients with acute myocardial infarction or unstable angina pectoris, with acceptable haemodynamics.^{20–22} Both blockade of nociceptive afferent nerves and relief of myocardial ischaemia may contribute to the relief of angina.²² In addition, left ventricular global and regional wall motion abnormalities and ST-segment changes are improved.²³

A recent study has shown benefits of thoracic epidural anaesthesia/analgesia for CABG surgery.^{9,10,17} These included better haemodynamic stability, earlier awakening and extubation, better pulmonary variables and less catecholamine response.

Economic pressures are increasing on the practice of cardiac surgery. Chong *et al.* have decreased expensive perioperative care of cardiac surgery patients by using a postoperative recovery area rather than an ICU, and performing extubation early.²⁴ Spinal anaesthesia may also expedite recovery. Without a formal protocol, same day extubation was achieved in half of our patients.

One brief report has compared general anaesthesia sup-

plemented with subarachnoid lidocaine and morphine, with general anaesthesia in patients undergoing coronary artery bypass grafting.* The combined anaesthetic regimen provided stable intraoperative haemodynamic variables and less postoperative opioid requirement. Subarachnoid lidocaine has a duration of action of approximately 90 min, a period shorter than the duration of surgery. Hence the contribution of subarachnoid lidocaine to postoperative analgesia may be small. There are no reports of the use of larger doses or longer acting agents, such as bupivacaine. In addition, there are reports which indicate that subarachnoid morphine without local anaesthetic provided better analgesia after cardiac surgery than did a conventional regimen.^{7,25} The relative contributions of subarachnoid local anaesthetics and opioids to postoperative analgesia are uncertain at present.

The risk of spinal haematoma is of concern.²⁶ Quantitating this risk precisely would require a large study due to the rarity of the event.²⁷ However, this complication has occurred when lumbar puncture has preceded heparinization.^{26,27} Rapid diagnosis and management would not be possible when cardiac surgery follows lumbar puncture. Surgeons at our hospital have agreed to postpone surgery in the event of a bloody lumbar puncture. We avoid SA in patients receiving intravenous heparin preoperatively. Risk of discontinuing heparin must be weighed against benefits of SA.²⁸

With complete sympathetic and motor blockade, patient awareness may not be detected. However, as discussed by Greene and Brull, very low concentrations of inhalational agents are required to maintain unconsciousness during high spinal anaesthesia.²⁹ These authors state that decreases in arterial blood pressure without changes in cerebral blood flow may contribute to decreased states of consciousness during high spinal anaesthesia. In some cases, direct depression of the reticular activating system by local anaesthetic may also contribute to altered consciousness. With postoperative questioning, we have not detected intraoperative awareness in patients receiving SA for cardiac surgery.

Given the limitations of a retrospective chart review, combined GA and SA appears to be an effective technique for CABG. High spinal anaesthesia may block the nociceptive and haemodynamic responses to common surgical events such as sternotomy. The extensive sympathectomy provided by high spinal anaesthesia has potential benefits and risks. If cardiac sympathectomy is

*Hanley ES, Williams JP, Chelly J, Sweeney M, Raj P, Gerger Z. The effect of intrathecal morphine with lidocaine on pain relief and hemodynamics in the patient for coronary artery bypass graft. Society of Cardiovascular Anesthesiologists. Twelfth Annual Meeting Proceedings. 1990; p. 254.

achieved, there may be improvements in coronary perfusion. Stress response may be diminished. However, when sympathectomy results in excessive hypotension, vasoconstrictor drugs may be needed. These agents may have detrimental effects on the coronary circulation, bypass grafts, and other organs.³⁰⁻³²

Studies using somatosensory-evoked potentials are underway to determine the extent and duration of the subarachnoid block. Given the small number of eligible patients at this institution, a multi-centre randomized trial of spinal anaesthesia for cardiac surgery may be warranted.

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