Cardiothoracic Anesthesia, Respiration and Airway

Ultra-fast-track anesthesia in off-pump coronary artery bypass grafting: a prospective audit comparing opioid-based anesthesia vs thoracic epidural-based anesthesia

[Un mode anesthésique ultrarapide pendant le pontage aortocoronarien à cœur battant : un audit prospectif comparant l'anesthésie avec opioïdes et l'anesthésie péridurale thoracique]

Thomas M. Hemmerling MD DEAA,* Ignatio Prieto MD FRCP(s),† Jean-Luc Choinière MD FRCPC,* Fadi Basile MD FRCP(s),† Joanne D. Fortier MD FRCPC*

Purpose: To examine the feasibility of immediate extubation after off-pump coronary artery bypass grafting (OPCAB) using opioid based analgesia or high thoracic epidural analgesia (TEA) and compare postoperative analgesia with continuous TEA vs patient-controlled analgesia (PCA).

Methods: One hundred consecutive patients undergoing OPCAB were included in this prospective audit. After induction of anesthesia using fentanyl 2 to 5 $\mu\text{g}\cdot\text{kg}^{-1}$, propofol 1 to 2 $\text{mg}\cdot\text{kg}^{-1}$ and endotracheal intubation facilitated by rocuronium, anesthesia was maintained using sevoflurane titrated according to bispectral index monitoring. Perioperative analgesia was provided by TEA ($n = 63$) at the T3/T4 interspace or T4/T5 interspace using bupivacaine 0.125% 8 to 14 $\text{mL}\cdot\text{hr}^{-1}$ and repetitive boluses of bupivacaine 0.25% during surgery. In patients who were fully anticoagulated or refused TEA, perioperative analgesia was achieved by iv fentanyl boluses (up to 15 $\mu\text{g}\cdot\text{kg}^{-1}$) and remifentanyl 0.1 to 0.2 $\mu\text{g}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$, followed by morphine PCA after surgery ($n = 37$). Maintenance of body temperature was achieved by a heated operating room and forced-air warming blankets.

Results: Ninety-five patients were extubated within 25 min after surgery (PCA, $n = 33$; TEA, $n = 62$). Five patients were not extubated immediately because their core temperature was lower than 35°C. One patient was re-intubated because of agitation (TEA group); one was re-intubated because of severe pain and morphine-induced respiratory depression (PCA group). Pain scores were low after surgery, with pain scores in the TEA group being significantly lower immediately, at six hours, 24 hr and 48 hr after surgery ($P < 0.05$).

Conclusion: Immediate extubation is possible after OPCAB using either opioid-based analgesia or TEA. TEA provides significantly lower pain scores after surgery in comparison to morphine PCA.

Objectif : Vérifier la faisabilité de l'extubation immédiatement après un pontage aortocoronarien à cœur battant (PACCB) en utilisant une analgésie avec opioïdes ou une analgésie péridurale thoracique (APT), et comparer l'analgésie postopératoire avec APT continue ou analgésie auto-contrôlée (AAC).

Méthode : Cent patients consécutifs devant subir un PACCB ont été inclus dans un audit prospectif. Après l'induction de l'anesthésie avec 2 à 5 $\mu\text{g}\cdot\text{kg}^{-1}$ de fentanyl, 1 à 2 $\text{mg}\cdot\text{kg}^{-1}$ de propofol et l'intubation endotrachéale facilitée par du rocuronium, l'anesthésie a été maintenue avec du sévoflurane ajusté selon le monitoring de l'index bispectral. L'analgésie périopératoire a été fournie par l'APT ($n = 63$) dans l'espace intervertébral T3/T4 ou T4/T5 avec de la bupivacaine à 0,125 % à raison de 8 à 14 $\text{mL}\cdot\text{h}^{-1}$ et de bolus répétés de bupivacaine à 0,25 % pendant l'opération. Chez les patients traités aux anticoagulants ou qui refusaient l'APT, l'analgésie périopératoire a été réalisée par des bolus iv de fentanyl (jusqu'à 15 $\mu\text{g}\cdot\text{kg}^{-1}$) et de 0,1 à 0,2 $\mu\text{g}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ de rémifentanyl, suivi de morphine en AAC postopératoire ($n = 37$). La température corporelle a été maintenue dans une salle d'opération chauffée et par des couvertures chauffantes à air forcé.

From the Departments of Anesthesiology* and Surgery,† Centre hospitalier de l'université de Montréal (CHUM), Hôtel-Dieu, Université de Montréal, Montréal, Québec, Canada.

Address correspondence to: Dr. Thomas M. Hemmerling, Centre hospitalier de l'université de Montréal (CHUM), Hôtel-Dieu, Department of Anesthesiology, 3840, rue Saint-Urbain, Montréal Québec H2W 1T8, Canada. Phone: 514-890-8000, ext. 14570; Fax: 514-412-7222; E-mail: thomashemmerling@hotmail.com

Accepted for publication June 25, 2003.

Revision accepted October 22, 2003.

Résultats : On a pu extuber 95 patients pendant les 25 premières minutes postopératoires (AAC, $n = 33$; APT, $n = 62$). Cinq patients n'ont pu être extubés immédiatement, étant donné leur température centrale plus basse que 35 °C. Deux patients ont été ré-intubés : l'un, du groupe d'APT, pour agitation, l'autre, du groupe d'AAC, à cause de douleurs intenses et de dépression respiratoire induite par la morphine. Les scores de douleur postopératoires ont été faibles, ceux du groupe d'APT étant significativement plus bas immédiatement après, puis à 6, 24 et 48 h postopératoire ($P < 0,05$).

Conclusion : L'extubation immédiate est possible après le PACCB en utilisant soit une analgésie avec opioïdes, soit une APT. L'APT, comparée à l'AAC avec morphine, produit des scores de douleurs postopératoires significativement plus bas.

OFF-PUMP coronary artery bypass (OPCAB) graft surgery has gained widespread use in cardiac centres around the world. In our hospital setting, 75% of all coronary artery bypass grafting (CABG) were performed without extracorporeal circulation in 2002. Those patients were enrolled in a fast-track anesthesia program with a mean extubation time of 5.5 hr after surgery.

Current anesthetic techniques may enable immediate extubation after OPCAB. Thoracic epidural analgesia (TEA) is advantageous as adjunctive anesthesia and analgesia to fast-track patients after cardiac surgery¹⁻³ with superior pain management,⁴⁻⁹ reduced opioid requirements, improved pulmonary function,^{10,11} and myocardial protection.^{12,13} Maintenance of body temperature is an important factor in achieving immediate extubation after OPCAB as shown by a recent retrospective study of ten patients, who were extubated in the operating theatre after OPCAB.¹⁴ A combination of TEA with active warming should guarantee the greatest chance of immediate extubation after OPCAB and provide superior pain relief after surgery. However, many patients present for cardiac surgery with unstable angina and full anticoagulation, preventing the use of TEA. Opioid-based analgesia would be required in these patients. Therefore, to determine the feasibility of the two techniques for immediate extubation after OPCAB, we undertook a prospective audit over 18 months of all patients undergoing OPCAB followed by immediate extubation in the operating room.

Methods

Between November 2001 and April 2003, 100 consecutive patients undergoing OPCAB by two surgeons and

anesthesia by three anesthesiologists were included in this prospective audit. Before surgery, patients were familiarized with the ultra-fast-track protocol. Patients who consented for epidural catheter insertion were aware that surgery would be delayed for at least 24 hr if arterial puncture occurred during catheter insertion as determined via blood gas analysis.¹⁴ All patients consented to immediate extubation after surgery in the operating room. Consent was obtained for PCA or TEA, depending on the modality to be used.

After arrival in the operating room, five-lead electrocardiography, pulse oximetry and non-invasive blood pressure monitoring were initiated. A femoral arterial catheter was inserted, under local anesthesia, into the right femoral artery for invasive blood pressure monitoring. In the TEA group, patients received an epidural catheter, which was inserted at T3/T4 interspace or T4/T5 interspace. Bupivacaine 0.125% was started at 10 mL·hr⁻¹, and boluses of 4 to 8 mL of bupivacaine 0.25% were given ten to 20 min before incision and extubation. Verification of correct placement of epidural catheter placement was performed using 4 mL of lidocaine 1.5% with epinephrine 5 µg·mL⁻¹. For patients receiving *iv* heparin or refusing TEA (PCA group), analgesia was provided using increments of fentanyl less than a total of 15 µg·kg⁻¹, supplemented using remifentanyl 0.1 to 0.2 µg·kg⁻¹·min⁻¹. In the TEA group, analgesia was solely achieved using TEA.

For both groups, induction consisted of fentanyl 2 to 5 µg·kg⁻¹, propofol 1 to 2 mg·kg⁻¹ and rocuronium 0.6 mg·kg⁻¹. After the trachea was intubated, a right subclavian central venous catheter was inserted. Anesthesia was maintained using sevoflurane, titrated to maintain a bispectral index of 50 (A-2000 BIS monitoring system, Aspect Medical Company, Newton, MA, USA); neuromuscular blockade was achieved using boluses of rocuronium. In all patients, the thoracic drains were infiltrated at the end of surgery with a total of 10 to 15 mL bupivacaine 0.25%. All patients received 100 mg indomethacin as a suppository after induction.

Active temperature control was achieved with forced-air warming therapy and increased temperature in the operating room (at least 22°C). Forced-air warming therapy used two BAIR Hugger (Augustine medical company, Eden Prairie, MN, USA) warming devices, one attached to the sterile lower body cardiac warming blanket (Augustine medical company, Eden Prairie, MN, USA, Model 630 cardiac blanket), applied after saphenous vein harvesting, and the other attached to a modified plastic cover to provide warm air flow around the patient's head, started immediately after induction of anesthesia.

During the ischemic period, treatable bradycardia was defined as a heart rate lower than 40 min⁻¹ and treatable hypotension as a systolic blood pressure lower than 60 mmHg. Bradycardia was treated with increments of *iv* ephedrine 5 mg and hypotension with increments of *iv* phenylephrine 50 µg *iv*. Heparin 150 IU·kg⁻¹ was given five minutes prior to ischemia in all patients.

Extubation criteria were the following: a cooperative, alert patient; complete neuromuscular transmission as determined by train-of-four stimulation (TOF > 0.8) at the adductor pollicis muscle; peripheral oxygen saturation of more than 96% on an FiO₂ of 100%; PETCO₂ less than 45 mmHg; stable hemodynamics without inotropic support; absence of arrhythmias; and core (bladder) temperature of more than 35°C. Temporary pacing was not regarded as a contraindication to extubation.

Immediate extubation in the operating theatre was followed by a short-term stay in the postanesthesia care unit (PACU). Two recovery nurses, who were specially trained and familiar with the ultra-fast-tracking program, took care of all patients on a 1:1 nurse : patient ratio. All patients were to be transferred at two hours, if hemodynamic and respiratory conditions were stable with adequate analgesia, to the intensive care unit where a 1:1 or 1:2 nurse : patient ratio was used overnight. Two forms of postoperative analgesia were used: continuous TEA with bupivacaine 0.125% 6 to 14 mL·hr⁻¹ supplemented with hydromorphone 0.5 to 1 mg *sc* for pain in areas not covered by the TEA (TEA group) or nurse- and PCA (as soon as the use of the PCA device was possible) using morphine (2.5–5 mg nurse-controlled analgesia in the PACU or 1 mg PCA bolus with six-minute lockout period; PCA group).

Patient demographic data, preoperative medical status, left ventricular function, and operative data (total ischemic time, number of grafts, hypotensive or bradycardic episodes, use of phenylephrine or ephedrine) were recorded. Time to extubation and pain intensity, as measured by a numeric pain score at rest (0 = no pain, 10 = maximum imaginable pain) at the earliest possible time after surgery, and then the highest pain score within six hours, 24 hr and 48 hr after surgery were recorded. Postoperative blood pressure and heart rate were documented at two hours, four hours, and six hours after surgery. Complications such as bleeding, hemodynamic problems (including the need for cardiac pacing), arrhythmias, and respiratory dysfunction (arterial PO₂ and PCO₂ immediately after extubation) were also noted. Confusion or drowsiness as side effects of morphine were noted after surgery. When drowsiness or confusion occurred, patients were advised to use the

PCA less often or PCA morphine was replaced by non-opioid drugs. Nausea and vomiting were also noted after surgery and treated with anti-emetic medication. Neurological sequelae, such as paresthesia or muscle weakness in the legs or arms, were noted after surgery and led to the discontinuation of TEA, followed by neurological investigation.

Group size was calculated to achieve a power of more than 90%. We calculated a group size of 20 patients to show at least a 25% difference between immediate pain scores. Categorical and numerical data were compared using Fisher's exact test, t test, and analysis of variance as appropriate between the two groups; Bonferroni correction was applied for multiple testing. A *P*-value < 0.05 was considered statistically significant. Data are shown as mean ± standard deviation.

Results

All 100 patients presented with stable or unstable angina and were treated using beta-blockers, calcium channel blockers, nitrates, or angiotensin converting enzyme inhibitors. Mean age, weight, gender distribution, preoperative medical conditions, left ventricular function (ejection fraction) and number of grafts performed for all patients are presented in the Table without any statistical difference between the two groups. There was a significantly higher incidence of patients with chronic obstructive lung disease in the TEA group including four patients with sleep apnea syndrome requiring nocturnal respiratory therapy (*P* = 0.01). Of the 72 patients without *iv* heparinization, 62 consented to thoracic epidural catheter insertion and ten patients did not. Those ten patients and the

TABLE Characteristics of study patients

	PCA (<i>n</i> = 37)	TEA (<i>n</i> = 63)
Age (yr)	58 ± 9	62 ± 12
Weight (kg)	82 ± 12	80 ± 14
Sex (m/f)	33 / 4	47 / 16
Previous myocardial infarction	14	36
Hypertension	16	42
Diabetes mellitus	11	18
Chronic obstructive lung disease	4	12
Renal dysfunction	1	4
Previous strokes	0	4
Ejection fraction (%)	56 ± 10	58 ± 9
Ischemic time (min)	16 ± 6	16 ± 6
Length of surgery (min)	125 ± 27	117 ± 27
Grafts	3 ± 1	3 ± 1
Mammary/radial	26 / 6	54 / 4

Continuous variables are reported as mean ± standard deviation; discrete variables are reported as absolute values. PCA = patient controlled analgesia with morphine; TEA = high thoracic epidural analgesia.

FIGURE Mean postoperative pain scores at rest by group (PCA, black; TEA, white) and time (the highest pain score immediately after surgery and within six, 24 and 48 hr after surgery). Data are presented as means $\pm$ standard deviation. PCA = patient controlled analgesia with morphine; TEA = high thoracic epidural analgesia. * $P < 0.05$.

28 patients receiving *iv* heparin for unstable angina consented to postoperative PCA morphine. Thoracic epidural catheter insertion was successful in all patients. No arterial or venous puncture occurred.

The mean ambient temperature in the operating theatre was $22.4 \pm 0.8^{\circ}\text{C}$ for all patients and did not differ between the two groups. Ninety-five patients were successfully extubated. Four patients in the PCA group and one patient in the TEA group were not extubated because of their low core temperatures. One patient was re-intubated in each group within 60 min of extubation because of confusion and agitation (TEA group) or severe pain (PCA group) requiring postoperative morphine of 30 mg within one hour of surgery that led to respiratory depression. Both patients were extubated within eight hours after surgery. Mean extubation time, initial PO_2 and PCO_2 values in the PCA group *vs* TEA group were 16 ± 11 min *vs* 14 ± 8 min, 149 ± 43 mmHg *vs* 152 ± 62 mmHg, and 49 ± 8 mmHg *vs* 46 ± 9 mmHg, respectively. Systolic and diastolic blood pressures for the PCA *vs* TEA group at two hours, four hours and six hours after surgery were stable and did not differ between the two groups at $130 \pm 18/68 \pm 12$ mmHg *vs* $129 \pm 20/67 \pm 11$ mmHg, $123 \pm 20/70 \pm 11$ mmHg *vs* $126 \pm 19/68 \pm 12$ mmHg, and $126 \pm 21/71 \pm 13$ mmHg *vs* $127 \pm 15/65 \pm 11$ mmHg. These parameters were not different between the two groups. There was no incidence of intraoperative bradycardia; phenylephrine was given during ischemia in five patients in the PCA group and seven patients in the TEA group. Sixteen patients in the PCA group

and 19 patients in the TEA group received temporary pacing that was discontinued within 12 hr after surgery. No patient needed inotropic support after surgery. Three patients suffered from postoperative bleeding. Two patients received two units of blood within four hours after surgery (PCA group) and one patient needed four units of blood (TEA group). All these patients had been treated preoperatively with low molecular weight heparin that had been stopped more than 24 hr prior to surgery. Postoperative pain scores were significantly lower in the TEA group than in the PCA group (Figure). Patients in the PCA group received a mean total of 8 ± 3 mg morphine prior to initiation of PCA. Eight patients complained about drowsiness or confusion. Five of these patients were advised to use the PCA less often; in three patients, PCA was stopped and replaced by non-opioid drugs (at day three after surgery). Four patients complained about nausea and vomiting and needed anti-emetic medication. Additional hydromorphone of 3 ± 2 mg within the first 24 hr after surgery was given to 31 patients in the TEA group. Fifteen patients showed signs of regional anesthesia at the T1 dermatome; reduction of the bupivacaine infusion rate diminished or abolished anesthesia in the arms. TEA and PCA were discontinued at 2.8 ± 0.6 and 3.2 ± 0.5 days after surgery, respectively. All patients were transferred to the intensive care unit at 2 ± 0.5 hr after surgery.

Discussion

Extubation was achieved in 95 patients immediately in the operating room after surgery. In these patients, active temperature control (moderately increased temperature in the operating theatre and forced-air warming blankets of the head and the lower body) maintained a sufficient body temperature. In patients with a core body temperature below 35°C , no attempt for immediate extubation was made. TEA proved superior to PCA morphine in pain control after surgery. There was no difference in the frequency of hypotension or bradycardia between the two groups during or after surgery and no difference in respiratory parameters after surgery as assessed using arterial PO_2 and PCO_2 , but there were more adverse effects from PCA morphine than from TEA.

There are few studies in the literature presenting techniques for immediate extubation after on- or off-pump CABG. The earliest study, a prospective study by Royse *et al.*¹⁵ using either TEA or opioid-based analgesia during on-pump CABG, showed that immediate extubation was possible with both techniques whenever core body temperature was maintained. However, pain scores were not measured in these patients. A more

recent retrospective study by Djaiani *et al.*¹⁴ of immediate extubation after OPCAB stressed the importance of maintaining normal body temperature in cardiac patients; although only few patients were presented, it is interesting to note that patients were actively warmed in the TEA group only. The fact that extubation was possible, in the group with conventional opioid-based intraoperative analgesia and no active warming, in patients with normal body temperature indicates that maintenance of body temperature might be more important than specific anesthetic techniques. In the most recent prospective study, Straka *et al.*¹⁶ used remifentanyl-based analgesia during and after surgery to immediately extubate patients after OPCAB. Once again, pain scores were not reported.

The superiority of pain control using TEA after cardiac surgery in comparison to *iv* opioids¹ or PCA, as used in our study, is not only a difference between a regional analgesic technique and an *iv* opioid technique but also a difference in the mode of delivery. Whereas one technique prevents pain by a continuous infusion, the other technique is based on an on-demand delivery whenever pain is experienced. Unfortunately, improved analgesia achieved by adding a background infusion of morphine to PCA is counterbalanced by increased side effects such as confusion, sedation, intestinal ileus, or respiratory depression. Despite the differences in drug delivery, the overall reasonable pain scores in the PCA group make this technique an attractive alternative for anesthesiologists who do not want to insert an epidural catheter in patients undergoing cardiac surgery.

No patient experienced an arterial or venous epidural puncture. Although this did not occur in any of our patients, our practice is based on our belief that only an arterial puncture should lead to a delay of surgery.¹⁷ Estimates of the risk of spinal injury from an epidural hematoma has been recently calculated to range from 1:150000 to 1:1500 for conventional on-pump cardiac surgery.¹⁸ However, risk assessment in OPCAB should be lower - because of the lower doses of heparine given - and has to take into account the probability of turning an off-pump case into an on-pump case. The risk of this conversion needs to be calculated for each centre since it is dependent on specific surgical conditions and attitudes and patient demographics. None of our patients required extracorporeal circulation. Proper evaluation of postoperative lung function would certainly include a more extensive evaluation of the respiratory function other than just arterial blood gases.

The initial study protocol included preoperative and postoperative lung function tests. We quickly abandoned these measurements since they would have dis-

turbed the patients unnecessarily after surgery. The goal after surgery was a comfortable patient or a patient in a sleepy state. The higher incidence of patients with obstructive pulmonary disease in the TEA group makes judgement difficult on the appropriateness of conventional opioid-based analgesia for this subgroup of patients. Better pulmonary function after cardiac surgery with TEA^{10,11} would especially favour TEA for patients with obstructive pulmonary disease.

The question of the economic impact of immediate extubation is a difficult one to answer and we did not study it. Immediate extubation in the operating theatre negated the need for a respiratory therapist to set up a ventilator and allowed a quicker change in the nurse-patient ratio; thus, it freed human and technical resources for other patients. Furthermore, the nursing staff could concentrate on control of pain and hemodynamics, bleeding, or other complications after surgery; thus, better quality of care delivered.

A weakness of our study is the lack of a randomized design. Our study was designed as a prospective audit investigating the best possible treatment for our patients to achieve the highest possible rate of success for immediate extubation. Maintenance of body temperature was considered a key factor; TEA was considered another key factor based on the literature that suggested excellent pain relief and shorter extubation times with TEA¹⁹ compared to conventional techniques. PCA was reserved for patients, who either did not consent for TEA or were on anticoagulant therapy for the treatment of unstable angina. However, the hypothesis that preoperative unstable angina had an influence on the degree of postoperative pain is rather unlikely.

Our study is the first prospective study to compare an intraoperative opioid-based analgesia and postoperative patient-controlled morphine analgesia with perioperative TEA in patients who are immediately extubated after OPCAB. Both PCA and TEA allow immediate extubation after OPCAB and provide sufficient postoperative pain control. Better analgesia and lower rate of side effects make TEA the preferred modality for postoperative pain control; however, opioid-based analgesia during surgery combined with PCA after surgery is an alternative for patients presenting with contraindications to the insertion of an epidural catheter or for anesthesiologists concerned about the risk of accidental epidural vascular puncture.

Acknowledgement

The authors are enormously grateful to the enthusiastic support this audit received from the nurses in the PACU and the postoperative cardiac surgery care unit without which this endeavor would not have been possible.

References

- 1 Priestley MC, Cope L, Halliwell R, et al. Thoracic epidural anesthesia for cardiac surgery: the effects on tracheal intubation time and length of hospital stay. *Anesth Analg* 2002; 94: 275–82.
- 2 de Vries AJ, Mariani MA, van der Maaten JM, Loeff BG, Lip H. To ventilate or not after minimally invasive direct coronary artery bypass surgery: the role of epidural anesthesia. *J Cardiothorac Vasc Anesth* 2002;16: 21–6.
- 3 Fillinger MP, Yeager MP, Dodds TM, Fillinger MF, Whalen PK, Glass DD. Epidural anesthesia and analgesia: effects on recovery from cardiac surgery. *J Cardiothorac Vasc Anesth* 2002; 16: 15–20.
- 4 Scott NB, Turfrey DJ, Ray DA, et al. A prospective randomized study of the potential benefits of thoracic epidural anesthesia and analgesia in patients undergoing coronary artery bypass grafting. *Anesth Analg* 2001; 93: 528–35.
- 5 Dhole S, Mehta Y, Saxena H, Juneja R, Trehan N. Comparison of continuous thoracic epidural and paravertebral blocks for postoperative analgesia after minimally invasive direct coronary artery bypass surgery. *J Cardiothorac Vasc Anesth* 2001; 15: 288–92.
- 6 Flisberg P, Tornebrandt K, Walther B, Lundberg J. Pain relief after esophagectomy: thoracic epidural analgesia is better than parenteral opioids. *J Cardiothorac Vasc Anesth* 2001; 15: 282–7.
- 7 Riedel BJ, Wright IG. Epidural anesthesia in coronary artery bypass grafting surgery. *Curr Opin Cardiol* 1997; 12: 515–21.
- 8 Overdyk FJ, Gramling-Babb PM, Handy JR Jr, Faller NI, Miller MJ. Thoracic epidural anesthesia as the last option for treating angina in a patient before coronary artery bypass surgery. *Anesth Analg* 1997; 84: 213–5.
- 9 Nakamura T, Yokoo H, Hamakawa T, Takasaki M. Preemptive analgesia produced with epidural analgesia administered prior to surgery (Japanese). *Masui* 1994; 43: 1024–8.
- 10 Dopfmer UR, Dopfmer S, Beck DH, Kox WJ. Thoracic epidural analgesia increases vital capacity after cardiac surgery. *Acta Anaesthesiol Scand* 2002; 46: 338–9.
- 11 Visser WA, Liem TH, Brouwer RM. High thoracic epidural anesthesia for coronary artery bypass graft surgery in a patient with severe obstructive lung disease. *J Cardiothorac Vasc Anesth* 2001; 15: 758–60.
- 12 Loick HM, Schmidt C, Van Aken H, et al. High thoracic epidural anesthesia, but not clonidine, attenuates the perioperative stress response via sympatholysis and reduces the release of troponin T in patients undergoing coronary artery bypass grafting. *Anesth Analg* 1999; 88: 701–9.
- 13 Fawcett WJ, Edwards RE, Quinn AC, MacDonald IA, Hall GM. Thoracic epidural analgesia started after cardiopulmonary bypass. Adrenergic, cardiovascular and respiratory sequelae. *Anaesthesia* 1997; 52: 294–9.
- 14 Djaiani GN, Ali M, Heinrich L, et al. Ultra-fast-track anesthetic technique facilitates operating room extubation in patients undergoing off-pump coronary revascularization surgery. *J Cardiothorac Vasc Anesth* 2001; 15: 152–7.
- 15 Royse CF, Royse AG, Soeding PF. Routine immediate extubation after cardiac operation: a review of our first 100 patients. *Ann Thorac Surg* 1999; 68: 1326–9.
- 16 Straka Z, Brucek P, Vanek T, Votava J, Widimsky P. Routine immediate extubation for off-pump coronary artery bypass grafting without thoracic epidural analgesia. *Ann Thorac Surg* 2002; 74: 1544–7.
- 17 Williams JP. Thoracic epidural anesthesia for cardiac surgery. *Can J Anesth* 2002; 49: R7.
- 18 Ho AM, Chung DC, Joynt GM. Neuraxial blockade and hematoma in cardiac surgery: estimating the risk of a rare adverse event that has not (yet) occurred. *Chest* 2000; 117: 551–5.
- 19 Norris EJ, Beattie C, Perler BA, et al. Double-masked randomized trial comparing alternate combinations of intraoperative anesthesia and postoperative analgesia in abdominal aortic surgery. *Anesthesiology* 2001; 95: 1054–67.