Reports of Investigation

A comparison of thoracic and lumbar epidural techniques for post-thoracoabdominal esophagectomy analgesia

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Purpose: To compare thoracic epidural analgesia (TEA) using a bupivacaine/fentanyl mixture and lumbar epidural analgesia (LEA) with morphine, in respect to the time to extubation and the quality of post-operative analgesia, in patients having thoracoabdominal esophagectomy.

Methods: Twenty two patients scheduled for elective thoracoabdominal esophagectomy were randomized to TEA or LEA. Postoperatively, the TEA group received Patient Controlled Epidural Analgesia (PCEA) with bupivacaine 0.125% and 5 $\mu g \cdot ml^{B1}$ fentanyl, and the LEA group received PCEA with 0.2 $\mu g \cdot ml^{B1}$ morphine. A blinded observer assessed criteria for tracheal extubation and the time of tracheal extubation was recorded. Early extubation was defined as tracheal extubation within four hours postoperatively. Visual analogue pain scores at rest (Static Visual Analogue Pain Scores, SVAPS) and with movement (Dynamic Visual Analogue Pain Scores, DVAPS) were recorded at 1, 6, 12, 18 and 24 hr post-extubation. Failure of the epidural protocol (FEP) was defined as a request for additional analgesia.

Results: Tracheal extubation was achieved in 70% of the LEA and 100% of the TEA at four hours postoperatively (P=NS). However, the TEA group achieved earlier extubation times when assessed with log rank testing (P = 0.01). By six hours post-extubation FEP had occurred in 50% of the LEA group but in none of the TEA group (P = 0.01). Mean SVAPS and DVAPS were lower in the TEA than in the LEA group at all measured times ($P < 0.01$).

Conclusion: This study has demonstrated superior pain control in patients undergoing thoraco-abdominal esophagectomy treated with TEA than with LEA, particularly for pain with movement. Tracheal extubation occurred earlier in the TEA group, but this difference was not significant at four hours postoperatively.

Objectif : Comparer l'analgésie péridurale thoracique (APT), à base d'un mélange de bupivacaïne/fentanyl, avec l'analgésie péridurale lombaire (APL) à la morphine, en regard du moment de l'extubation et de la qualité de l'analgésie postopératoire, chez des patients qui subissent une œsophagectomie thoraco-abdominale.

Méthode : Vingt-deux patients devant subir une œsophagectomie thoraco-abdominale élective, ont été répartis en deux groupes : APT et APL. Après l'intervention, le groupe APT a reçu une analgésie péridurale contrôlée par le patient (APCP) avec de la bupivacaïne 0,125 % et 5 $\mu g \cdot ml^{-1}$ de fentanyl, et le groupe APL a reçu une APCP avec 0,2 $\mu g \cdot ml^{-1}$ de morphine. Un observateur impartial a évalué les critères de l'extubation et a noté le moment de l'extubation endotrachéale. L'extubation était jugée précoce si elle avait lieu en moins de quatre heures après l'opération. Les scores de douleurs au repos à l'échelle visuelle analogue (scores de douleurs statiques de l'échelle visuelle analogue SDSEVA) et lors de mouvements (scores de douleurs dynamiques de l'échelle visuelle analogue SDDEVA) ont été enregistrés à 1, 6, 12, 18 et 24 h après l'extubation. L'échec du protocole péridural (EPP) était défini comme des besoins d'analgésie supplémentaire.

Résultats : L'extubation était réalisée chez 70 % des patients du groupe APL et 100 % de ceux du groupe APT quatre heures après l'intervention (P = NS). Cependant, le groupe d'APT a affiché des temps d'extubation plus précoces d'après une évaluation avec le test de rang logarithmique (P = 0,01). Six heures après l'extubation, l'EPP s'etait produit chez 50 % des cas du groupe d'APL mais chez aucun du groupe d'APT (P = 0,01). Les SDSEVA et SDDEVA moyens etaient plus bas dans le groupe d'APT que dans le groupe d'APL pour toutes les mesures de temps ($P < 0,01$).

Conclusion : Cette étude a fait la preuve d'un contrôle superieur de la douleur chez les patients subissant une œsophagectomie thoraco-abdominale avec un traitement d'APT plutôt qu'avec une APL, surtout quant il s'agissait de douleur lors de mouvement. L'extubation trachéale a eu lieu plus tôt dans le groupe APT, mais cette différence n'était pas significative 4 h après l'intervention.

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PATIENTS requiring esophagectomy are usually high risk patients undergoing an extensive thoracoabdominal incision. They tend to be old, have a high incidence of cardiopulmonary disease, and are undergoing extensive surgery with a high rate of cardio-pulmonary complications.

Epidural analgesia for postoperative pain management has become a standard of care in many centres.[1] Thoracic epidural analgesia has been claimed to offer advantages compared with lumbar epidural analgesia including segmental blockade and limited sympathectomy with local anesthetics,[2] less lower limb motor block,[3] more effective use of lipophilic opioids,[2] and better preservation of respiratory,[4,5] cardiovascular[6-8] and gastrointestinal function.[9,10] However, there are concerns for direct trauma to the spinal cord. Numerous reports have failed to demonstrate this risk when thoracic epidural catheterisation is performed by an experienced anesthesiologist in an awake patient.[11,12]

The aim of this study was to compare two epidural techniques, thoracic epidural analgesia (TEA) and lumbar epidural analgesia (LEA), with respect to the time to extubation and the quality of post-operative analgesia. There has not been a randomized controlled trial comparing these two popular epidural techniques for managing severe postoperative pain.[13]

Materials and methods

Patients

This observer blinded, randomized controlled trial was approved by the Research and Ethics committee of St. Joseph's Hospital, Hamilton, Ontario, Canada. Patients scheduled for elective thoracoabdominal esophagectomy between February 1996 and April 1997, who had no contra-indication to epidural analgesia (patient refusal, coagulopathy, infection at the site), were capable of using Patient Controlled Epidural Analgesia (PCEA), and were not allergic to morphine, fentanyl or bupivacaine, were eligible for the study. Written informed consent was obtained from all patients. Twenty two patients were recruited. They were randomly assigned to two groups: (1) thoracic epidural analgesia (TEA) and (2) lumbar epidural analgesia (LEA).

Anesthetic and epidural protocol

Prior to induction of general anesthesia, the TEA group had an epidural catheter inserted between the 6th and 8th thoracic intervertebral spaces, and the LEA group had an epidural catheter inserted between the 2nd and 4th lumbar intervertebral spaces. The epidural catheters were tested with 3 ml lidocaine 1.5% with 1:200 000 epinephrine to exclude subarachnoid or intravenous insertion. Patients randomized to thoracic epidural catheters had a sham epidural catheter taped to the lumbar area. The catheters were then taped with an opaque red tape from the lumbar to the cervical area, thus obscuring the site of the epidural catheter from blinded observers.

The TEA group received 5-10 ml bupivacaine 0.5% via the epidural catheter prior to induction of general anesthesia. This group received a combined epidural-general anesthetic. General anesthesia was induced with 2 $mg \cdot kg^{-1}$ propofol, tracheal intubation was facilitated with 0.1 $mg \cdot kg^{-1}$ vecuronium, and general anesthesia was maintained with nitrous oxide 50%, oxygen 50% and isoflurane 0.5-1%. Neuromuscular blockade was maintained with a vecuronium infusion titrated against the train of four response of the adductor pollicis longus to ulnar nerve stimulation. Bupivacaine 0.5% was titrated via the epidural catheter to blunt hemodynamic responses to surgical stimulation. Supplemental analgesia was provided by intravenous fentanyl to a maximum of 5 $\mu g \cdot kg^{-1} \cdot hr^{-1}$. The LEA group received a similar balanced general anesthetic, but no local anesthetic was used in the epidural catheter. Both groups were limited to a maximum dose of intravenous fentanyl of 5 $\mu g \cdot kg^{-1} \cdot hr^{-1}$.

One hour before completion of surgery, the TEA group received 10 ml bupivacaine 0.125% with 100 µg fentanyl via the epidural catheter and a continuous epidural infusion of bupivacaine 0.125% with 5 $\mu g \cdot ml^{-1}$ fentanyl, was started at 10 $ml \cdot hr^{-1}$. The LEA group received 5 mg preservative free morphine via the epidural catheter and a continuous infusion of morphine 0.6 $mg \cdot hr^{-1}$ was started via the epidural catheter.

Tracheal extubation protocol

At the completion of surgery, a blinded observer assessed the patient for tracheal extubation according to the following criteria: vital capacity > 10 $ml \cdot kg^{-1}$, minimal inspiratory pressure, < -30 cm H_2O, respiratory rate > 6 and < 20 bpm, oxygen saturation > 95% breathing FiO_2 1.0, temperature > 34.5°C and eye opening on command. All these criteria had to be fulfilled before extubation. These were assessed at 0 (in the OR), 1, 2, 3, 4 hr postoperatively. Tracheal extubation within four hours of completion of surgery, was defined as early extubation. After four hours, the tracheas were extubated at the discretion of the ICU staff, who were also blinded to the epidural protocol. For ethical reasons, analgesia and sedation were not restricted while tracheas were intubated.

Post-extubation analgesia protocol

Following tracheal extubation, the TEA group received PCEA with a bolus of 9 ml bupivacaine

TABLE General data

Group	*Male (n)*	*Female (n)*	*Age (yr)*	*FEV_1 % predicted**	*FEV_1 < 50% Predicted**	*Age > 80 yr*
TEA	10	1	61 ± 12†	76 ±21†	1	0
LEA	8‡	2	62 ± 14†	81 ± 17†	0	0

* % predicted based on age and height

‡ one patient excluded as procedure was limited to a laparotomy

† mean values ± SD

0.125% with 5 $\mu g \cdot ml^{-1}$ fentanyl, a lockout time of 30 min and a maximum of three boluses in six hours. This was with a background epidural infusion of bupivacaine 0.125% with 5 $\mu g \cdot ml^{-1}$ fentanyl, at 10 $ml \cdot hr^{-1}$. The LEA group received PCEA with a 1.8 mg morphine bolus, a lockout time of 30 min, a maximum of three boluses in six hours and a background epidural infusion of 0.6 $mg \cdot hr^{-1}$ morphine. All epidural infusion syringes were unlabeled, but numbered.

A blinded member of the Acute Pain Service (APS) managed postoperative analgesia, and side effects and complications were managed according to existing APS protocols. Patients requesting analgesia during the study period (within 24 hr post-extubation) in addition to the above protocols, were considered to have a Failed Epidural Protocol (FEP). When this occurred, these epidural catheters were then tested with 5-10 ml lidocaine 1.5% with epinephrine 1:200 000 to ascertain that the catheter had not become displaced. These patients received combinations of extrapleural bupivacaine, intravenous morphine and NSAIDs for further analgesia. Patients with displaced epidural catheters were excluded from analysis, and not categorized as F E P.

Visual analogue pain scores (VAPS) were performed at rest (Static VAPS, SVAPS) and on moving unassisted from the supine to sitting position (Dynamic VAPS, DVAPS). These were performed at 1, 6,12, 18 and 24 hr post-extubation, using an unmarked sliding rule. These scores were not done in patients with FEP. A VAPS <3 was not considered to be clinically significant.

Statistical analysis

Sample size calculation was based on tracheal extubation in 20% of the LEA group and in 80% of the TEA group at four hours post-operatively, using a two- tailed Fisher exact test, $\alpha = 0.05$ and $ß = 0.2$. An FEV_1 < 50% predicted or age > 80 yr was used as a stratification variable, ensuring equal distribution of higher risk patients between the groups. Age as a stratification variable was based on a retrospective chart analysis of 17 thoracoabdominal esophagectomies performed at our institution, from 93/04/01 to 94/02/28. All patients > 82 yr old died (4/17). A sample size of 22 patients gave a power of 87%.

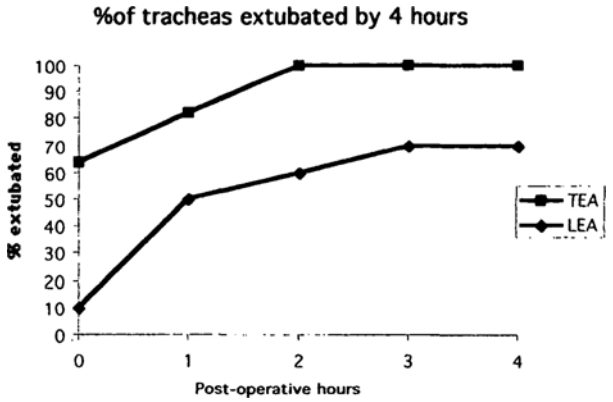

FIGURE 1 The percentage of tracheas extubated by four hours post-operatively.

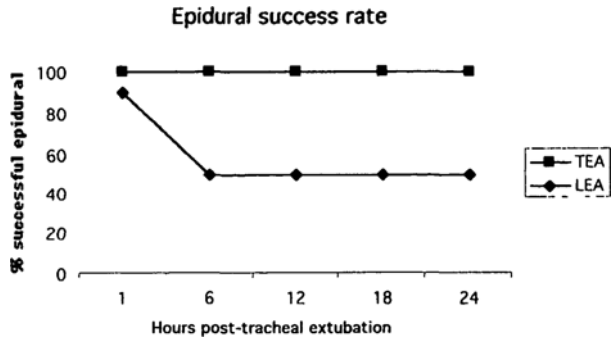

FIGURE 2 The percentage of undisplaced epidural catheters not requiring additional analgesia.

Two-tailed Fisher Exact test was used to assess extubation within four hours; survival analysis with log rank testing was used to analyze extubation times. Static and dynamic visual analogue pain scores were analyzed by analysis of variance for repeated measures. To assess the relative differences between SVAPS and DVAPS, the 95% Confidence Intervals for differences between means of DVAPS and SVAPS [mean DVAPS-mean SVAPS] within each group as well as between the groups [mean DVAPS(LEA)-mean DVAPS(TEA)] and [mean SVAPS(LEA)-mean SVAPS(TEA)] were analysed. Failed Epidural Protocol (FEP) was analyzed with a two-tailed Fisher Exact test. *P*-values < 0.05 were considered to be statistically significant.

Statistical analysis was performed using StatXact 3 for Windows and Logxact-Turbo, by Cytel Software Corporation, Cambridge, MA.

Results

General data

The groups were similar with respect to age, sex and FEV_1. One patient in the TEA group was considered to be at higher risk, with an FEV_1 of 30% predicted. One patient in the LEA group was eliminated from the study as the surgical procedure was limited to diagnostic laparotomy. The remaining 21 patients underwent thoraco-abdominal esophagectomy and were available for analysis. (Table)

Extubation times

In 70%of the LEA group and 100% of the TEA group the tracheas were extubated at four hours. (Fisher Exact test $P = 0.09$). However, earlier extubation times (Log rank test $P = 0.01$) were demonstrated in the TEA group (Figure 1).

Epidural success rate

Figure 2 represents a Survival analysis curve for successful epidural analgesia. Dislodged epidural catheters were not included in the analysis. There were no dislodged epidural catheters in the LEA group. One epidural catheter in the TEA group was dislodged at 18 hr post-extubation. As the epidural catheter was dislodged, this patient was not considered a FEP. All patients in the TEA group were able to keep themselves comfortable.

In the LEA group, 50% of patients requested additional analgesia by six hours post-extubation *vs* none in the TEA group ($P = 0.01$). None of these epidural catheters was displaced as assessed by the response to 10 ml lidocaine 1.5% with 1:200 000 epinephrine injected into the epidural catheter. These patients were eliminated from further analysis and were considered to have FEP.

Visual analogue pain score

Figure 3 represents mean Visual Analogue Pain Scores (VAPS) in the LEA (the remaining 50% who did not have FEP) and TEA at rest (SVAPS) and when moving unassisted from supine to sitting (DVAPS).

Figures 4-7 represent the means and 95% Confidence Intervals (CI) for differences between measured values. These CI are pointwise CI, and do not take into account the longitudinal nature of the repeated measures taken on the same patients over time. As 50% of the LEA had FEP, these measures

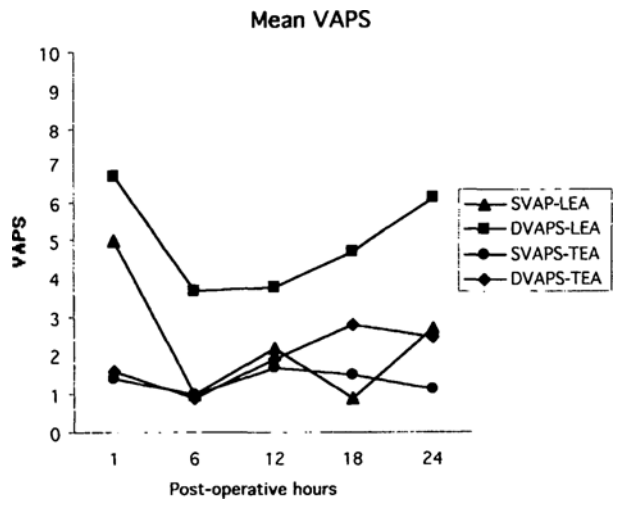

FIGURE 3 Mean VAPS in the LEA and TEA groups. (50% of the LEA group had been excluded as they had a Failed Epidural Protocol).

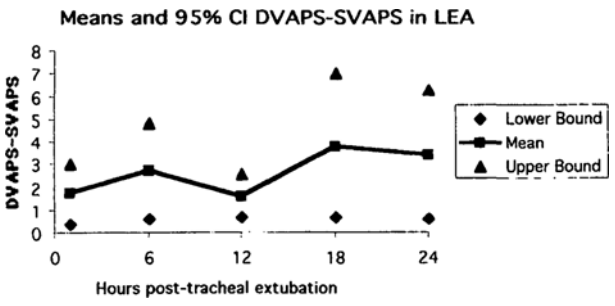

FIGURE 4 Means and 95% Confidence Intervals for differences between the means of DVAPS and SVAPS in the LEA group. When the Lower Bounds (LB) are above O, this indicates a significant difference. (50% of the LEA group had been excluded as they had a Failed Epidural Protocol).

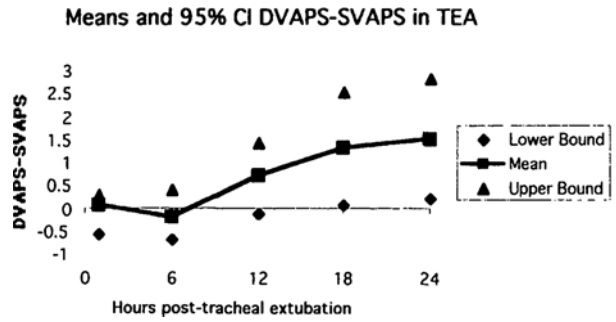

FIGURE 5 Means and 95% Confidence Intervals for differences between the means of DVAPS and SVAPS in the TEA group. When the Lower Bounds (LB) are above O, this indicates a significant difference.

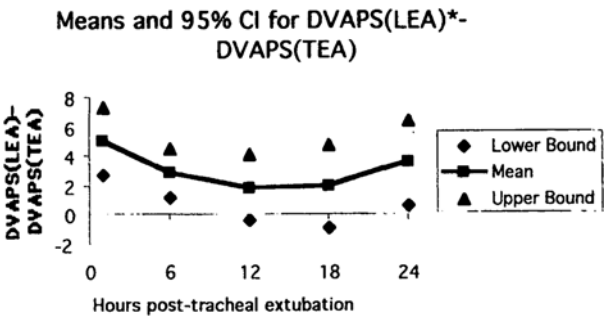

FIGURE 7 Means and 95% Confidence Intervals for differences between the means of DVAPS (LEA) and DVAPS (TEA). When the Lower Bounds (LB) are above O, this indicates a significant difference. (50% of the LEA group had been excluded as they had a Failed Epidural Protocol).

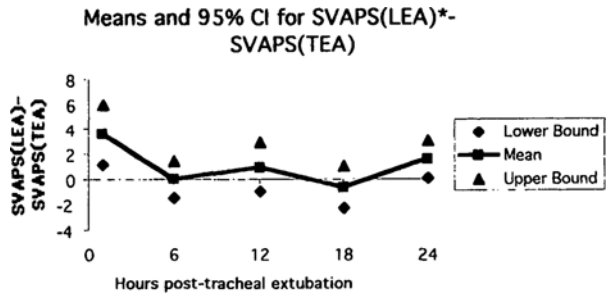

FIGURE 6 Means and 95% Confidence Intervals for differences between the means of SVAPS (LEA) and SVAPS (TEA). When the Lower Bounds (LB) are above O, this indicates a significant difference. (50% of the LEA group had been excluded as they had a Failed Epidural Protocol).

were on the remainder of the group. Lower Bounds (LB) above 0 indicate a detectable difference between the means.

Figure 4 represents the 95% Confidence Intervals (CI) for differences between the means of DVAPS and SVAPS [mean DVAPS-mean SVAPS] within the LEA group. The lower bounds (LB), means and upper bounds (UB) are all positive, indicating a detectable difference between the means of DVAPS and SVAPS in the LEA group at all times. This indicates poor dynamic pain control in the LEA.

Figure 5 represents 95% CI for the [mean DVAPS-mean SVAPS] within the TEA group. The LB were negative and the UB were positive at 1, 6 and 12 hr, demonstrating a lack of detectable difference between DVAPS and SVAPS at these times. However, the LB and UB and means were positive at 18 and 24 hr, indicating a detectable difference at these times.

Figure 6 represents the 95% CI for differences between the means of SVAPS in the LEA and TEA groups [mean SVAPS(LEA)-mean SVAPS(TEA)]. Detectable differences were seen at 1 and 24 hr.

Figure 7 represents the 95% CI for differences between the means of DVAPS in the LEA and TEA groups [mean DVAPS(LEA)-mean DVAPS(TEA)]. The LBs, UBs and means are positive at 1, 6, and 24 hr, indicating a detectable difference at these times.

Discussion

This study demonstrated earlier extubation times in the TEA group, but no difference between the groups at four hours postoperatively. There was a failure rate in the LEA group with regards to providing adequate analgesia as seen in the FEP (50% at six hours, $P = 0.01$). Detectable differences in VAPS were apparent when the LB of the 95% CI were above 0. It should be reiterated that comparisons in VAPS between the groups were done between the remainder of the LEA without FEP and the TEA (which had no FEP). Poor dynamic pain control (detectable differences between mean DVAPS and mean SVAPS at all times) was demonstrated in the LEA group (Figure 4). Good dynamic pain control was seen in the TEA group (no detectable difference between mean DVAPS and mean SVAPS at 1, 6, and 12 hr, with some difference seen at 18 and 24 hr (Figure 5). There was no detectable difference in SVAP between the LEA and the TEA groups, except at 1 and 24 hr post-tracheal extubation

(Figure 6). This needs to be interpreted with caution as 50% of the LEA had been excluded. The DVAPS were lower in the TEA group, with less difference detected at 12 and 18 hr (Figure 7). However the VAPS at these time were still considered to be low (<3) (Figure 3).

There are many studies comparing thoracic and lumbar epidural analgesia.[14–18] However, these studies have only compared various opioids administered at different spinal levels. In a metaanalysis by Ballantyne *et al.*,[19] no differences in analgesia or pulmonary function were demonstrated when opioids were administered via a lumbar or thoracic catheter. Our study is the first randomized controlled study comparing two popular analgesic techniques, thoracic epidural analgesia using a bupivacaine/fentanyl mixture and lumbar epidural analgesia using morphine. This study has demonstrated earlier extubation times and improved postoperative analgesia in the TEA group, when compared to the LEA group.

Several studies have examined the effects of epidural analgesia in patients having thoraco-abdominal esophagectomy. In a retrospective chart analysis of patients who had an esophagectomy, Watson *et al.*[20] compared a combined thoracic epidural/general anesthetic (n=75) followed by continuous infusion of bupivacaine 0.125%/diamorphine postoperatively, with a non-epidural/ electively ventilated group (n=81). They showed a lower rate of respiratory complications, mortality and ICU stay in the thoracic epidural opioid/local anesthetic group. Brodner *et al.*[21] prospectively studied 42 patients who had a thoraco-abdominal esophagectomy with a combined general anesthetic and intraoperative thoracic epidural bupivacaine followed by postoperative PCEA with forced mobilization. This group was compared with an historical control which received general anesthesia and postoperative thoracic epidural analgesia. They showed earlier extubation times, shorter ICU stay and better analgesia in the prospective group. We did not measure any other postoperative outcomes in this study because the sample size required to show outcome differences would need to have been much larger than in the present study.

Tracheal extubation is dependent on many factors including anesthetic technique, and the quality of analgesia[22] in the immediate post-operative period. Anesthetic techniques were partially controlled by limiting the amount of intraoperative intravenous fentanyl in both groups, and using a combined epidural/light general anesthetic in the TEA group. This difference in anesthetic technique may account for earlier extubation times in the TEA group, independent of the type of postoperative epidural analgesia. Liem *et al.*[23] demonstrated earlier extubation times in patients undergoing coronary artery bypass grafting with thoracic epidural bupivacaine/light general anesthesia *vs* a high dose sufentanil based general anesthetic. We avoided epidural local anesthesia in the LEA group because we were concerned this technique would result in an extensive sympathectomy and hemodynamic instability, as well as motor blockade in the lower limbs, preventing mobilization.[24,25]

The concept of 'goal directed ventilation', i.e. mechanically ventilating lungs until extubation criteria are met, has received much attention,[26] emphasizing the importance of early extubation in patients who fulfill extubation criteria, and avoiding routine postoperative ventilation. Earlier tracheal extubation has many implications for patient management. In addition to reducing ventilator associated morbidity, shorter ICU stay may offer important economic savings. Cheng *et al.*[27] in a randomized controlled trial, demonstrated in coronary artery bypass patients, a 25% reduction in total cost by tracheal extubation within six hours. This saving was predominantly in nursing and ICU costs.

Differences in VAPS between TEA and LEA might in part, be due to epidural local anesthetic used in the TEA. Epidural local anesthetic has been demonstrated in other studies[28,29] to improve dynamic pain. The quality of dynamic pain control may correlate better with a reduction in postoperative morbidity, as this allows a patient to ambulate, cough and endure physiotherapy more effectively.[24,30]

We intentionally allowed for generous PCEA dosing in both groups to exclude inadequate dosing as a cause for inadequate analgesia. These PCEA doses would be greater than those usually used in a non-study setting. We were interested in the ability of the epidural protocol to maintain analgesia,[31] not the amount of additional PCA morphine required, as has been used in other studies, which would interfere with the interpretation of VAPS. This study differs from similar studies in that our end point for failed analgesia was determined by the specific request by the patient for additional analgesia, despite using a generous PCEA protocol.

There appears to be some reluctance on the part of anesthesiologists to insert thoracic epidural catheters because it may be technically more difficult and be associated with a high risk of neurological damage. The rate of neurological complications with thoracic epidural insertion is unknown. Several retrospective studies[12,32–36] have not reported permanent neurological sequelae. Giebler *et al.*[11] reported a series of 4,185 patients, of which 2,059 were prospectively studied,

who received thoracic epidural catheterisation. There were no permanent neurological complications attributable to the epidural catheter.

In conclusion, TEA with fentanyl/bupivacaine compared with LEA with morphine, resulted in earlier tracheal extubation, although this difference was not significant at four hours postoperatively. Superior pain control, particularly with movement, was demonstrated in the TEA group.

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