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A Novel Approach for Pain Management in Cardiac Surgery via Median Sternotomy: Bilateral Single-Shot Paravertebral Blocks

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ABSTRACT

Regional analgesia has entered cardiac anesthesia in the form of spinal or epidural analgesia. However, the risk of spinal or epidural hematoma is a constant worry. Alternative regional techniques might be applicable in cardiac surgery. The purpose of this study is to present a novel technique of bilateral single-shot paravertebral blocks (BSS-PVB) for cardiac surgery via median sternotomy and compare its efficacy versus high thoracic epidural analgesia (TEA). Fifty-two patients were compared in this prospective cohort audit. In 26 patients, cardiac surgery was performed using low-dose fentanyl/BSS-PVB (bilateral blocks of 3 mL bupivacaine 0.5% each, T1-7) and general anesthesia; in another 26 patients, TEA (bupivacaine 0.125% at 10 mL/hour) and general anesthesia were used. Patients were assigned to cohorts according to their preoperative data and types of surgery. All patient data are shown as mean ± SD; pain scores were compared between groups using the *t* test immediately, 6 hours, and 24 hours after surgery ($P < .05$). In the BSS-PVB-group (19 men, 7 women), mean age was 65 ± 11 years, weight 74 ± 16 kg, ejection fraction 59% ± 12 %, and duration of surgery 130 ± 27 minutes; in the TEA-group (17 men, 9 women), mean age was 63 ± 10 years, weight 75 ± 16 kg, ejection fraction 58% ± 12%, and duration of surgery 113 ± 27 minutes. These data and preoperative comorbidity variables were not significantly different between the two groups. In each group, 18 patients underwent off-pump coronary artery bypass grafting, 3 on-pump and 5 mitral valve replacements. All patients were successfully immediately extubated. Postoperative pain scores were at any point significantly lower with TEA, immediately at 2.4 ± 2.2 versus 3.7 ± 2.6, at 6 hours at 1.1 ± 1.5 versus 2.4 ± 1.8, and at 24 hours at 1.0 ± 1.4 versus 2.3 ± 1.6 (0 = no pain, 10 = maximum pain). There was no complications related to epidural catheter placement or BSS-PVB. Using both techniques, immediate extubation after cardiac surgery is feasible; TEA provides better pain relief after cardiac surgery than BSS-PVB.

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INTRODUCTION

Thoracic paravertebral blocks (PVB) are used in various types of surgeries for intraoperative as well as postoperative pain management. Injection of local anesthetic is adjacent to the thoracic vertebra close to the spinal nerve emergence from the intervertebral foramina. From this injection site the local anesthetics migrate both caudally and rostrally. It results in ipsilateral somatic and sympathetic nerve blockade in multiple contiguous thoracic dermatomes above and below the site of injection [Karmakar 2001]. The reported advantages include a simple and easy to learn technique, it is safe to perform on sedated and ventilated patients, a low incidence of complications, facilitation of early mobilization, and early discharge [Karmakar 2001; Ganapathy 2005].

Applications of PVB are often for surgeries where pain is mainly unilateral (eg, thoracotomy, chest wall trauma, rib fractures, breast surgery, cholescystectomy, herniorraphy, renal surgery). PVB can also be useful in high-risk patients in whom central neuraxial techniques pose increased risks (eg, patients with coagulopathies at risk of hematoma). This technique can equally be applied for chronic pain management [Ganapathy 2005]. While usually used in a unilateral setting, bilateral blocks have been described [Karmakar 2001; Ganapathy 2005]. Bilateral blocks were described in bilateral breast surgery [Weltz 1995; Coveney 1998; Klein 2000], in pediatrics [Karmakar 1997], in thoracic surgery [Soni 1994; Karmakar 1997], vascular surgery [Richardson 1995], and for obstetric analgesia [Nair 2001]. In cardiac surgery, continuous unilateral PVB was described for minimally invasive direct coronary artery bypass grafting (MIDCAB) [Ganapathy 1999].

However, cardiac surgery via median sternotomy requires bilateral application of continuous PVB; in addition, a wide territory of dermatomes (usually T1-T7) needs to be covered. We therefore present a novel technique of bilateral single-shot (BSS)-PVB in cardiac surgery via median sternotomy covering T1-7, applied immediately before surgery.

Figure 1. Epidural technique (thoracic epidural analgesia). After injection of a local anesthetic (1% lidocaine skin prick), a 22 G catheter is inserted through a 17 G Tuohy needle after loss of resistance; median approach, T2-3.

In this prospective audit, we compared postoperative analgesia in two groups of patients undergoing an equal number of off-pump CABG, on-pump CABG, or mitral valve replacement procedures receiving either BSS-PVB or high thoracic epidural analgesia (TEA).

METHODS

Between September 2003 and January 2006, 52 consenting patients undergoing off-pump coronary artery bypass grafts by 3 surgeons were included in this prospective audit to receive either TEA (control group) or BSS-PVB (study group) in adjunct to general anesthesia. Before surgery, patients were familiarized with TEA or BSS-PVB and ultra–fast-track protocol (immediate extubation). All patients consented to the insertion of the epidural catheter or BSS-PVB before the surgery. They also consented to immediate extubation after the surgery.

We included patients aged between 18 and 85 who had an ejection fraction of at least 30%. Exclusion criteria were patient refusal to participate, pregnant women, and patients with contraindications against insertion of TEA [Horlocker 2004]. Routine monitoring included electrocardiography, invasive blood pressure, central venous pressure, pulse oximetry, and bispectral index monitoring.

In group TEA, at arrival in the operating theater, an epidural catheter was inserted at T1-T3 under local anesthesia (Figure 1). If the patient was anticoagulated, heparin was stopped >6 hours before, and international normalized ratio and activated partial thromboplastin time were controlled to be normal prior to the insertion of the epidural catheter or BSS-PVB.

The epidural catheter was inserted at level T1-T2 or T2-T3 using the loss of resistance technique. Catheters were inserted 3 cm within the epidural space. Verification of correct placement was performed using lidocaine 1.5% with epinephrine 5 µg/mL. After insertion, TEA was started and maintained at 10 mL/hour of bupivacaine 0.125%.

In the BSS-PVB group, thoracic PVB were performed at levels T1 to T7 by the same anesthesiologist (TH), using a 22 G spinal needle and the loss of resistance technique, bilaterally, with 3 mL bupivacaine 0.5% at each level (Figure 2).

In all patients, anesthesia was then provided by fentanyl 3 µg/kg, followed by propofol 1-2 mg/kg, and mask ventilation using 100% oxygen; endotracheal intubation was facilitated by rocuronium 0.6 mg/kg. After the trachea was intubated, a subclavian central venous catheter was inserted. Intraoperative anesthesia was maintained by sevoflurane in 50% oxygen/air titrated to maintain a BIS around 50.

In the TEA group, a bolus of 4 to 8 mL of bupivacaine 0.25 % was given 15 minutes before skin incision and 20 minutes before extubation in the operating theater. Active and

Figure 2. Bilateral single-shot paravertebral block. Injection of local anesthetic adjacent to the thoracic vertebra close to where the spinal nerve emerges from the intervertebral foramina. Spinal processus are marked (T1-7), on each side 2.5 cm is measured; after skin prick using 1% lidocaine at each site, a 22 G spinal needle is advanced until bone contact with the transverse processus of each dermatoma, slightly withdrawn and then advanced just above the transverse processus until loss of resistance. Three mL of bupivacaine 0.5% is injected at each site.

aggressive temperature control was achieved with force air warming therapy and increased room temperature (22°C or more). Forced air warming therapy was achieved using two Bair Hugger warming blankets (Augustine Medical Company, Eden Prairie, MN, USA). The first one was attached to a modified plastic cover to provide warm air around the patient's head and was started immediately after induction of anesthesia. The second one was attached to a sterile lower body cardiac warming blanket (Model 630 cardiac blanket; Augustine Medical Company) applied after saphenous vein harvesting.

During the ischemic period in off-pump cases, treatable bradycardia was defined as a heart rate lower than 40 minutes^{-1} and was treated with increment doses of intravenous ephedrine 5 mg. Hypotension was defined as a systolic blood pressure inferior to 70 mmHg and was treated with increments of intravenous phenylephrine 50 μg. Heparin 350 (150 in beating heart cases) IU/kg was given 5 minutes prior to ischemia for all patients and at least one hour after epidural catheter placement. After completion of graft or mitral valve surgery, heparin was reversed with protamine in a 1:1 ratio.

Extubation criteria were a cooperative and alert patient, complete neuromuscular function assessed by train-of-four > 0.9 at the adductor pollicis muscle, pulse oxymetry superior to 96%, P_{ETCO2} less than 45 mmHg, stable hemodynamics, and core (bladder) temperature superior to 35°C (temporary pacing, intra-aortic balloon pump placement, and inotropic medications were not a contraindication to extubation).

After extubation in the operating room, patients were transferred to the post-anesthesia care unit for a short-term stay. Specially trained nurses familiar with immediate extubation in cardiac surgery took care of the patient on a 1:1 nurse:patient ratio. After a stay of about 2 hours in the post-anesthesia care unit, patients were transferred to the intensive care unit if hemodynamics and respiratory conditions were stable and analgesia was adequate. In the intensive care unit, a 1:1 or 1:2 nurse:patient ratio was maintained overnight. In the TEA group, TEA was continued at 10 mL/hour then adjusted depending on analgesia of the patient at a rate between 6 and 14 mL/hour. The rate was increased if patients had pain over the thoracic area covered by the epidural. The rate was decreased in case of paresthesia in dermatoma C8 or higher in a painless patient. Doses of morphine 5 mg subcutaneous were available for pain in areas not covered by the epidural such as leg pain. In the BSS-PVB group, patient-controlled analgesia using boluses of 1 mg of morphine (lockout: 6 minutes) was used.

We recorded patient demographic data, preoperative medical status (hypertension, chronic renal failure, myocardial infarction, chronic obstructive lung disease, stroke, diabetes), current medications, left ventricular function as well as operative data (number of grafts, duration of ischemia, hemodynamic data, and any complications), and time to extubation.

Pain intensity measured by a numeric pain score at rest (0 = no pain, 10 = maximum pain) was recorded immediately, 6 hours and 24 hours after surgery. Postoperative blood pressure and heart rate were documented for the first 6 hours after surgery. Side effects such as drowsiness, nausea, pruritus, and paresthesia were recorded and treated. Neurological symptoms such as muscle weakness in the legs or arm were noted and led to discontinuation of TEA, followed by neurological investigations. A difference with a $P < .05$ was considered as significant.

Table 1. Demographic and Surgery Data

	Paravertebral Block, n = 26	Epidural, n = 26
Sex, F/M	7/19	9/17
Age, y	65 ± 11	63 ± 10
Weight, kg	74 ± 16	75 ± 16
Ejection fraction, %	59 ± 12	58 ± 12
Duration of surgery, min	130 ± 27	113 ± 27
Myocardial infarction, n	11	12
Hypertension, n	14	14
Diabetes, n	6	7
Chronic obstructive pulmonary disease, n	6	4
Chronic renal failure, n	0	6*
Stroke, n	1	2

*$P < .05$.

RESULTS

There was no significant difference between the two groups for age, sex, weight, ejection fraction, number of grafts, and ischemic time (Table 1). The incidence of past myocardial infarction or stroke, hypertension, diabetes, and chronic obstructive pulmonary disease were also similar. There were significantly more patients with renal insufficiency in the TEA group. Room temperature and body temperature at the beginning of the surgery and at the moment of extubation was not different. There were few postoperative complications and these were not statistically different between the two groups (Table 2).

Thoracic epidural catheter insertion was successful in all patients in the TEA group. All patients were successfully extubated at the end of surgery in the operating theater. In each group, 5 patients underwent mitral valve replacement, 3 patients on-pump coronary artery bypass grafting, and 18 off-pump coronary artery bypass grafting. There was no occurrence of intraoperative bradycardia. There was no difference in systolic and diastolic pressure in the two groups.

Postoperative pain scores were at any point significantly lower with TEA, immediately at 2.4 ± 2.2 versus 3.7 ± 2.6, at 6 hours at 1.1 ± 1.5 versus 2.4 ± 1.8, and at 24 hours at 1.0 ± 1.4 versus 2.3 ± 1.6 (0 = no pain, 10 = maximum pain) (Figure 3). There was no complication related to epidural catheter placement or paravertebral injections. In no patient was there a neurological sign or symptom for epidural hematoma, such as sudden onset of motor blockade. There was one reintervention necessary for one of the patients for sternal wound infection.

DISCUSSION

TEA and BSS-PVB can both be used to facilitate perioperative pain management in ultra–fast-tracking cardiac

Table 2. Postoperative Complications*

	Paravertebral Block, n = 26	Epidural, n = 26
Myocardial infarction	0	1
Intra-aortic balloon pump	0	0
Atrial fibrillation	4	2
Permanent pacemaker	0	0
Re-operation for bleeding	1	1
Low-output syndrome	1	1
Inotropic drugs >15 min	1	1
VT/VFIB	0	1
Sternal infection	1	0
Mediastinitis	0	0
Acute renal failure	2	1
Blood transfusion	4	3
Pneumonia	1	0
Mortality	1	0

*VT indicates ventricular tachycardia; VFIB, ventricular fibrillation.

surgery. While both techniques provide mean pain scores lower than 4/10 up to 3 days, TEA provides significantly better analgesia.

TEA provides good stress protection [Moore 1995; Ganapathy 2001], good hemodynamic stability [Stenseth 1994], allows for early extubation [Joachimsson 1989; Hemmerling 2004a, Hemmerling 2005], improves distribution of coronary blood flow, and reduces demand for oxygen [Stenseth 1995]. Patients have better postoperative pulmonary functions and less postoperative pain in comparison to purely opioid based strategies [Liem 1992; Hemmerling 2004b]. More recently, it has also been suggested that TEA permits a reduction of morbidity; eg, by reducing the incidence of respiratory complications, such as pneumonia, and perioperative arrhythmias, such as supraventricular arrhythmias [Turfrey 1997; Scott 2001]. However, the risk of epidural hematoma must be considered. The exact incidence of this devastating event in cardiac surgery is still not known for sure. In 2000, Ho estimated that this risk was inferior to 1:1500 [Ho 2000]. Ruppen et al estimated that the maximal risk in cardiac surgery is 1:1700 [Ruppen 2006], a risk comparable to vascular and thoracic surgeries. Royse estimated that the risk was inferior to 1:10000 [Royse 2003].

The technique of PVB has been described for several types of surgeries and is known since the beginning of this century. It has been most widely used for thoracic procedures. For surgeries performed via thoracotomy, PVB seems to provide the same quality of analgesia compared to TEA but is associated with fewer side effects [Richardson 1998; Davies 2006]. PVB are associated with less urinary retention, less nausea and vomiting, as well as hypotension compared to TEA. Less pulmonary complications were found with PVB for patients undergoing thoracotomy [Davies 2006]. However, the side-effect profile of TEA depends also on the regimen of drugs used; the addition of opioids certainly increases the incidence of nausea and vomiting and might have an impact on urinary retention. In our audit, no opioids were added to the TEA, based on a prior study [Olivier 2005] showing no additional pain control efficacy by adding opioids to bupivacaine in TEA when used for cardiac surgery.

In this audit, we did not insert a catheter for PVB under the presumption that single-shot PVB could provide analgesia for up to 24 hours after injection. One group [Vogt 2005] studied the effect of a single-shot at T4-T5 for thoracoscopic surgery. They found a significant reduction in visual analgesia score lasting up to 24 hours. This was associated with a reduction in narcotics consumption, although the difference was not statistically different [Vogt 2005]. These authors concluded that this technique improved postoperative pain treatment after thoracoscopic surgery in a clinically significant fashion.

In another study, however, multilevel single shot unilateral paravertebral nerve blockade in thoracoscopic procedures [Hill 2006] was effective in reducing pain for only the first 6 hours after the thoracoscopic procedure. The author concluded that, given that limited duration of effect, single-shot PVB were not indicated for this kind of procedure.

The experience with PVB in cardiac surgery is limited. In 1999, Ganapathy et al reported the use of continuous PVB for minimally invasive cardiac surgery, inserted in T4-5 for cardiac surgery performed via this thoracotomy approach. In 2001, Dhole et al compared TEA with continuous unilateral PVB for MIDCAB surgery in 41 subjects. These authors found that continuous PVB was easier to perform and was as effective as TEA in pain control since no difference was noted in VAS between the two groups. The TEA groups had one patient develop hypotension and one patient with a backache, so the authors concluded that the PVB technique was possibly safer. The limitation of PVB block in this type of surgery is that it provides unilateral analgesia that can be used only for MIDCAB surgery through an anteolateral thoracotomy. This technique is neither suitable for complete sternotomy nor for ministernotomy, which is becoming more popular than MIDCAB surgery.

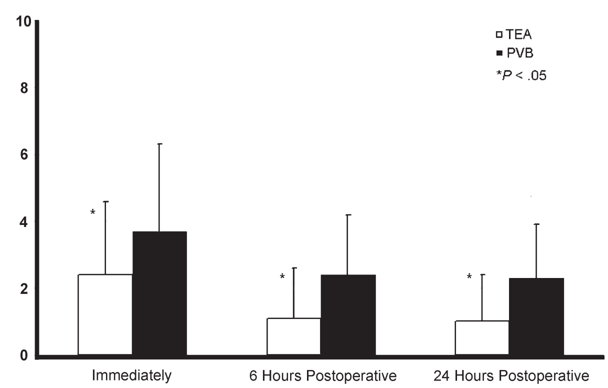

Figure 3. Pain scores depicted for each group; white columns are the thoracic epidural analgesia group. *$P < .05$; data as number of patients or mean ± SD.

In 2003, Canto et al reported the use of bilateral PVB using a continuous bilateral catheter technique for conventional cardiac surgery with complete sternotomy in 111 patients [Canto 2003]. They concluded that this technique was associated with good hemodynamic stability, good postoperative analgesia and short times of extubation with few complications. Interestingly, there was an incidence of 2.7% of upper limb paresthesia that resolved after discontinuation of paravertebral infusion. They also reported somnolence in few patients that was easily reversible by decreasing or stopping the infusion. These complications might be attributed to either increased spread of infusion, epidural placement of the PVB-catheter, or systemic absorption of either ropivacaine, fentanyl, or combined effects of these two drugs. Also, in contrast to our study, no comparison was made with epidural analgesia and pain scores were not evaluated using a standardized score ranging from 0 to 10.

So far, no publication has reported the use and effectiveness of BSS-PVB for analgesia in cardiac surgery. We therefore began this study to see if this technique is feasible and how it provides analgesia compared to TEA, which has been proven to be very efficient for pain control after cardiac surgery. Since somnolence is a major impairment of immediate extubation [Canto 2003], we chose not to use any opioids in BSS-PVB or TEA. The BSS-PVB was performed immediately before surgery with a mean total of 42 cc of bupivacaine 0.5% using the loss of resistance technique with a 22 G spinal needle. To block bilaterally T1-7, 14 injections have to be performed, which, however, took less than 15 minutes for experienced professional to complete the BSS-PVB in all patients. We had no complications in terms of somnolence or paresthesia related to this technique, making it feasible and apparently safe. It is notable that there was also no case of epidural hematoma and all TEA catheters were removed at a mean of 54 hours after surgery.

To our knowledge, this is the first study describing BSS-PVB in cardiac surgery and to compare it with a control group of TEA. Fifty-two patients were enough to show a significant decrease of pain scores in the TEA group compared to BSS-PVB. However, this sample size was underpowered to show any other significant differences in terms of outcomes. We conclude that BSS-PVB, although less effective than TEA for pain control, is an easy and safe technique that allows immediate extubation after cardiac surgery. It is an alternative pain management technique for anesthesiologists reluctant to use or not familiar with TEA.

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