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ORIGINAL ARTICLE

Anesthesia management with single injection paravertebral block for aorta coarctation in infant

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Summary

Background: Thoracotomy causes severe pain in the postoperative period. Perioperative thoracic paravertebral block reduces pain score and may improve outcome after pediatric cardiac surgery. This prospective study was designed for the efficacy and duration of a single level, single injection ultrasound–guided thoracic paravertebral block (TPVB) for fifteen infants undergoing aortic coarctation repair.

Methods: After approval of the ethical committee and the relatives of the patients, 15 infants who had undergone thoracotomy were enrolled in the study. The patients received 0.5 $ml \cdot kg^{-1}$ a bolus 0.25% bupivacaine with epinephrine 1 : 200 000 at T5-6 level after standard general anesthesia induction. Anesthesia depth with Index of Consciousness (IOC) and tissue oxygen saturation with cerebral (rSO2-C) and somatic thoracodorsal (rSO2-S) were monitored. Intraoperative hemodynamic and postoperative hemodynamic and pain scores were evaluated for 24 h after surgery. Face, Legs, Activity, Cry, Consolability (FLACC) score was utilized to measure postoperative pain in the intensive care unit. Rescue 0.05 $mg \cdot kg^{-1}$ IV morphine was applied to patients in whom FLACC was >3.

Results: The median age of the patients was 4.5 (1–11) months, and the median intraoperative endtidal isoflurane concentration was 0.6% (0.3–0.8). The amount of remifentanil used intraoperatively was 4.5 (2.5–14) $\mu g \cdot kg^{-1} \cdot h^{-1}$. Intraoperative heart rate and blood pressure values significantly decreased compared with values detected at 5th, 10th, and 15th min after TPVB application, after incision prior and after cross-clamp ($P < 0.01$). The median time of first dose of morphine application after block was 320 (185–430) min. The median morphine consumption in 24 h was 0.16 (0.09–0.4) $mg \cdot kg^{-1}$. The median length of postoperative intensive care unit and in-hospital stay times was 23 (1–67) h and 4 (1–10) days, respectively.

Conclusion: We believe that TPVB, as part of a balanced anesthetic and analgesic regime, provides effective pain relief in patients undergoing aortic coarctation repair.

Introduction

In aortic coarctation anesthesia, isoflurane has been frequently used for both anesthetic and blood pressure titration, and fentanyl has been used for pain control (1). Vasoactive agents should be available to treat sudden alterations in the blood pressure associated with clamping and declamping of the aorta (1). Paravertebral blockage is one of the regional techniques that provides intense sensory blockage. It is preferred to improve the analgesia in pediatric cardiac surgery because it is an opioid-sparing approach, as well as it has been shown to

be associated with lower rate of complications compared with epidural block in recent years (2–4). Thus, the aim of this observational prospective study was to delineate the efficacy and duration of a single level, single injection ultrasound–guided PVB in 15 infants who underwent repair of aortic coarctation.

Material and methods

After approval of the ethical committee and the relatives of patients (KA11/23), a cohort of 15 patients undergoing aortic coarctation repair were enrolled in the study between February 2012 and February 2013.

After premedication with midazolam (0.05 $mg \cdot kg^{-1}$ IV), all patients were admitted to the operating room. As part of routine practice, noninvasive blood pressure, pulse-oximetry, and electrocardiography were monitored continuously. General anesthesia was initiated with 2 $\mu g \cdot kg^{-1} \cdot min^{-1}$ remifentanil infusion and 2 min later propofol 2 $mg \cdot kg^{-1}$, remifentanil 1 $\mu g \cdot kg^{-1} \cdot min^{-1}$, and rocuronium 0.6 $mg \cdot kg^{-1}$ were given for anesthesia induction. In addition to standard monitoring, invasive right radial artery pressure was monitored. Anesthesia depth was monitored with Index of Consciousness (IOC) (Morpheus Medical, Barcelona, Spain) (5). Tissue oxygen saturation with cerebral (rSO2-C) and somatic thoracodorsal (rSO2-S) were monitored. The rSO2-C sensor was placed at the left side of forehead. The rSO2-S sensor was placed on the back, with the free end oriented toward the spine and the connector end to the flank, in the thoracodorsal (T10–L2) region. Data (Pediatric SomaSensor, Model SPFB, for children 4–40 kg by Somanetics Corporation, Troy, Michigan for the INVOS 5100 Cerebral Oximeter) were continuously updated at two readings per second and average recordings saved at 1-min intervals. In all patients, after intubation with conventional tracheal tubes, anesthesia was maintained with isoflurane in 50% oxygen/air and continuous infusion of remifentanil (0.01–1 $\mu g \cdot kg^{-1} \cdot min^{-1}$) until the end of surgical procedures with the aim of keeping IOC values within 40–60 and heart rate and blood pressure within the 30% range. Heart rate and blood pressure increase over 10% following surgical incision was accepted as failed block. The body temperature of the children was allowed to drift to 35°C during coarctation repair under the cross-clamp, and normothermia was maintained following the removal of the clamp. Nitroglycerin (Perlinganit®) infusion was used at the rate of 0.5–2 $\mu g \cdot kg^{-1} \cdot min^{-1}$ to treat sudden increase in the blood pressure during the operative periods, and also during the first 24 h of the postoperative period. All patients were planned to be extubated at the end of surgery. None of the patients waited for more than 30 min in the operation room for extubation. The patients were extubated when they woke up and started to breathe spontaneously in normal respiratory rate and with tidal volume greater or equal to half the normal tidal volume for their age. The other criteria for extubation were stable hemodynamics, uneventful intraoperative course and normal arterial blood gas values.

All TPVB were performed by a single anesthesiologist (AT) with the patient in the lateral decubitus position and left side facing upward. We used ultrasound-guided approach for paravertebral block except for the first four patients in whom the Lönnqvist technique was used (6). Ultrasound-guided (The Sonosite HST is a hockey stick ultrasound transducer probe. The Sonosite HST has a frequency range from 5 to 10 MHz and compatible with: Sonosite 180 Plus/Titan) approach was performed as follows: The Desired thoracic vertebral level (T5-6) is marked by means of counting the vertebra prominens (C7). Under sterile conditions, transducer is placed at a point approximately 2 cm lateral to the tip of the spinous process in the vertical orientation with alongside the probe in an 'out-of-plane' technique (Figure 1). After a sonographic view demonstrating the pleura and transverse process was obtained, and the needle was advanced into the paravertebral space until the pleural border has been reached. As loss of resistance to saline is felt, the saline injection was detected on the ultrasound image. Then, the patients received a bolus of 0.5 $ml \cdot kg^{-1}$ 0.25% bupivacaine with epinephrine 1 : 200 000 at T5–6 thoracic level.

Systolic arterial blood pressure (SABP), heart rate (HR), arterial oxygen saturation (SpO2), IOC values, and SctO2-c and SctO2-s values were recorded at the following times: pre-induction, after induction, before TPVB, after TPVB (at the 2nd, 5th, 10th, and 15th min) after skin incision, before, during, and after aortic clamp, and after extubation. At the end of surgery, procedure duration, analgesic (remifentanil), fluid volume, vasodilator, and inotrope consumption were recorded.

At the end of surgery, all patients received acetaminophen, 20 $mg \cdot kg^{-1}$, in the form of a rectal suppository, later to be followed by same doses every 6 h. After the operation, patients were transferred to the intensive care unit (ICU). Postoperative pain was measured by the behavioral FLACC score (7) and monitored for 24 h. The scores were documented at 0, 1/2, 1st, 2nd, 4th, 8th, 12th, 24th h during the postoperative 1st day in ICU. Systolic arterial pressure and heart rates were recorded at the same time intervals. FLACC score was assessed at predetermined time points and in case of apparent patients' discomfort during the first postoperative 24 h. 0.05 $mg \cdot kg^{-1}$ IV morphine was administered to patients in whom FLACC>3. The duration of postoperative

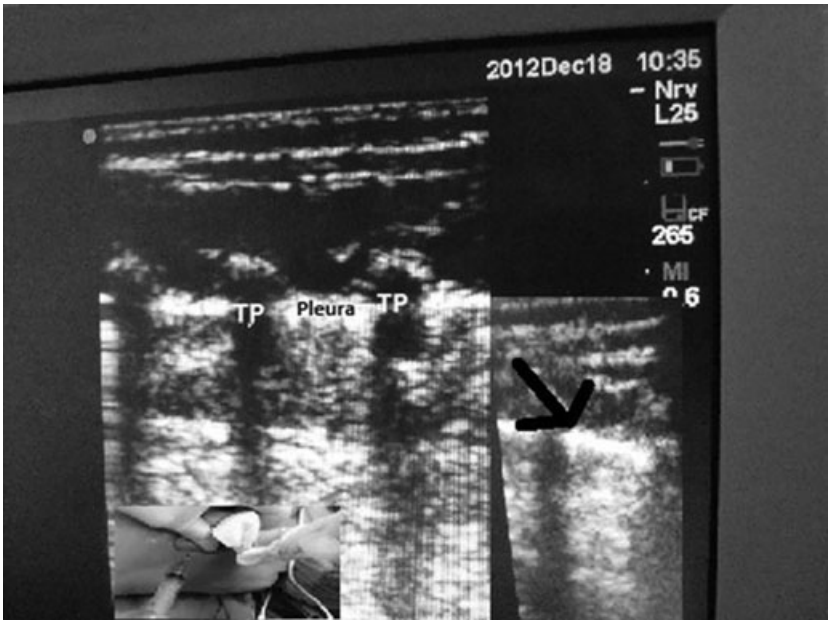

Figure 1 Ultrasound-guided paravertebral block in an 'out-of-plane' technique.

analgesia was defined as the interval between PVB and the first dose of supplemental administration of a rescue opioid analgesic. The incidence of complications and adverse reactions were also recorded.

Statistical analyses were performed with SPSS software (Statistical Package for the Social Sciences, version 9.05, SSPS Inc, Chicago, IL, USA). All variables were given as the median (range) or n (%). The Friedman test followed by the Wilcoxon signed-rank test was used for nonparametric values. A value of $P < 0.05$ was accepted as statistically significant.

Results

In seven of 15 patients co-existing pathologies were present (VSD in 2; PDA in 4, and ASD in one patient). Table 1 summarizes demographic and descriptive median and range of data. A successful paravertebral block was noted in 14/15 patients (93%). A failed block was noted in the second patient in whom heart rate and blood pressure were increased 40% from basal measurement along with IOC, which increased from 40 to 78 level at the time of incision. The TPVB was applied by the same anesthetist in single application (except for 2 cases) in the median duration of 4 (0.5–5) min. Bloody tap was not encountered in any patient. In all of our cases, 22 G, 5-cm-injection needle was inserted at the 5th–6th thoracic level lateral to the spinal process. The needle was inserted 1.7 (1.2–2) cm laterals to the midline of spinous process.

Table 1 Demographic and descriptive data

Number of patients	15
Age, months	4.5 (1–11)
Sex M/F	10/5
Duration of surgery, min	120 (100–180)
Duration of Cross-Clamp, min	27 (23–30)
Dose of remifentanil administered intraoperatively, $\mu g \cdot kg^{-1} \cdot h^{-1}$	4.5 (2.5–14)
Dose of morphine administered postoperatively, $mg \cdot kg^{-1} \cdot day^{-1}$	0.16 (0.09–0.4)

Data are presented as median (range).

Table 2 shows that the mean values of intraoperative variables. When the hemodynamic parameters throughout the operative periods were observed, the heart rate values at the post TPVB 5th, 10th, 15th, at the time of incision, before, during, and after aortic clamp decreased significantly compared with baseline value. Also in the same time periods, except for the results obtained during cross-clamp time, the systolic blood pressures decreased significantly compared with baseline values ($P < 0.01$). Dopamine infusion was initiated at the time of incision in four patients. Throughout the operation, brain and somatic $SctO_2$ values were similar to the baseline values (Figure 1). The median endtidal isoflurane concentration was measured as 0.6% (0.3–0.8). The intraoperative remifentanil consumption was 4.5 (2.5–14) $\mu g \cdot kg^{-1} \cdot h^{-1}$. All patients except for 3rd, 5th and 9th patients were extubated at the end of the operation. The ages of these patients were 2, 8, and 2 months, respectively. These patients were extubated at the postoperative 2th, 3rd and 11th h in the ICU, respectively.

Table 3 demonstrates the mean values of postoperative variables. The hemodynamic parameters including

Table 2 İntraoperative variables

Variables	1	2	3	4	5	6	7	8	9	10	11
SAB	116 ± 31	118 ± 25	114 ± 24	98 ± 21*	93 ± 23*	97 ± 26*	93 ± 25*	99 ± 26*	128 ± 33	88 ± 22*	120 ± 18
HR	148 ± 18	140 ± 18	131 ± 17	126 ± 16*	104 ± 10*	96 ± 9*	105 ± 14*	106 ± 15*	114 ± 18*	115 ± 14*	130 ± 22
SctO2-C	66 ± 8	68 ± 8	67 ± 7	66 ± 13	67 ± 10	66 ± 8	67 ± 9	66 ± 9	71 ± 9	68 ± 9	68 ± 9
SctO2- S	64 ± 8	70 ± 6	65 ± 6	67 ± 10	72 ± 10	72 ± 9	71 ± 10	71 ± 13	60 ± 13	72 ± 10	70 ± 10
IOC	84 ± 13	58 ± 10*	55 ± 10*	51 ± 6*	48 ± 6*	52 ± 8*	51 ± 9*	54 ± 9*	55 ± 9*	55 ± 8*	89 ± 6
Remifentanil infusion(ml/h)	2 ± 0	1 ± 0	0.7 ± 0.3	0.5 ± 0.4	0.1 ± 0.1*	0.1 ± 0.1*	0.1 ± 0.1*	0.1 ± 0.1*	0.5 ± 0.4	0.1*±0.1	0 ± 0*

Data are presented as mean ± SD.

*$P < 0.05$. Variables 1: pre-induction, 2: after induction, 3: before TPVB, 4: 5th min after TPVB, 5: 10th min after TPVB, 6: 15th min after TPVB, 7: after skin incision, 8: before aortic clamp, 9: during aortic clamp, 10: after aortic clamp, 11: 5th min after extubation.

heart rate and systolic blood pressure measured during ICU stay were found to be similar with that of obtained at the time of ICU admission. In only one patient (7%), FLACC score was above 3 at the postoperative 185th min. The median time of block duration was 320 (185–430) min. Supplemental administration of morphine was 0.16 (0.09–0.4) $mg \cdot kg^{-1}$ IV in the first postoperative 24 h, and nitroglycerin (Perlinganit®) was used in six patients for hypertension treatment during the ICU stay in the first postoperative day. One patient was re-intubated in ICU due to pneumothorax and was extubated at the postoperative 8th h. The median ICU stay time was 23 (1–67) h, and the mean in-hospital stay time was 4 (1–10) days.

Discussion

In our study, we found that single injection ultrasound–guided TPVB was highly effective in pain control treatment during operation and in the first postoperative 24 h in patients who underwent aortic coarctation repair through thoracotomy. Thoracotomy produces one of the most intense postoperative pain experiences (8,9). The pain is multifactorial in origin; the post-thoracotomy pain derives from the surgical wound, the disruption of the ribs and intercostal nerves, the damage to the chest wall and the pleura, and the presence of thoracotomy tubes (10). Therefore, inadequately-treated postoperative pain compromises respiratory function and may result in adverse effects in children undergoing aortic coarctation repair. Numerous studies have demonstrated that, in adult patients, after thoracotomy, the most favorable outcomes were obtained when adequate analgesia was provided by paravertebral block (11–14). It is reported that paravertebral block procedure is technically easy to learn and as effective as epidural block (13,14). It also improves patient's well-being in terms of reduction in opioid use, postoperative nausea and vomiting, less urinary retention, improved hemodynamic changes, early discharge, prevention of pulmonary functions, and improvement in oxygenation and reduction in stress response (13,14).

In the preliminary studies that evaluated the effect of paravertebral block on post-thoracotomy pain, the paravertebral catheters were introduced under direct vision after thoracotomy in pediatric patients (2,3,15). This provided perfect postoperative analgesia in 90–100% of the cases (2,3,15). In these studies, a bolus of 0.25% bupivacaine 0.5 $ml \cdot kg^{-1}$ was used, and no clinical toxic sign was shown after bolus or 24 h of infusion. Following the block application, the local anesthetic was shown to spread between 4th and 6th ribs longitudinally. The technique is reliable providing

Table 3 Postoperative variables

Variables	0	1/2	1	2	4	8	12	24
SAB (mmHg)	121 ± 13	107 ± 17	113 ± 17	127 ± 17	124 ± 16	117 ± 11	116 ± 12	117 ± 14
HR (beat/min)	125 ± 14	127 ± 15	139 ± 20	135 ± 4	134 ± 16	133 ± 16	136 ± 12	137 ± 14
FLACC	1.9 ± 1.7	1.7 ± 1.1	1.8 ± 1.8	1.6 ± 1.3	1.3 ± 1.3	1.4 ± 1.2	1.0 ± 1.0	1.0 ± 1.0
Rescue analgesia (mg)	0.1 ± 0.1	0 ± 0	0 ± 0	0.2 ± 0.2	0.5 ± 0.2*	0.3 ± 0.2	0.3 ± 0.2	0.3 ± 0.2

Data are presented as mean ± SD.

*$P < 0.05$. Variables were documented at 0, 1/2, 1st, 2nd, 4th, 8th, 12th, 24th h 1st day in ICU.

fewer and more favorable postoperative complications compared with epidural anesthesia (2,3,15). However, despite world-wide use of ultrasound-guided perioperative paravertebral block application in adults, our extensive search of the scientific literature has not revealed any study concerning the use of this method in a pediatric group after thoracic surgery. Only in El Morsey's and colleagues study, nerve stimulator guided paravertebral block was used in the aforementioned bupivacaine doses in 10 aortic coarctation cases (16). The authors stated that the technique provided efficient post-thoracotomy analgesia and fewer complications when compared to epidural analgesia; however, they did not evaluate the intraoperative efficacy of the paravertebral block in the study. In our study, we observed that the technique has decreased the perioperative opioid use. We are planning to run a prospective randomized study to investigate the additional effects of the application such as providing controlled hypotension during x-clamp, steady cardiac rhythm, and diminished antihypertensive agent use in the ICU during the postoperative course.

Due to these advantages, we chose to apply single-shot PVBs to children undergoing coarctation of the aorta surgery. In all cases, the block level was enough for surgical procedure. In all infants, starting from the 2nd min following PVB (in accordance with the onset time of PVB effect), the blood pressure and the heart rate decreased progressively and reached peak values at the 15th min and at the time of incision**.** In all of our cases, 20% drop in blood pressure and heart rate that precluded prompt intervention was only observed in 4 cases (which might be related to the bilateral sympathetic nerve distribution). The remifentanil infusion was decreased to 0.1 ml h^{-1} at the 5th min of TPVB as seen in Table 2 and was only needed during cross-clamp time. Also, in none of the patients in whom block was successful, blood pressure, heart rate, and IOC values increased after surgical incision. After TPVB, first rescue morphine was injected at 185th min, and the mean PVB duration (time to first iv morphine application after TPVB) was 320 min. Berta and colleagues observed a median duration of 10 h following a single injection PVB in their study (17). This could be related to more intense pain related to thoracotomy. On the other hand, in infants, supplemental administrations of 0.16 mg·kg^{-1} doses of morphine were needed in the first postoperative 24 h. In 2 studies with children who underwent thoracotomy (without regional anesthesia), the postoperative morphine requirement was reported as 0.02 mg·kg^{-1}·h^{-1} and 0.544 mg·kg^{-1}·day^{-1} (18,19). When compared to our study, the amount of morphine used in the postoperative 24 h was less than that of these studies. One may conclude that the analgesic effect of TPVB continues after the operation. A limitation of the study is that our study lacks a control group. We performed aortic coarctation repair via thoracotomy in infants using paravertebral block combined with general anesthesia under anesthetic depth monitoring that allows adequate intraoperative analgesia. The method provides minimal adverse effect and rapid recovery. We believe that single injection ultrasound–guided TPVB, as part of a balanced anesthetic and analgesic regime, provides effective pain relief.

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Conflict of interest

No conflicts of interest declared.

References

1 Hastings LA, Nichols DG. Coarctation of the aorta and interrupted aortic arch in: Critical heart disease in infants and children. Philadelphia, PA: Mosby, Elsevier's Health Sciences, 2006; 625–648.

2 Eng J, Sabanathan S. Continuous paravertebral block for post-thoracotomy analgesia in children. *J Pediatr Surg* 1992; **27**: 556–557.

3 Karmakar MK, Booker PD, Franks R, *et al.* Continuous extrapleural paravertebral infusion of bupivacaine for post-thoracotomy analgesia in young infants. *Br J Anaesth* 1996; **76**: 811–815.

4 Davies RG, Myles PS, Graham JM. A comparison of the analgesic efficacy and side-

effects of paravertebral vs epidural blockade for thoracotomy-a systematic review and meta-analysis of randomized trials. *Br J Anaesth* 2006; **96**: 418–426.

5 Revuelta M, Paniagua P, Campos JM *et al*. Validation of the index of consciousness during sevoflurane and remifentanil anaesthesia: a comparison with the bispectral index and the cerebral state index. *Br J Anaesth* 2008; **101**: 653–658.

6 Lönnqvist PA. Continuous paravertebral block in children: initial experience. *Anaesthesia* 1992; **47**: 607–609.

7 Voepel-Lewis T, Merkel S, Tait A, *et al*. The reliability and validity of the Face, Legs, Activity, Cry, Consolability observational tool as a measure of pain in children with cognitive impairment. *Anesth Analg* 2002; **95**: 1224–1229.

8 Parkhouse J, Lambrechts W, Simpson P. The incidence of postoperative pain. *Br J Anaesth* 1961; **33**: 345–353.

9 Loan W, Morrison J. The incidence and severity of postoperative pain. *Br J Anaesth* 1967; **39**: 695–698.

10 Kavanagh B, Katz J, Sandler A. Pain control after thoracic surgery. *Anesthesiology* 1994; **81**: 737–759.

11 Shelley B, Macfie A. Where now for thoracic paravertebral blockade? *Anaesthesia* 2012; **67**: 1317–1320.

12 Karmakar MK. Thoracic paravertebral block. *Anesthesiology* 2001; **95**: 771–780.

13 Ganapathy S, Nielsen KC, Steele SM. Outcomes after paravertebral blocks. *Int Anesthesiol Clin* 2005; **43**: 185–193.

14 Richardson J, Lönnovist PA. Thoracic paravertebral block. *Br J Anaesth* 1998; **81**: 30–38.

15 Cheung SL, Booker PD, Franks R, *et al*. Serum concentrations of bupivacaine during prolonged continuous paravertebral infusion in young infants. *Br J Anaesth* 1997; **79**: 9–13.

16 El-Morsy GZ, El-Deeb A, El-Desouky T, *et al*. Can thoracic paravertebral block replace thoracic epidural block in pediatric cardiac surgery? A randomized blinded study. *Ann Card Anaesth* 2012; **4**: 259–263.

17 Berta E, Spanhel J, Smakal O, *et al*. Single injection paravertebral block for renal surgery in children. *Pediatr Anesth* 2008; **18**: 593–597.

18 Shah R, Sabanathan S, Richardson J, *et al*. Continuous paravertebral block for post thoracotomy analgesia in children. *J Cardiovasc Surg (Torino)* 1997; **38**: 543–546.

19 Gibson MP, Vetter T, Crow JP. Use of continuous retropleural bupivacaine in postoperative pain management for pediatric thoracotomy. *J Pediatr Surg* 1999; **34**: 199–201.