Parasternal Intercostal Block With Ropivacaine for Postoperative Analgesia in Pediatric Patients Undergoing Cardiac Surgery: A Double-Blind, Randomized, Controlled Study

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Objective: **The objective of this study was to assess the effectiveness of 0.5% ropivacaine used for parasternal intercostal blocks for postoperative analgesia in pediatric patients undergoing cardiac surgery.**

Design: **A randomized, controlled, prospective, double-blind study.**

Setting: **A tertiary care teaching hospital.**

Participants: **Thirty children scheduled for cardiac surgery with a median sternotomy.**

Interventions: **A 0.5% ropivacaine injection with 5 doses of 0.5 to 2.0 mL on each side in the 2nd to 6th parasternal intercostal space with a total dose of ropivacaine below 5 mg/kg or the same volume of saline before sternal wound closure.**

Measurements and Main Results: **The time to extubation was significantly lower in patients administered the parasternal blocks with ropivacaine than in the control group; the mean values were 2.66 hours and 5.31 hours, respectively ($p < 0.001$). The pain scores were lower in the ropivacaine group compared with the saline group; mean values were 2.20 for the ropivacaine group and 4.83 for the saline group on a scale of 10. The cumulative fentanyl dose requirement over a 24-hour period was higher in the saline group than the ropivacaine group ($p < 0.001$).**

Conclusions: **Parasternal blocks with ropivacaine appear to be a simple, safe, and useful technique of supplementation of postoperative analgesia in pediatric patients undergoing cardiac surgery with a median sternotomy.**

KEY WORDS: pediatric cardiac patients, parasternal intercostal block, sternotomy, ropivacaine, postoperative pain

REDUCING THE PAIN from surgical procedures performed early in life psychologically reduces the pain experienced by children in subsequent procedures.[1] This reduction in pain perception may increase the child's willingness to return for further necessary procedures. Pediatric cardiac surgical patients usually undergo multiple surgical interventions and hospital admissions and will benefit from effective pain relief during their initial surgery. In a fast-track protocol, used in modern-day cardiac surgical care, early extubation may be facilitated by effective postoperative pain control, which also helps in maintaining hemodynamic stability.[2]

Parasternal infiltration of local anesthetic for nerve blocks is a simple adjunct to postoperative analgesia. This can be performed safely even in anticoagulated patients. There are a very limited number of studies on the use of parasternal blocks for postoperative analgesia. The present authors have not come across any published study of parasternal blocks in pediatric patients. This prospective randomized study was conducted based on the hypothesis that parasternal blocks administered in pediatric patients undergoing cardiac surgery through median sternotomy can provide effective postoperative analgesia, thereby reducing the requirement of opioids for postoperative pain relief.

METHODS

After approval from the institute's ethics committee, written informed consent from parents and assent from the children of appropriate age were obtained. The study was performed on 30 children between the ages of 1 and 10 years undergoing cardiac surgical procedures with median sternotomy; they were all candidates for fast tracking and extubation within 6 hours postoperatively. The details of the diagnosis and the surgical procedures in the study are shown in Table 1. The children were randomized into 2 groups: R, the ropivacaine group (0.5% ropivacaine), and S, the saline group. Patients with an ejection fraction <35%, with low-cardiac-output syndrome, on inotropic support preoperatively, with an allergy to the amide type of local anesthetics, with recurrent ventricular arrhythmias, with postoperative complications requiring a return to the operating room, requiring intubation for more than 10 hours, and requiring redo or emergency surgery were excluded from the study.

All preoperative cardiac medications were continued until the morning of surgery. Intramuscular morphine, 0.1 mg/kg, with promethazine, 0.5 mg/kg, were given as premedication 1 hour before the surgery. Inside the operating room, initial monitoring included a 5-lead electrocardiogram, noninvasive blood pressure, and pulse oximetry. Anesthetic induction was performed with sevoflurane with oxygen and air, 50% each. Anesthesia was supplemented with intravenous midazolam, 0.05 to 0.1 mg/kg; fentanyl, 5 to 10 μg/kg; and 0.8 mg/kg of rocuronium. The maintenance of anesthesia was achieved with midazolam, fentanyl, isoflurane, and vecuronium as required.

Using the sealed envelope method, patients were randomized into group R or group S with either ropivacaine or saline. The ropivacaine and saline preparations were prepared in the operating room by a cardiac anesthesiology trainee who was not part of the study; the saline and ropivacaine solutions looked identical. Medication administration and data collection were performed in a double-blinded manner such that the patient, the surgeon administering the block, the anesthesiologist providing anesthesia, and the intensive care unit staff giving postoperative care, including the intensivist were not aware of medication assignment. Patients received a parasternal block with 0.5% ropivacaine or 0.9% saline administered in 0.5- to 2-mL aliquots depending on the weight injected into 5 anterior (2nd-6th) intercostal spaces on each side 1 to 1.5 cm lateral to the sternal edge. The dose of ropivacaine in the literature for adult patients for the intercostal block is 4 mL per intercostal space, which is approximately 0.05 to 0.06 mL/kg/space of 0.75% ropivacaine. In the present study, a dose of 0.08 mL/kg/space of 0.5% ropivacaine was used. For a 5 kg child, it comes to $0.08 \times 5 \times 10 = 4$ mL

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Table 1. Demographic Data: Values Expressed as Mean ± Standard Deviation and Numbers

Variable	R Group (n = 14)	S Group (n = 13)	*p* Value
Age (y)	5.5 ± 1.82	5.7 ± 1.58	0.76
Weight (kg)	14.5 ± 4.2	15.9 ± 4.32	0.42
BSA (m^2)	0.70 ± 0.12	0.76 ± 0.10	0.17
Sex (M/F)	11/3	9/4	0.42
CPB time (min)	71.0 ± 7.6	75.3 ± 7.1	0.14
Aortic cross-clamp time (min)	48.6 ± 6.0	49.3 ± 5.0	0.75
Total intraoperative fentanyl (μg/kg)	8.6	9.1	0.32
Total intraoperative midazolam (mg/kg)	0.23	0.21	0.41
Surgical procedures			
VSD closure	6	5	
ASD closure	2	2	
Intracardiac repair for tetralogy of Fallot	4	5	
DORV repair	1	1	
Aortic valve repair	1	—	

Abbreviations: BSA, body surface area; DORV, double-outlet right ventricle; ASD, atrial septal defect; VSD, ventricular septal defect.

of 0.5% = 20 mg, which is 4 mg/kg of ropivacaine. The total dose of ropivacaine was kept well below 5 mg/kg. The block was administered by the operating surgeon before sternal suture placement for sternal wound closure. Care was taken to ensure that there was no blood aspirated to avoid intravascular injection or vascular injury. Patients were observed for 10 minutes for any bleeding caused by an inadvertent vascular injury before the closure of the sternum.

All the patients then were shifted to the intensive care unit (ICU) after the surgery and managed with the institution's ICU protocol for postoperative pain management and ventilation. The postoperative analgesia protocol at the authors' institution involves the use of intravenous fentanyl, a 1- to 2 μg/kg bolus as required, in addition to oral acetaminophen, 15 mg/kg every 6 hours through the nasogastric tube, until the child is put on oral food. Criteria for administering intravenous fentanyl were signs of sympathetic stimulation in the form of undue tachycardia, a rise in mean arterial pressure (rise of >20% from the baseline), and a pain score of >4, or if the children were in obvious pain and distress at any time point during a subjective assessment by the intensivist. Tracheal extubation was performed when the children met the following criteria: awake/arousable, hemodynamically stable, no active bleeding, warm peripheries, satisfactory arterial blood gas with an F_IO_2 <0.5, no electrolyte abnormalities, minimal inotropic support, or no escalation in inotropic support. The outcome measures of the study were the time to extubation in hours, the postoperative sternal wound pain as judged by the Modified Objective Pain Score[3] (MOPS) on a scale of 10 points (Table 2), and the 24-hour cumulative fentanyl dosage. MOPS is the score used at the authors' institution for postoperative pain assessment in children. The ICU staff and the clinicians are well versed with MOPS; hence, it was the preferred method of pain assessment in this study. Pain scores were recorded every 2 hours for 24 hours after surgery.

The authors calculated the size of the study assuming the baseline values of pain scores preoperatively to be the same in both groups; the pain scores at the end of the study were 3.8 ± 0.82 in the R group and 4.35 ± 0.75 in the S group. By method of change, 30 children were needed, 15 in each group with an alpha error of 5% and power of study 90% with a correlation coefficient between baseline and follow-up of 70%. Data were analyzed using SSPS version 11 (SPSS Inc, Chicago, IL) software. The techniques applied were the Student *t* test/Mann-Whitney *U* test wherever applicable to compare the two groups in case of continuous data. The qualitative data were compared with the Fisher exact test. To see the change in pain score over time, repeated-measure analyses followed by postoperative comparison by the LSD method were used; a *p* value <0.05 was considered significant.

RESULTS

A total of 30 children were enrolled in the study. The two groups were similar in demographic characteristics (Table 1) including age, weight, body surface area, and other parameters like cardiopulmonary bypass time, aortic cross-clamp time, and intraoperative doses of fentanyl and midazolam. Table 1 also shows the distribution of congenital defects in both the groups for which the surgical procedure was performed. One child from group R and 2 children from group S could not complete the study and had to be excluded. The child in group R underwent re-exploration for excessive bleeding, and the children in group S were excluded because one of them had prolonged ventilatory support due to hemodynamic instability and the other one underwent re-exploration for a residual defect. The measured parameters are summarized in Table 3, and the pain scores (MOPS) over a 24-hour period are depicted in Figure 1.

The time to extubation was significantly lower in group R compared with group S with a mean value of 2.66 ± 0.66

Table 2. Modified Objective Pain Score (MOPS)

Criteria	Finding	Points
Crying	None	0
	Consolable	1
	Not consolable	2
Movement	None	0
	Restless	1
	Thrashing	2
Agitation	Asleep	0
	Calm	0
	Mild	1
	Hysterical	2
Posture	Normal	0
	Flexed	1
	Holds injury site	2
Verbal	Asleep	0
	No complaint	0
	Complains but cannot localize	1
	Complains and can localize	2

NOTE. The minimum score was 0, and the maximum score was 10. The higher the score, the greater the pain experience for the child.