

Postoperative Outcomes of Analgesic Management with Erector Spine Plane Block at T5 Level in Pediatric Patients Undergoing Cardiac Surgery with Sternotomy: A Cohort Study

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Introduction: There is limited evidence on the impact of erector spinae plane block (ESPB) as part of multimodal analgesia in pediatric population undergoing cardiac surgery.

Methods: A retrospective cohort study was conducted in patients under 18 years of age, who underwent cardiac surgery Risk Adjusted classification for Congenital Heart Surgery (RACHS-1) ≤ 3 by sternotomy. The study aims to evaluate the effect of ESPB as part of multimodal analgesia in pediatric patients undergoing cardiac surgery compared to conventional analgesia (CA) on relevant clinical outcomes: length of hospital stay, length of ICU stay, opioid consumption, time to extubation, mortality, and postoperative complications. The participants included were treated in a reference hospital in Colombia from July 2019 to June 2022.

Results: Eighty participants were included, 40 in the ESPB group and 40 in the CA group. There was a significant decrease (Log rank test $p = 0.007$) in days to length of hospital stay in ESPB group (median 6.5 days (IQR: 4–11)) compared to the CA group (median 10.5 days (IQR: 6–25)). Likewise, there was a higher probability of discharge from the ICU in the ESPB group (HR 1.71 (95% CI: 1.05–2.79)). The ESPB group had lower opioid consumption ($p < 0.05$). There were no differences in time to extubation, mortality, and postoperative complications.

Conclusion: ESPB as part of multimodal analgesia in pediatric patients undergoing cardiac surgery is feasible and associated with shorter hospital length of stay, faster ICU discharge and lower opioid consumption.

Keywords: erector spinae plane block, cardiac surgery procedures, pediatric age group, anesthesia, perioperative, pediatric anesthesia

Introduction

The management of perioperative pain in patients with congenital heart disease undergoing surgery has evolved, leaning towards balanced anesthesia and regional techniques.¹ Inadequate pain management in the perioperative period and cardiac surgery in pediatric patients may contribute to discomfort, prolonged intubation, recovery, and mobility delay.^{1–3} Pain control through multimodal analgesia is the mainstay of treatment; however, adverse events related to some of the drugs, such as opioids, could contribute to longer hospitalizations.¹

Multiple strategies have been proposed to improve pain management, reduce undesired outcomes, and improve fast recovery.^{4–7} With the growing interest in the Enhanced Recovery After Surgery (ERAS) after cardiac surgery and the safety profile of local anesthetics, perioperative pain management focused on regional strategies has gained popularity as it may reduce opioid consumption.^{8,9} Regional ultrasound-guided analgesic modalities with a single anesthetic dose

promise pain management during cardiac surgery without major complications.^{8,10–12} ESPB anesthetizes the dorsal and ventral branches of the spinal nerve roots, thus producing deep analgesia of the ipsilateral hemithorax.¹³

Although previous studies suggest that regional techniques during anesthesia in patients undergoing sternotomy effectively reduce operative and postoperative pain,¹⁴ there is limited evidence on the impact of those techniques, such as erector spinae plane block (ESPB), in pediatric population, and the evidence is currently limited to patients with septal and ventricular defects.^{1,2} In addition, pain management using ESPB in patients according to the RACHS-1 Classification Risk Score has not been reported and there is no information about the effectiveness of this technique in South America. This study aimed to compare postoperative outcomes in a cohort of Latin American pediatric patients undergoing low and moderate-risk cardiac surgery after multimodal analgesic management with ESPB compared to patients with conventional analgesia (CA) in terms of hospital and ICU length of stay, opioid consumption, time to extubation, mortality, and postoperative complications.

Materials and Methods

Study Design, Setting, and Participants

A retrospective cohort study was conducted at Fundación Valle del Lili, a tertiary hospital that serves as a reference center in pediatric cardiovascular surgery for southwestern Colombia. Patients under 18 years of age with cardiac pathology who underwent cardiovascular surgery with sternotomy as the only surgical approach or with a combined approach between July 2019 and June 2022 were pre-selected. Inclusion and classification criteria in the ESPB group were all pediatric patients with RACHS-1 risk classification less than or equal to three, who received ESPB at the end of surgery as part of multimodal analgesia management, at the discretion of the anesthesiologist in charge of the patient. The conventional analgesia (CA) group included all patients undergoing the same surgical procedures, with RACHS-1 risk classification less than or equal to three, treated without the ESPB. All patients were operated by two pediatric cardiovascular surgeons.

Outcomes and Exposure Measures

The primary outcome variable was time in days of hospital stay and ICU stay. Secondary outcomes were opioid consumption, extubation time, complications, and in-hospital mortality.

The exposure variable at the end of surgery was the type of analgesic intervention (ESPB group vs CA group). All patients classified in the ESPB group underwent a 0.7 mL/kg of 0.125% of bupivacaine bilateral single-shot in the intersection between each of the erector spinae plane muscles and the transverse process of the fourth and fifth thoracic vertebrae. This was performed under ultrasound guidance and after performing an aseptic technique. The mentioned process was followed by opioid intravenous injections for both groups (morphine range between 50 and 200 µg/kg), alpha-2 agonists (dexmedetomidine 0.5 µg/kg/h), and paracetamol (10 mg/kg). For the CA group, opioid (morphine dose 0.1 mg/kg), paracetamol (10 mg/kg), and alpha-2 agonists (0.5 µg/kg/h) were administered at the same pre-established doses according to institutional protocol for perioperative pain management.

Covariates included demographics (age, gender, weight and height, body surface, comorbidities) and clinical (RACHS-1, type of surgery, cardiopulmonary bypass time, aortic cross-clamp, intraoperative opioid consumption). Post anesthesia information (time to extubation in hours and days, time to first rescue analgesia, postoperative vital signs: systolic, diastolic, and mean blood pressure, heart rate, oxygen saturation at 1, 3, 6, 12, 24, 48 hours, days of ICU stay, overall in hospital stay in days, complications, adverse events and postoperative pain evaluation according to the FLACC (Face, Legs, Activity, Cry, Consolability) scale at 1, 3, 6, 12, 24, 48 hours were also included. All data were obtained from the clinical history, and anesthetic variables were obtained from the anesthesia record. Two investigators extracted patient information in a protected electronic data collection form independently. When the information was completely collected, we randomly analyzed 10% of the database. If discordant data were found, errors were immediately corrected.

Sample Size

We calculated the sample size necessary to find a mean difference in the number of days of hospital stay of one or more days, aiming for a statistical power of 80%, with a confidence interval of 95% and an alpha of 0.05%. We calculated a minimum of 32 patients to achieve this objective for each group. A convenience sampling was conducted and all participants who met the inclusion criteria for the ESPB group were included. Afterwards, subjects with CA were completed to meet the ESPB group sample size according to the database provided by the institutional statistics department.

Statistical Methods

We used conventional descriptive statistical methods. For continuous data, normality was evaluated using q-q plot and Shapiro Wilk test. Continuous data with normal distribution is presented as mean and standard deviation, while those with no normal distribution are presented as median and interquartile range (IQR). Categorical variables are reported as absolute frequencies and percentages.

A bivariate analysis was performed between patients undergoing ESPB and those treated with CA to evaluate differences in baseline characteristics of both groups. To compare quantitative variables, Student's *t*-test or Mann Whitney *U*-test were used according to the distribution of the variables. Categorical variables were analyzed using the Chi test or Fisher's exact test according to compliance of statistical assumptions. After comparing the baseline characteristics of both clinical groups, comparisons were made for extubation time (days), opioid consumption (morphine or equivalents during hospital stay), postoperative complications (cardiovascular, pulmonary, fever, nausea and emesis, pruritus, rash), and mortality.

For the main outcomes, evaluation (hospital length of stay and ICU length of stay), Kaplan–Meier survival analyses were performed. Subsequently, the statistical significance between the differences in the survival curves was evaluated using the Log rank test and the Wilcoxon test (Breslow) according to the fulfillment of statistical assumptions. Univariate and multivariate Cox regression models were constructed to establish the strength of association between the intervention and the outcome variable. Those tests with a *p*-value <0.05 were considered statistically significant for all analyses. All analyses were performed in STATA version 16[®] (StataCorp, College Station, TX, USA).

Ethics Statement

This research is considered as research “without risk” in accordance with resolution 8430 of the Colombian Ministry of Health and “minimal risk” research according to the Federal Policy for the Protection of Human Subjects in Research of the United States. This study was approved and monitored by the Institutional Review Board of Fundación Valle de Lili (approval number: 083–2021, Act No. 06 of 2021). The guidelines and recommendations of the Council for International Organizations of Medical Sciences (CIOMS) were considered for all study procedures. Waiver of informed consent for the use of data was requested and accepted.

Results

Eighty participants were included; 40 (50%) corresponded to the CA group and 40 (50%) to the ESPB group. The median age in the study population was 9.5 months (IQR: 4–54), with no statistically significant differences between exposure groups (*p*=0.17).

The median weight for all patients was 7.5 kg (IQR: 4.8–17), and there were marginally significant differences in body surface area between treatment groups (*p*=0.08). In total, 50 (62.5%) participants had some comorbidity in addition to their cardiovascular pathology, with no significant differences between the ESPB group and the CA group (*p*=0.92). Likewise, no significant differences were found between the RACHS-1 classification in the treatment groups (*p*=0.6). And 16.25% of the participants were classified as risk 1 according to the RACHS-1 classification, 50% as risk 2, and 33.75% as risk 3. The median aortic cross-clamp and cardiopulmonary bypass time were 34 minutes and 52 minutes, respectively, with no significant differences between treatment groups (*p*>0.05). Table 1 summarizes the sociodemographic, clinical, and intraoperative characteristics of the study population.

Table 1 Demographic, Clinical and Intraoperative Characteristics of the Study Population

	Overall, n = 80	CA Group, n = 40	ESPB Group, n = 40	p value
Demographic characteristics				
Age (months) mean (SD)	44.49 (62.09)	45.59 (67.03)	43.4 (57.56)	0.17
Age (months)^{†*}	9.5 (4–54)	7.5 (2–72)	15.5 (6–54)	
Gender, n (%)				0.5
Female	45 (56.25)	23 (57.5)	22 (55)	
Male	35 (43.75)	17 (42.50)	18 (45)	
Clinical characteristics				
Weight (kg)^{†*}	7.5 (4.8–17)	6 (3.65–21.55)	9.5 (6.1–15.5)	0.08
Body surface[†]	0.39 (0.282–0.77)	0.33 (0.236–0.95)	0.47 (0.334–0.71)	0.08
Comorbidities, n (%)	50 (62.5)	26 (65)	24 (60)	0.92
Pulmonary	18 (22.5)	9 (22.5)	9 (22.5)	
Renal	4 (5)	0 (0)	4 (5)	
Endocrine	8 (10)	3 (7.5)	5 (12.5)	
Gastrointestinal	15 (18.75)	5 (12.5)	10 (25)	
Neurologic	17 (21.25)	7 (17.50)	10 (25)	
Prematurity	15 (18.75)	7 (17.50)	8 (20)	
Others	31 (38.75)	18 (45)	13 (32.5)	
Surgical procedure, n (%)				0.6
RACHS-I Risk 1	13 (16.25)	5 (12.5)	8 (20)	
RACHS-I Risk 2	40 (50)	20 (50)	20 (50)	
RACHS-I Risk 3	27 (33.75)	15 (37.50)	12 (30)	
Intraoperative variables^{†*}				
Time of cardiopulmonary bypass (minutes) [†]	57 (32–78)	66 (49–85)	52 (29–72)	0.05
Time of aortic arch clamp (minutes) [†]	34 (18–52)	37 (23–56)	32 (15–42)	0.12

Notes: [†]Median (IQR). *p value obtained by the Mann–Whitney U-test.

Additionally, no differences in postoperative vital signs hours were found (see [Table S1](#)). Overall, the median time to extubation in the CA group was 21 hours (IQR: 6–140) versus 6.5 hours (IQR: 3–72) in the ESPB group; however, these differences were not statistically significant ($p=0.12$). The ESPB group had lower opioid consumption than CA group ((Me 1242 $\mu\text{g/kg/48h}$ vs Me 4854 $\mu\text{g/kg/48h}$ ($p=0.0014$)). After classifying patients according to weight, it was found that patients with 6.3 kg or less required higher doses of opioids compared to those with more than 6.3 kg (1388 $\mu\text{g/kg/48h}$ versus 350 $\mu\text{g/kg/48h}$, respectively ($p<0.001$)). There were no complications associated with the ESPB technique, and the rate of adverse events between the ESPB and CA groups was not statistically different ($p=0.5$). Further details are presented in [Tables 2](#) and [3](#).

The Kaplan–Meier analysis showed that patients undergoing ESPB (Wilcoxon Breslow test $p=0.007$) were more likely discharged sooner from the hospital (median of 6.5 days (IQR: 4–11)) compared to the CA group (median of 10.5

Table 2 Comparison of Postoperative Clinical Outcomes Between Therapeutic Groups

Variable	Overall, n = 80, Median (IQR)	CA Group, n = 40, Median (IQR)	ESPB Group, n = 40, Median (IQR)	p value
Global in-hospital stay (days)****	8 (5–17)	10.5 (6–25)	6.5 (4–11)	0.007
ICU stay (days)***	5 (3–10.5)	6 (3–14.5)	4 (2–7)	0.01
Time to extubation (hours)**	17 (5–120)	21 (6–140)	6.5 (3–72)	0.12
Time to first analgesia (hours)** n=26	3 (2–7)	6 (4–18)	3 (2–7)	0.30
Opioid consumption at 48 POP hours (micrograms/kg)** n=57	456.45 (267.94–2706.63)	1041.66 (294.88–8333.33)	378.40 (250.2–534.1)	0.0011

Notes: **p value obtained by Mann–Whitney U-test. ***p value obtained by Wilcoxon (Breslow) test. ****Value obtained by the Log rank test.

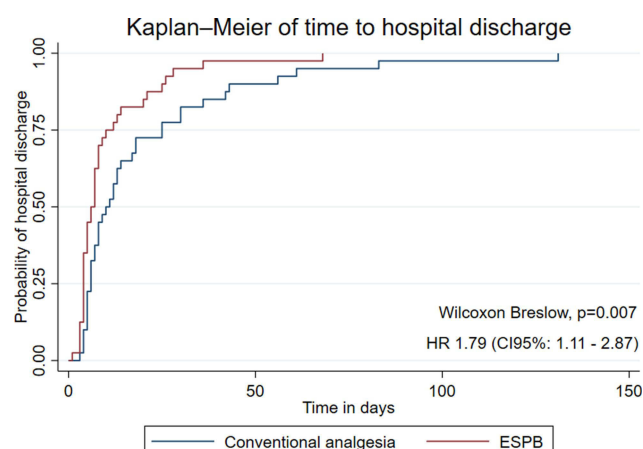
Table 3 Comparison of Postoperative Adverse Events Between Therapeutic Groups

Variable	Overall, n = 80	CA Group, n = 40	ESP Group, n = 40	P value
None	47 (58.75)	22 (55)	25 (62.5)	0.5
Cardiovascular	3 (3.75)	1 (2.5)	2 (5)	
Pulmonary and Pneumonia	8 (10)	4 (10)	4 (10)	
Fever	4 (5)	3 (7.5)	1 (2.5)	
Gastrointestinal	4 (2.5)	1 (2.5)	3 (7.5)	
Bleeding and reintervention	2 (2.5)	1 (2.5)	1 (2.5)	
Electrolytic disturbances	1 (1.25)	1 (2.5)	0	
Tracheostomy and pulmonary	1 (1.25)	1 (2.5)	0	
Cardiovascular and pulmonary	1 (1.25)	0	1 (2.5)	
Cardiovascular and gastrointestinal (NV)	1 (1.25)	0	1 (2.5)	
Cardiovascular and neurologic (convulsions)	1 (1.25)	0	1 (2.5)	
Cardiovascular and urinary	1 (1.25)	1 (2.5)	0	
Cardiovascular, pulmonary and infectious	1 (1.25)	0	1 (2.5)	
Pulmonary and renal or pulmonary with tracheostomy	2 (2.5)	2 (5.0)	0	
Gastrointestinal and pulmonary	1 (1.25)	1 (2.5)	0	
Gastrointestinal and bleeding with blood transfusion	1 (1.25)	1 (2.5)	0	
Reoperation for bleeding control	1 (1.25)	1 (2.5)	0	

days (IQR: 6–25 days)) (see [Figure 1](#)). Bivariate analysis showed that patients in the ESPB group were significantly more likely to be discharged from the hospital during the entire study period than patients in the CA group (HR 1.73, 95% CI: 1.10–2.72). Likewise, when constructing a multivariate model that included type of treatment, RACHS-1 classification risk score, adverse events and the presence of comorbidities, a statistically significant difference was still found (HR 1.79, 95% CI: 1.11–2.87).

Finally, we performed a second Kaplan–Meier analysis to evaluate the impact of ESPB on ICU length of stay, with significant differences in favor of the use of ESPB to reduce ICU length of stay (Wilcoxon Breslow $p=0.02$). When constructing the bivariate model, an HR of 1.75 (95% CI: 1.09–2.80) was found, which remained significant in the multivariate analysis (HR of 1.71 (95% CI: 1.05–2.79)) (see [Figure 2](#) and [Table 4](#)).

We verified compliance with statistical assumptions for the construction of the models, the estimates were not affected by extreme values, and the independence test was verified (see [Figures S1–S4](#)).

**Figure 1** Kaplan–Meier analysis of time to hospital discharge according to the type of analgesic intervention.

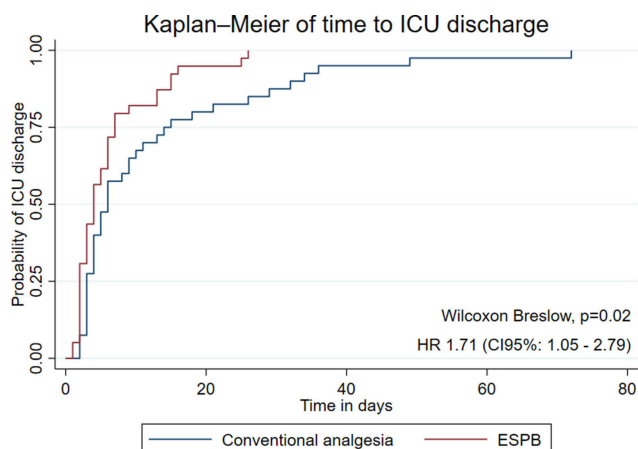


Figure 2 Kaplan–Meier analysis of time to ICU discharge according to the type of analgesic intervention.

Discussion

This study was performed to evaluate the effectiveness of bilateral ESPB in postoperative outcomes after pediatric cardiac surgery through sternotomy in a Latin American cohort. Our hypothesis was based on better pain control, decreased mechanical ventilation time, early feeding, reduction in the effect of pain over respiratory dynamics, prompt ICU discharge, and in-hospital length of stay. The ESPB was associated with reduced hospitalization and ICU length of stay compared with CA. This association, added to the absence of block-related complications, as well as the no difference in the proportion of adverse events compared to the CA group, support the applicability of ESPB in our setting as part of the perioperative management of pediatric patients to facilitate early recovery in cardiovascular surgery.⁸

Table 4 Comparison of Unadjusted and Adjusted Hazard Ratios in Multivariate Cox Regression Models

Variable /Outcome	Hospital Discharge	
	Unadjusted HR	HR*
ESPB group	1.73 (95% CI: 1.10–2.72)	1.79 (95% CI: 1.11–2.87)
Age (months)	1.00 (95% CI: 1.0–1.0)	–
Gender (male)	1.20 (95% CI: 0.75–1.93)	–
Comorbidities	0.50 (95% CI: 0.31–0.82)	0.49 (95% CI: 0.29–0.82)
RACHS-I Classification – Risk 2	0.18 (95% CI: 0.09–0.39)	0.27 (95% CI: 0.12–0.58)
RACHS-I Classification – Risk 3	0.09 (95% CI: 0.04–0.22)	0.17 (95% CI: 0.07–0.39)
Cardiopulmonary bypass (min)	0.99 (95% CI: 0.98–1.00)	–
Opioid consumption (µg/kg)	0.99 (95% CI: 0.99–1.01)	–
Adverse events	0.46 (95% CI: 0.29–0.751)	0.51 (95% CI: 0.30–0.85)
	ICU Discharge	
	Unadjusted HR	HR*
ESPB group	1.75 (95% CI: 1.09–2.80)	1.71 (95% CI: 1.05–2.79)
Age (months)	1.00 (95% CI: 1.00–1.00)	–
Gender (male)	1.27 (95% CI: 0.80–2.01)	–
Comorbidities	0.42 (95% CI: 0.26–0.69)	0.42 (95% CI: 0.25–0.72)
RACHS-I Classification - Risk 2	0.22 (95% CI: 0.11–0.45)	0.31 (95% CI: 0.50–0.65)
RACHS-I Classification - Risk 3	0.13 (95% CI: 0.05–0.28)	0.20 (95% CI: 0.08–0.47)
Cardiopulmonary bypass (min)	0.99 (CI:95%: 0.98–0.99)	–
Opioid consumption (µg/kg)	0.99 (95% CI: 0.99–0.99)	–
Adverse events	0.54 (95% CI: 0.34–0.87)	0.67 (95% CI: 0.40–1.11)

Notes: *Cox regression model using type of treatment, comorbidities, complications, and RACHS-I classification.

Currently, ESPB is being used rarely among surgeries in the pediatric population. Hernández et al¹⁵ performed a single local anesthetic injection in the ESPB at the level of the transverse process of T1 in a 3-year-old boy who underwent resection of a giant parasternal lipoma. This block showed excellent pain control from T2 to T8 dermatomes without compromising hemodynamic stability. Another case report reports the successful use of an ESPB with continuous infusion in a 3-year-old boy with a history of hypoplastic heart syndrome who underwent thoracoscopic diaphragmatic application, obtaining analgesic coverage and excellent postoperative recovery.¹⁶ Kaushal et al¹² and Karacear observed a significantly lower requirement for postoperative opioid doses in pediatric patients undergoing cardiac surgery. Our study did also find a difference in opioid consumption between the study groups, and ESPB group patients had lower consumption of opioids. In Tirotta's study, patients over 6.3 kg were suggested to have bigger opioid consumption.⁵ However, in our study, patients weighing >6.3 kg were found to have lower opioid consumption per kilogram than patients below this point.

Adequate management of perioperative pain decreases the sympathetic response to stimulus.⁴ It is suggested that arterial hypotension in patients undergoing ESPB is due to a sympathetic block by diffusion of the local anesthetic towards the anterior region through the costotransverse foramen, penetrating the thoracic paravertebral space generating blockage of the spinal branches and sympathetic fibers.¹⁷ However, studies such as Kaushal et al¹² and our study did not report hemodynamic changes in patients with ESPB during the first 24 hours (Table S1).

No complications were associated with ESPB in our registry. Anecdotal cases of complications such as pneumothorax, motor block, and local anesthetic intoxication (LAST), apparently due to rapid absorption¹⁸ associated with this procedure, have been described. In a prospective cohort study of bilateral ESPB with catheters, Roy et al reported mild complications associated with catheter insertion, such as mild leakage of the solution and a catheter kinked that did not compromise the administration of the drugs; nevertheless, no other complications were observed.¹² Also, Cassai et al¹⁹ conducted a systematic review of studies, including ESPB in which no complications were reported. However, although the report of zero complications is encouraging, we cannot infer zero risks based on this evidence. Pneumothorax, involuntary motor block, local anesthetic systemic toxicity, hematomas, puncture of organs, injection in the epidural or paravertebral space, and failure of the technique may occur.

Evidence on the use of ESPB in pediatric patients undergoing cardiovascular surgery by sternotomy is limited. In the clinical trial published by Kaushal et al,¹² it was reported that patients undergoing ESPB had shorter ICU length of stay, which is consistent with our results. One of the strengths of our study is that we included length of hospital stay as another outcome of interest, which was not analyzed until Karacaer in a prospective, blinded, randomized controlled study. We found that the length of hospital stay was shorter in patients who underwent ESPB. Despite no differences in ICU and global hospital stay were found by Karacaer et al,²⁰ greater sample size of randomized controlled studies is needed to clarify our results. In addition, the fact that we used Kaplan–Meier analysis and Cox regression models allow us to perform a better adjustment of factors associated with ICU length of stay and hospitalization, considering temporality and event occurrence rate between the ESPB and CA groups.

We found that the ESPB group was almost twice older as the CA group. A study by Agarwal et al in 2014 found that younger patients significantly required prolonged mechanical ventilation. Regardless of these reported results, since we found an apparent difference between the age of the participants included in both groups (ESPB and CA) and considering that age-related physiological changes could play a role in the inflammatory response and recovery processes after surgery, we decided to include age in the multivariate analysis model. However, when adjusting for these variables and other possible confounders, we found no association of age with clinical outcomes, and performing ESPB remained significantly associated with reduced ICU stay and hospital stay.²¹ In addition, in the Roy et al's study, it was reported that patients with bilateral ESPB and continuous infusion of analgesia had adequate pain control, reduced the requirement for opioids at 48 hours and concluded that ESPB is a feasible alternative in patients over 5 years of age.¹² Our study provides similar evidence and information about the safety of ESPB use in younger patients.

Some disadvantages of the study: first, the sample size was relatively small, although no published registry collects this number of cases among this population. Second, as a retrospective design, it may have been a potential for bias in care; for this reason, prospective trials are needed. Third, the pain evaluation during the perioperative period in the pediatric population is still challenging, for this reason, opioid consumption may be considered as an indirect pain evaluation.

Conclusions

In our study, ESPB used in Latin American pediatric patients undergoing moderate- and low-risk cardiovascular surgery according to the RACHS-1 risk category proved to be a feasible alternative for pain management with a reduction in hospital length of stay, ICU length of stay and lower opioid consumption. No differences were found in mortality or in the proportion of postoperative complications or adverse events. Randomized clinical trials including Latin American populations are required to verify the findings of our study before giving a strong recommendation in favor of the performance of ESPB in pediatric cardiovascular surgery.

Abbreviations

ESPB, erector spine plane block; CA, conventional analgesia; EC, extracorporeal circulation; HR, hazard ratio; ERAS, Enhanced Recovery After Strategy; ICU, intensive care unit; LAST, Local anesthetic intoxication; VAS, visual analog scale; NRS, numerical rating scale.

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Disclosure

The authors report no conflicts of interest in this work.

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