RESEARCH PAPER

Ultrasound Guided Erector Spinae Plane Block versus Caudal Block for Pain Relief in Pediatric Patients Undergoing Major Hip Surgeries in Suez Canal University Hospital

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ABSTRACT

Background: Effective pain management in pediatric patients undergoing major surgeries is crucial for ensuring patient safety, comfort, and optimal recovery. The ultrasound-guided Erector Spinae Plane block has emerged as a technique that provides extensive, long-lasting analgesia. The study aimed to evaluate the clinical efficacy of the Erector Spinae Plane block compared to the caudal block in providing pain relief for pediatric patients undergoing major hip surgeries.

Methods: This randomized controlled single-blinded clinical trial was conducted at the operating theatre at a tertiary hospital. Our study population included 50 pediatric patients who underwent major hip surgeries. They were randomized into two equal groups of 25 patients each: the caudal and Erector Spinae Plane groups, following predetermined inclusion and exclusion criteria.

Results: The time to the first request for analgesia was significantly longer in the Erector Spinae Plane Group ($p < 0.001$). The Erector Spinae Plane group had significantly lower FLACC pain scores at 30 and 60 min postoperatively ($p<0.001$). However, pain scores became comparable at 2, 4, 6, and 8 h postoperatively. The Erector Spinae Plane block required less postoperative paracetamol, had quicker recovery times, and reduced hospital stays. The Erector Spinae Plane group had significantly higher patient satisfaction scores than the caudal group ($p=0.04$).

Conclusion: Ultrasound-guided Erector Spinae Plane block was superior to caudal block in post-operative pain control.

Trial registration number: PACTR202511631422162

Keywords: ESPB; Caudal Block; Postoperative Pain; Major Hip Surgeries; Pediatric Surgeries.

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INTRODUCTION

The most prevalent medical issue is postoperative pain. Up to one-third of patients experience moderate to severe postoperative pain (1). In pediatrics, the benefits of efficient postoperative pain management include decreased healthcare costs, quicker recovery, earlier mobility, and improved patient comfort. Following short-stay surgery, adequate control of postoperative pain reduces suffering at home, which is linked to behavioral disruption and longer absence from school. One of the objectives of perioperative anesthetic therapy is to reduce postoperative pain. Pharmacological and interventional perioperative methods are part of postoperative pain management (1).

Children's perceptions of pain vary from those of adults. It may be difficult for pain therapists to distinguish between pain and distress. Moreover, assessing pain severity in children is more difficult than in that in adults. Preoperative evaluation of anxiety, pain, and the effectiveness and safety of analgesic methods and medications in pediatric patients should be the first step in postoperative pain management, as preoperative anxiety is linked to increased pain during postoperative recovery in children (2).

A combination of analgesics, such as acetaminophen (paracetamol), non-steroidal anti-inflammatory drugs (NSAIDs), opioids, and/or local/regional anesthesia, may effectively manage postoperative pain in children. However, the use of these approaches with children is limited due to the high proportion of negative consequences they can induce. The most common side effects include severe motor block, hypotension, and urinary retention (3).

A single injection of Erector Spinae Plane block (ESPB) may cover a large number of dermatomes because of the cranio-caudal distribution of local anesthetics along the fascial plane underneath the Erector Spinae Muscle (ESM). Additionally, local anesthetics may indirectly enter the paravertebral area, where they may block the dorsal and ventral rami of spinal neurons. Also, it can inhibit sympathetic nerve fibers. It is effective in producing broad somatic and visceral abdominal analgesia at the T7-9 levels and thoracic analgesia at the T5 level. There are very few

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instances of ESP block being used in pediatric patients outside the thoracic location. These include inguinal hernia repair, nephrectomy, and laparoscopic cholecystectomy procedures, and only one case report in lower limb surgeries in the juvenile population, which has been shown to provide effective postoperative analgesia (4).

For postoperative analgesia in adult patients undergoing hip and proximal femur operations, Tulgar et al. described a successful ultrasound-guided ESP block performed at the L4 transverse process level (5). Accordingly, this study was conducted to evaluate the analgesic effect after ESPB among children undergoing major hip surgeries.

METHODS

This was a randomized, controlled, and single-blinded clinical trial conducted in the elective orthopedic operating theatre at Suez Canal University Hospitals. The target population was pediatric patients aged 2–7 years, of both sexes, with physical status ASA I–II, who were planned for major hip surgeries. Patients with a history of local anesthetic-related allergic reactions, infection or rash at the injection site, anomaly in the spinal column's anatomy, bleeding disorders, or obesity (BMI [kg/m^2] is 95^{th} percentile or above for children of the same age and sex) were excluded from the study (6).

All the participants were assessed preoperatively for a history of medical conditions, such as congenital illnesses, to evaluate the physical condition of ASA, Previous history of surgery, hospital admission, and blood transfusions. Any history of anesthetic difficulties, hypersensitivity to anesthetic medications, or breathing issues were documented.

Physical examination including vital signs, abdomen, heart, and chest examination was done. Airway assessment, including thyromental distance, neck and tempro-mandibular joint mobility, mouth opening, and Mallampati class were done.

Back examination was done to identify any skin infections at the caudal and ESP block sites.

Laboratory assessment was done including complete blood count, partial thromboplastin time (PTT), prothrombin time (PT) and international normalization ratio (INR).

Ethical committee approval was obtained from the Faculty of Medicine of Suez Canal University. Explanation of the anesthetic technique for parents was done and written informed permission was obtained.

Preoperative instructions for fluid and food fasting were given to the parents to be two hours and six to eight hours respectively.

Using the sealed envelope approach and basic randomization (computerized random numbers), the enrolled patients were divided into two equal treatment groups: ***•Caudal group:*** Children were given caudal block after general anesthesia. ***•ESP group:*** Children were given an erector spinae plane block after general anesthesia.

At the preparation room, Sedation and anxiolysis was achieved within 20 minutes after Intramuscular administration of midazolam at a dose of 0.2 mg/kg, with a maximum dose of 10 mg.

In the operating room, both groups were monitored by Datex ohmeda for noninvasive blood pressure, heart rate, temperature and SPO_2. Intravenous access was secured prior to anesthetic induction. Atropine was administered intravenously at a dosage of 0.02 mg/kg. Sevoflurane was used to induce general anesthesia by inhalation, starting with MAC 8% and ending with 2%. After adequate depth of anesthesia, endotracheal intubation was performed using an endotracheal tube of the appropriate size. End tidal CO2, BIS, and inhalational anesthetic concentration was recorded intraoperatively.

The patient was set on mechanical ventilation (volume-controlled mode). Tidal volume and respiratory rate were adjusted to maintain the end-tidal CO_2 between 30 and 35 mmHg. Anesthesia was maintained using isoflurane MAC 1-2% as directed by Bispectral index (BIS) to be around 40-60. Regional block was performed after the induction of general anesthesia and before surgical incision. The same researcher anesthesiologist performed the whole approach and anesthetic management.

The children were positioned with the surgical side facing up on the lateral side. The ultrasonic probe was sheathed and sterile drape was applied once the skin had been cleaned and sterilized.

The Caudal block Group: After disinfecting the skin, a transverse (axial) ultrasonic probe with a 6 to 13 MHz linear-array transducer (SonoSite Edge, M-Turbo c, fig. 2) was placed. The caudal region was then seen longitudinally by rotating the probe 90 degrees. The image of "teddy bear ears" appeared on the screen because the hyperechoic sacral cornua. The white band between the cornua, known as the sacro-coccygeal ligament, was likewise hyperechoic. Conversely, the sacral hiatus was hypoechoic and located beneath the ligament. The probe was now rotated 90 degrees to produce a longitudinal view.

A local anesthetic injection was used for confirmation. A caudal block using 1 ml/kg of bupivacaine 0.25%, with a maximum dosage of 20 ml, was administered (2).

The ESP block: The probe was positioned 1 cm from the midline in a parasagittal plane, and the block's level was the transverse process of L2. The sacrum was counted upward to determine the L2 level. A 22G echogenic needle (blue cannula needle) was inserted using aseptic method in a cephalad to caudal direction until the (L2) transverse process struck. The needle was then cautiously removed in the plane between the transverse process and the ESM fascia. By injecting 0.5–1 ml of saline, the proper placement of the needle tip was confirmed. A bolus of 1 ml/Kg bupivacaine 0.25% was administered under LA distribution vision (2).

The same team of surgeons operated on patients with developmental dysplasia of the hip (DDH) in both groups.

Fluid treatment was maintained as follows (7): The first 10 kg of child weight was 4 ml/kg/h, while the subsequent 10 kg of child weight was 2 ml/kg/h. The remaining kg of the child weighed 1 ml/kg/h. Ringer lactate solution was used to replace the third space loss, which was approximately calculated to be 2-4 ml/kg/h. Every 1 ml blood loss was replaced with 3 milliliters of Ringer lactate solution.

Intraoperative administration of intravenous paracetamol 15 mg/kg as an analgesic was guided by a rise in bispectral index (BIS) > 60.

At the end of surgery, awake extubation was done after closure of inhalational anesthesia. Children were moved to the post- anesthesia care unit (PACU). Follow-up of hemodynamics (BP, HR, RR) during 24 hours postoperatively was done. Paracetamol 15 mg/kg each dosage, every 4–6 hours, with a daily maximum of 60 mg/kg, was administered on-demand analgesics.

Primary outcomes measures included: a) The time of first postoperative analgesia request, b) evaluation of pain intensity at different time points following surgery using the FLACC score (8). (A: Activity, C: Cry, L: Legs, F: Face, and C: Consolability score), and c) the total amount of analgesic required for each patient 24 hours after surgery.

Secondary outcome measures included: a) The amount of time required to complete each block, b) The C-reactive protein, total leukocyte count, differential leukocyte count (neutrophils and lymphocytes and neutrophil-to-lymphocyte ratio, or NLR), and platelet-lymphocyte ratio in peripheral blood (pre-block baseline and 12 hours postoperatively) are indicators of inflammatory stress reactions, c) hemodynamics were recorded intraoperative and at PACU's, including heart rate, systolic and diastolic blood pressure, and mean arterial pressure. Then six, eight, twelve, and twenty-four hours after surgery, d) the duration of hospitalization, the time to recover milestones to fully conscious, the frequency of postoperative complications and adverse effects like postoperative nausea and vomiting, urinary retention, ileus, and respiratory depression that can postpone discharge, e) The amount of intravenous paracetamol required for analgesia, f) The overall amount of isoflurane used. Molecular weight divided by 2412 x density (dialed concentration x fresh gas flow x duration at that concentration) where iso density = 1.5 (6) and iso MW = 184, and g) Using a 5-point rating system, the overall parental satisfaction score 24 hours after surgery was obtained using a scale ranging from very satisfied to very dissatisfied with a score ranging from 5 to 1, respectively.

Sample size calculation:

The sample size is calculated from results of a pilot study using the following equation (9):-

$$n = 2\ SD^2\ (Z\alpha + Z\beta)^2 / \Delta^2$$

Where: - n = the number of the subject of each group.

Zα = the value of standard normal distribution for p value 5% for one sided test = 1.64.

Zβ=the value of a standard normal for the desired statistical power 90% and it equals 1.28

Δ = the detectable difference between the means of postoperative 24-Hr paracetamol consumption in children with developmental dysplasia of hip (DDH) between caudal block combined with general anesthesia [228.6 mg] and erector spinae block combined with general anesthesia [151.7 mg] it equals 76.9 mg

SD = the highest within group standard deviation 87.6

By calculation: n = 22.1284. An expected drop out of 10% was added. So, there should be about 25 patients for each group.

RESULTS

Fifty- seven pediatric patients were assessed for eligibility. Two patients did not meet the inclusion criteria and five patients, their parents declined to participate. Fifty patients were divided randomly into either Caudal Block or ESPB, 25 participants in each group (Figure 1).

Table 1 displays the demographic information for the study groups. Age, weight, and BMI did not significantly vary between caudal block group and ESPB group (P value > 0.05). Furthermore, there was no discernible change in the ASA categorization (p=1.000). There was no statistically significant difference between the two groups in terms of sex.

There were no appreciable differences between both groups in the baseline hemodynamic changes and the post-induction period prior to the block (SBP, DBP, and MAP). Likewise, there were no appreciable changes between the two groups at the time of the surgical incision or after the block. At 30, 60, 90, and 120 minutes, ESPB group SBP, DBP, and MAP levels were consistently lower than the caudal block group (P value < 0.05). Baseline readings and post-induction readings prior to the block did not demonstrate any significant differences between both groups (P value > 0.05). The heart rate in the caudal block group was substantially greater than ESPB group at 30 minutes, 60, 90, and 120 minutes (p<0.001 each) (Figure 2). There were no statistically significant differences between both groups in terms of intra-operative BIS measurements at any stage throughout the procedure (P value > 0.05).

Table 2 demonstrates that both groups differed significantly in terms of block duration, with caudal block group mean block time being longer than ESPB group (p<0.001). There was no discernible difference in the two groups' total isoflurane consumption (p=0.693). Neither group's patients required an intravenous dosage of paracetamol for analgesia during surgery.

There were no discernible differences between both groups in terms of the postoperative pain scores (FLACC) starting at 30 minutes till 6 hours (P value > 0.05). At 8, 12, and 24 hours, pain levels in the caudal block group were considerably greater than the other group (P value <0.05). Both groups were comparable in the level of inflammatory stress mediators (CRP, TLC, neutrophils, lymphocytes, neutrophil-to-lymphocyte ratio ratio), at base- line and 12 hours after surgery (P value > 0.05).

There were no significant changes in postoperative systolic and diastolic blood pressure, HR, and mean arterial pressure measurements between both groups (P value > 0.05).

Compared to ESPB group, the caudal block group needed a much larger dosage of paracetamol after surgery (p<0.001). Additionally, it took the ESPB group a considerably longer time than the caudal block group to get rescue analgesia during surgery (p<0.001). However, all groups began oral intake at the same time after surgery, and there was no discernible difference in the time to oral intake (p=0.140).

The caudal block group stayed in the hospital for a considerably longer period of time than the other group (p=0.049) (Table 3).

There were no discernible differences between the two groups in terms of postoperative problems (P value > 0.05).

Regarding parental satisfaction, both groups differed significantly in terms of the satisfaction levels. With a p-value of 0.04 and a mean satisfaction score of 4.36 ± 0.76, ESPB group outperformed the caudal block group, which scored 3.95 ± 0.72.

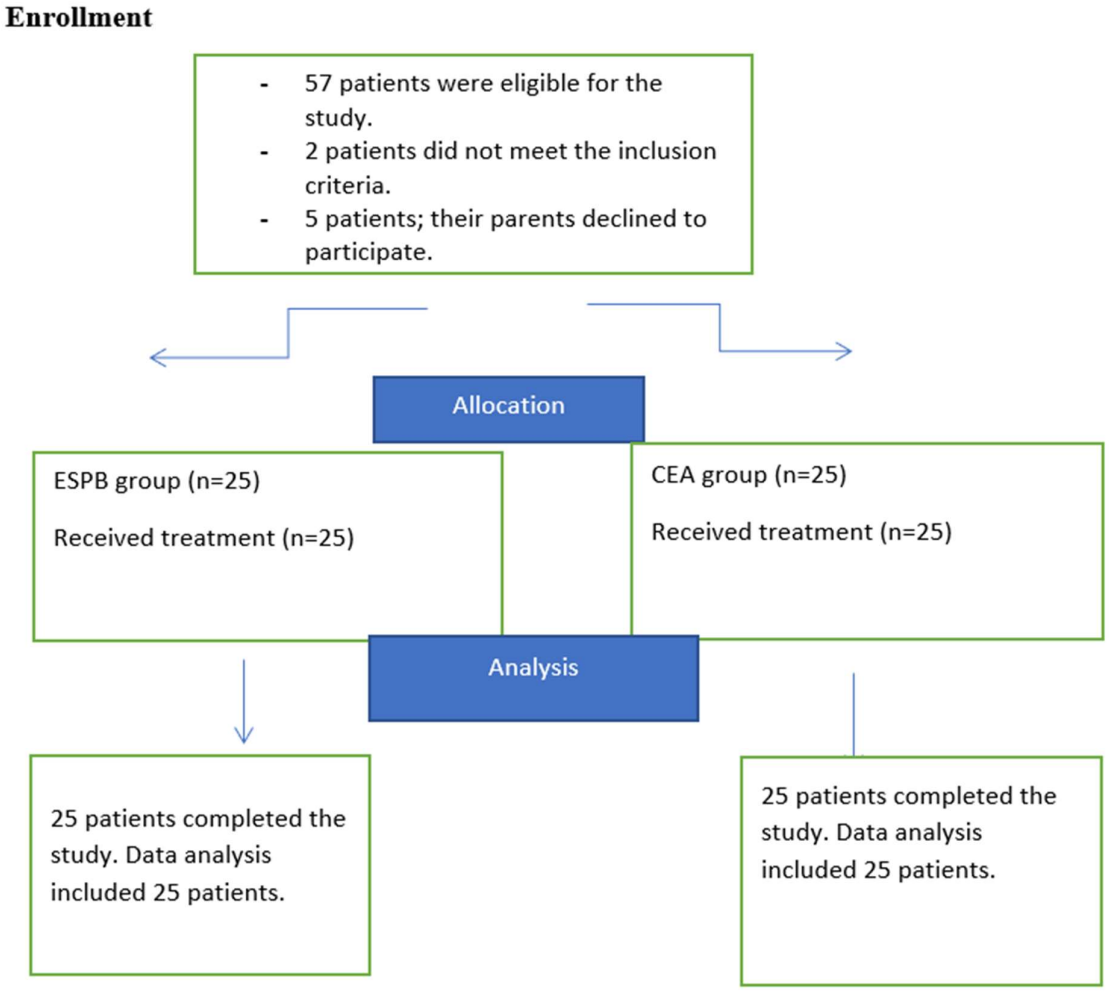

Figure 1. Patients' flow chart Flow chart: Consolidated Standards of Reporting Trials (CONSORT) flowchart. ESPB: erector spinae plane block, CEA: caudal epidural anesthesia.

Table 1. Demographic data of study groups and duration of surgery (min).

Variables		Caudal block group	ESPB group	Test, p-value
		n=25	n=25	
Age (years) Mean ± SD		4.35 ± 1.43	3.67 ± 1.71	t: 1.532, p=0.132
Weight (kg) Mean ± SD		16. 16 ± 3.67	16.80 ± 3.09	t: 1.762, p=0.508
BMI (kg/m^2) Mean ± SD		15.26 ± 0.47	15.09 ± 0.33	t: 1.428, p=0.160
Duration of surgery(min) Mean ± SD		125.40 ± 8.77	125.00 ± 10.40	t: .147, p=0.884
ASA (%)	**I**	25(100.0%)	24(96.0%)	X2: 0.000, p=1.000
	II	0(0.0%)	1(4.0%)	
Sex (%)	**Male**	2 (8.0%)	3 (12.0%)	X2: 0.222, p=0.637
	Female	23 (92.0%)	22 (88.0%)	

Table 2. Block time (min) and total isoflurane consumption (ml)

	Caudal block group	ESPB group	Test, p-value
	n=25	n=25	
Block Time (min) Mean ± SD	8.56 ± 1.61	6.92 ± 1.32	t: 3.939, p<0.001*
Total Isoflurane Consumption (mL) Mean ± SD	20.14 ± 6.64	20.93 ± 7.45	t: 0.397, p=0.693

t: Student t test, * for significant p value (<0.05)

Table 3. Post-operative outcomes in the study groups.

	Caudal block group	ESPB group	Test, p-value
	n=25	n=25	
Total Paracetamol Dose in first 24hrs post-operative (mg) Mean ± SD	1020 ± 300	510 ± 230	t:3.288, p<0.001*
First requested analgesic (Hours post-operative) Mean ± SD	6.70 ± 1.40	18.76 ± 5.17	t:-11.250, p<0.001*
Time to Oral Intake (hours) Mean ± SD	4.39 ± 1.17	3.95 ± 0.98	Z: 1.484, p=0.140
Length of Stay (days) Mean ± SD	2.10 ± 0.48	1.79 ± 0.65	Z: 1.979, p=0.049*

t: Student t test, Z: Mann Whitney test, * for significant p value (<0.05)

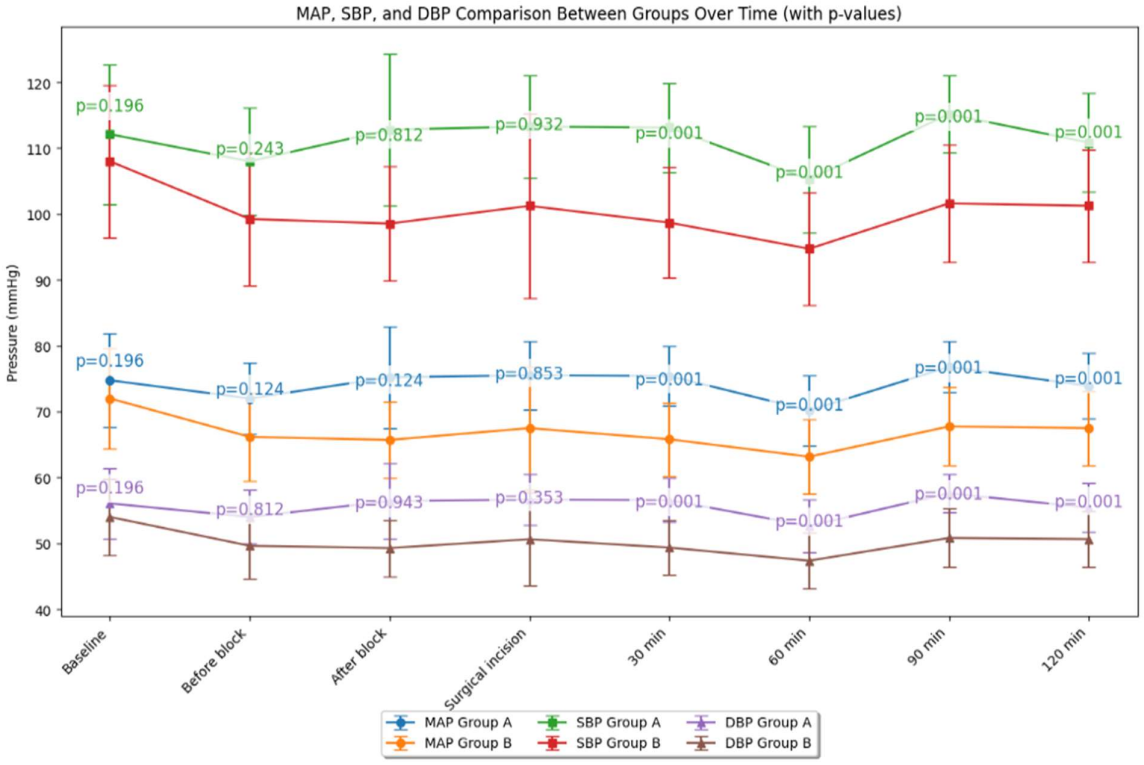

Figure 2. Intraoperative blood pressure changes in the study groups.

DISCUSSION

Our study's findings demonstrated the effectiveness of both caudal and ESP blocks, as they both significantly reduced intraoperative pain together with hemodynamic stability that was superior to ESP block. Additionally, neither group required intraoperative intravenous paracetamol doses, indicating that both blocks had a good analgesic effect and controlling pain. In terms of statistically significant analgesia and post-operative pain management, ESP block outperformed caudal block.

Mean arterial pressure, SBP, DBP, and HR all showed hemodynamic stability throughout the procedure, outperforming ESP block. These measurements showed a slight drop from baseline following the induction of

anesthesia due to the effects of the anesthetic drugs, followed by a slight increase following block administration. These readings remained steady throughout the procedure, indicating the effectiveness of both blocks in controlling intraoperative pain and hemodynamic stability, as supported by a previous study (10).

Contrary to these results, Elshazly et al (11), discovered that the hemodynamics were similar in the two groups, but for MAP being greater in the ESPB group than in the caudal group. Additionally, Abotaleb et al (12). discovered that caudal block was associated with lower HR and MAP than ESP at 45, 60, and 75 minutes as well as after the conclusion of operation ($P < 0.05$). This may be explained by the vasodilator effect of caudal block.

Furthermore, Bansal et al (3). examined the analgesic effects of caudal epidural block and ultrasound-guided sacral erector spinae plane block in juvenile patients having hypospadias surgery. They discovered that at various points in time, the two groups' mean HR, SBP, and DBP were similar.

Mean arterial blood pressure, SBP, DBP, and HR did not vary statistically between the caudal group and the ESP group in terms of post-operative hemodynamic parameters. This is consistent with the findings of Abotaleb et al (12) that the post-operative hemodynamic parameters (MAP and HR) in the study groups were statistically insignificant.

According to the current research, the caudal group required considerably more time to complete the block than the ESP group. This difference in time might be attributed to the placement and the two views (longitudinal and transverse) that were acquired during the caudal block.

The results of Elshazly et al (11), who claim equal procedural durations for giving both blocks, are at odds with the study's findings of substantial disparities in block time between the two groups. This discrepancy may result from the fact that, in our research, the whole process time was recorded, while in theirs, the procedure time was recorded after obtaining the ultra-sonography image in both blocks.

In different research, Abotaleb et al (12) examined the effectiveness of caudal block and ultrasound-guided lumbar erector spine plane block for postoperative pain management in 50 children lower limb procedures. They discovered that the caudal group's block performance time was substantially less than that of the ESP block group.

Our study demonstrated that neither the caudal nor the ESP groups required intraoperative intravenous paracetamol. This suggests that both caudal and ESP blocks are effective in controlling intraoperative pain, and it may be because of the effective block in both groups.

There was no significant difference in the two groups' total isoflurane intake, suggesting that both groups' intraoperative anesthetic requirements were comparable. In their research comparing ESP block with caudal block in pediatric patients undergoing unilateral inguinal hernia, Kart et al (7) found that the total inhalational consumption of the two groups was almost same.

When we compared the BIS of the two groups at various intervals throughout the procedure, we did not find any statistically significant differences between them, which agreed with previous results (7).

ESPB Group FLACC scores were considerably lower than caudal Group's at 8, 12, and 24 hours after surgery. This showed that although both blocks provide effective, comparable analgesia in the first six hours after surgery, ESP offers superior, longer-lasting pain management beyond six hours. Also, another researcher found that the ESPB group had a lower early post-operative FLACC score than the caudal Block group, and both groups' FLACC scores were significantly lower than the control group (13). This was confirmed by Bansal et al (3). Other studies reported that erector spinae plane block produced better postoperative analgesia than caudal block (6, 14, 15). The variable results reported by different studies would be attributed to the different dose of local anesthetic injected as well as the timing of block performance.

However, these results contradicted the main finding of Elshazly et al (11), who showed that in pediatric patients undergoing hip or proximal femur surgery, the analgesic effect of the ESPB was not superior to that of caudal epidural analgesia. The longer time to first rescue analgesia and lower FLACC scores in the early postoperative period in the CEA group suggested that CEA provided a better analgesic effect. The reason for this might be because they injected bupivacaine 0.25% at a dosage of 0.5 ml/kg, which is less than the amount used in the research, which injected bupivacaine 0.25% at a dose of 1 ml/kg.

Erector spinae block patients recovered significantly faster and spent less time in the hospital than the caudal block group. The effectiveness of ESP block in managing pain after surgery explains this. This was in line with Bansal et al, as the ESP group had a quicker recovery and hospital stay than the caudal group (3).

In terms of parent satisfaction, the ESP group had a statistically significant higher satisfaction level than the caudal group. Guan et al.'s research (14) revealed that although parent satisfaction in the ESPB and caudal block was comparable, it was much higher in the ESPB than in the control group. Conversely, Pandey et al (1) examined 50 children following abdominal surgery and contrasted ESPB with caudal epidural block. The caudal block group's median parental satisfaction levels were statistically higher than those of the ESPB group. Nonetheless, the median parental satisfaction score for both groups at the assessed timeframes ranged from 7 to 8, indicating that parents of both groups were happy with the pain reduction.

Strengths and limitations: There were a number of restrictions on our research. First, dermatomal assessment of the block impact was not possible since all of our blocks were conducted under general anesthesia. Second, subjective (although verified) pain measures were used to evaluate postoperative analgesia. In addition to pain, other variables such as hunger or temperature may also cause a kid to have a higher FLACC score. Finally, this research was limited to a single location and only included a certain patient demographic and surgical technique. Therefore, more analysis is necessary to ascertain if the results are generalizable.

There were no significant variations in the groups' levels of inflammatory stress mediators. This is because both blocks are effective in controlling pain, which reduces the impact of pain on the body's inflammatory stress response. In contrast to conventional anesthetic methods, ESP blocks did not substantially change inflammatory markers, according to research by Kot et al (16) who examined its use in a variety of surgical situations.

CONCLUSION:

Ultrasound-guided ESP block was superior to caudal block in post-operative pain control. Nonetheless, both blocks provide comparable early postoperative pain management and intraoperative hemodynamic stability. The ESP block group showed improved parent satisfaction and a shorter hospital stay.

Conflict of interest: None

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