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Comparison of conventional caudal block, ultrasound guided caudal block and ultrasound guided erector spinae block for pediatric hip surgery: A randomized double blinded study

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Abstract
Background: For these individuals, paediatric regional anaesthesia seems to be a preferable option for enhancing acute pain control with fewer side effects. The aim of this work was to compare the safety and efficacy of ultrasonography-guided caudal block (UC), conventional caudal block (CC), and erector spinae plane block (ESPB) for controlling pain following paediatric hip surgeries.
Methods: This prospective randomized controlled double blinded study was carried out on 105 children who had been scheduled for elective unilateral hip surgeries. After general anesthesia induction, patients were categorized into three groups; Group I: received CC utilizing 0.5ml/kg plain bupivacaine 0.25%, Group II: received UC utilizing 0.5ml/kg plain bupivacaine 0.25%, Group III: received US guided ESPB using 0.5ml/kg plain bupivacaine 0.25% at L2 level.
Results: Time to first rescue analgesic demand was substantially longer in group ESPB than groups CC and UC. Total consumption of tramadol was substantially reduced in group ESPB than groups CC and UC. Total paracetamol consumption, block performing time, side effects, success rate and parents' satisfaction were insignificantly different among the three groups. FLACC (Face, Legs, Activity, Cry, Consolability) scale in ESPB group was significantly decreased than CC group at 4h and UC group at 4h but was substantially increased in group ESPB than group CC at 8h and UC group at 8h.
Conclusions: In cases undergoing pediatric hip surgery, ESPB produced adequate analgesia that was comparable to CC and UC blocks with prolonged postoperative analgesia and less postoperative opioid consumption with more stable hemodynamic and low side effects.

Keywords: Caudal block, erector spinae block, ultrasound, pediatric hip surgeries

Introduction
Regardless of using systemic opioids, surgical hip repair in children is linked with significant postoperative pain and may be exceedingly severe [1, 2]. Perioperative pain management in pediatric population including distraction, cognitive behavioral therapy, conscious and deep intravenous sedation, local, regional, and dissociative anesthesia [3].
In order to give postoperative as well as intraoperative analgesia by impacting the area between the dermatomes T10 and S5 in procedures below the umbilical level, caudal epidural block became an extensively utilized regional anesthetic technique, particularly in pediatric surgery [4, 5].
When performing a traditional single-shot caudal block, there's a chance that the needle will puncture the dura or a blood vessel as it moves through the sacral canal. Bulging of soft tissue, intraosseous injections, and systemic toxicity are additional complications. [6, 7].
The sacral cornua and sacral hiatus have both been implicated in many anatomical variants. Consequently, different studies have reported various degrees of success with the traditional caudal epidural anesthesia in pediatrics. [8].
As it helps to visualize the sacral hiatus, epidural space, sacrococcygeal ligament (SCL), and the local anesthetic (LA) agent distribution within the epidural space, the use of ultrasonography in regional anesthesia has many benefits. Consequently, this substantially improves block success [9].
However, there is a considerable high rate of side effects including postoperative vomiting, nausea, retention of urine, severe motor block, and pruritus that restrict the utilization of caudal block (either conventional or ultrasound method) in pediatrics. [10].

For these individuals, regional anesthetic procedures appear to be a superior option for enhancing acute pain control with fewer side effects. Erector Spinae Plane block (ESPB), initially proposed by Forero *et al* 2016 [11] as analgesics for thoracic neuropathic pain, has additionally been documented for the treatment of additional sources of acute postoperative pain [11, 12]. By applying LA between the transverse process of the thoracic vertebra and the erector spinae muscle, this ultrasonography (US)-guided approach spreads the LA cephalad, caudally, and into the paravertebral area [12, 13].

Numerous publications have noted achievements with surgery on the thorax in adults. [11], surgery on the abdomen [13] and orthopaedic procedures [14]. Because of their prospects for safety and relative ease of placement when compared to neuraxial techniques, regional pediatric anesthesiologists have chosen ESPB. However, there aren't many specific ESPB-related case reports involving pediatrics. [15, 16]. As far as we aware, there haven't been many studies contrasting the ESPB to other regional pediatric procedures.

This research aimed to evaluate the safety and efficacy of US-guided ESPB, UC block, and CC block in the control of pain following surgeries on the hip in pediatrics.

Materials and Methods

This prospective randomized controlled double blinded study was performed on 105 children, their age varies between 4 and12 years of both sexes, possessed a physical status I or II determined by the American society of anesthesiologists (ASA), who had a planned elective unilateral hip surgery.

After receiving approval from the Ethical Committee Tanta University Hospitals, the research was carried out (approval code: 33143/05/19) and registered at clinicaltrials.gov (ID: NCT04712370). The children's parents provided signed, informed permission.

Criteria of exclusion were the presence of severe systemic disease, prior neurological or spinal conditions, clotting issues, history of preterm delivery, infection at the injection site for the block, prior LA allergies, and bilateral hip surgeries.

Preoperative evaluation

All patients had a medical history review, physical examination, and basic laboratory tests, including a coagulation profile. Parents were advised to keep their children fast from solid meals for six hours and from clear liquid for two hours.

Randomization and blindness

Randomization had been done by computer generated random numbers. The random number was placed in an opaque envelope. The patient guardians and outcome assessors were blinded.

Patients were categorized in to three equal groups in a parallel manner: Group I: received conventional caudal block (CC), Group II: caudal block administered with ultrasonography guidance, Group III: ESPB was performed using ultrasound guidance at the level of the L2's transverse process. The blocks were done after induction of general anesthesia using 0.5ml/kg plain bupivacaine 0.25% (Hospira, Inc) (maximum dose 2.5 mg/kg, 20 mL).

Intraoperative

On entering operating room, routine monitoring that includes ECG, noninvasive blood pressure (NIBP), pulse oximetry, capnogram and temperature probe were used.

To produce anaesthesia, a facemask containing 7-8% sevoflurane was used, 100% oxygen until the patient became anesthetized. A peripheral intravenous line was established using a 22G cannula. During the procedure, Ringer's acetate was administered at a rate of 5 mL/kg/h.

1mg /kg propofol was given over 20-30 s for children to deepen the level of anesthesia then fentanyl 1 µg/kg (Hospira, Inc) was administered. Endotracheal intubation with proper sized endotracheal tube was facilitated with Atracurium 0. 5mg/kg.

End-tidal expiratory sevoflurane (2%), a combination of oxygen and air (50-50%), was used to sustain the anaesthesia state. Atracurium (0.1 mg/kg) was administered as needed in gradual dosages to maintain muscle relaxation throughout the operation. End tidal carbon dioxide (ETCO2) was maintained at a level of around 35 mm Hg by adjusting the ventilator's parameters.

Ultrasound machine (Phillips®, Cx-50, Amsterdam, Netherlands) with a Superficial probe 5-12 MHz was used in two groups (US-guided erector spinea block and US-guided caudal block). Patients were positioned laterally (with the surgical side up in the ESPB group).

Conventional caudal block

Both the sacral hiatus and cornus had been palpated. Sterilization of the area was followed by the insertion of a 22-gauge needle at a 60-80-degree angle into the skin till the SCL was pierced, which was verified by a sensation of popping. In order to penetrate into the sacral canal, the needle's angle was subsequently lowered to 20 to 30 degrees and its insertion depth was raised by 2 to 3 mm. Under strict hemodynamic and monitoring of ECG, the LA solution containing a precalculated dose (0.5ml/kg) of 0.25% bupivacaine was injected over the course of one minute after ensuring there was no blood or cerebrospinal fluid present.

Ultrasound-guided caudal block

The transverse ultrasound probe was positioned at the midline and covered with a sterile plastic cover and gel, the sacral hiatus was visualised at the level of the sacral cornus using the superficial probe at 5-12 MHz, and the gain and depth were set up for optimal visual quality. First, the ultrasound transducer was positioned to get a transverse view of the sacral bone, sacral hiatus, SCL, and both cornua. The ultrasound transducer was positioned between the two cornua at this level after being rotated 90 degrees to acquire longitudinal images of the SCL and sacral hiatus. On the upper third of the SCL, a 22-gauge echogenic needle (Sonoplex, Pajunk, Germany) had been advanced. The needle progress was stopped as soon as it reached the SCL. After aspirationally determining there is no blood or cerebrospinal fluid. During monitoring a US longitudinal view, LA solution with a precalculated dosage (0.5ml/kg) of 0.25% bupivacaine was administered over the course of one minute. Figure 1

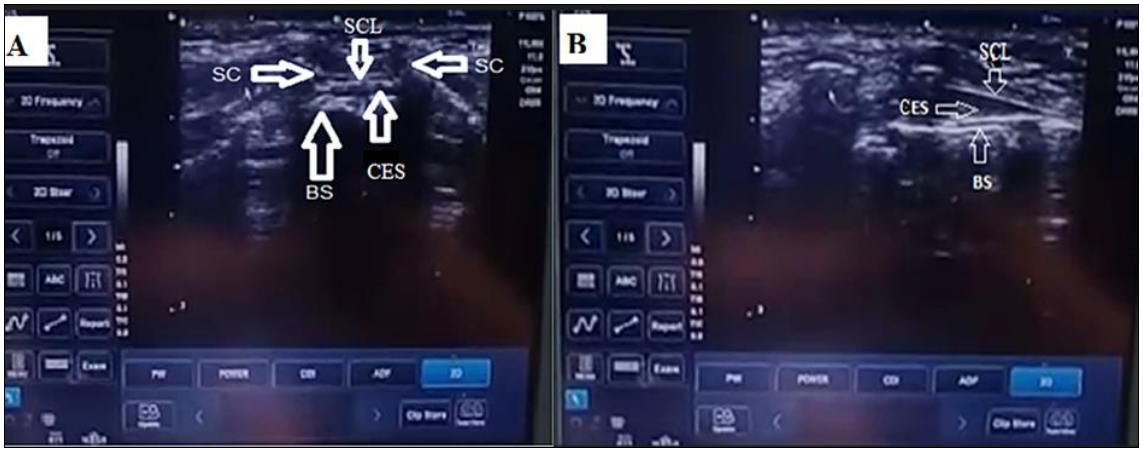

Fig 1: US-guided caudal block a) transverse view b) longitudinal view. BS, base of sacrum, CES=caudal epidural space, SC: Two sacral cornu, SCL=sacrococcygeal ligament

ESPB

At the level of the sacrum, a superficial (5-12 MHz) ultrasonography transducer was positioned longitudinally 1-2 cm lateral to the midline. We counted up from the sacrum and found the L2 level. An echogenic 22 G needle (Sonoplex, Pajunk, Germany) was punctured deep to the erector spinea muscle with a direction cranio-caudal after the transverse process and erector spinae muscle had been identified. The administration of 0.5-1ml LA followed a negative aspiration. Bupivacaine (0.25%) was administered into the interfascial plane between the transverse process and the erector spinea muscle at a precalculated dose (0.5ml/kg) of. When the injectate was administered beneath the erector spinea muscle, it spread linearly and freely (caudally and cranially), demonstrating successful blockage. Figure 2.

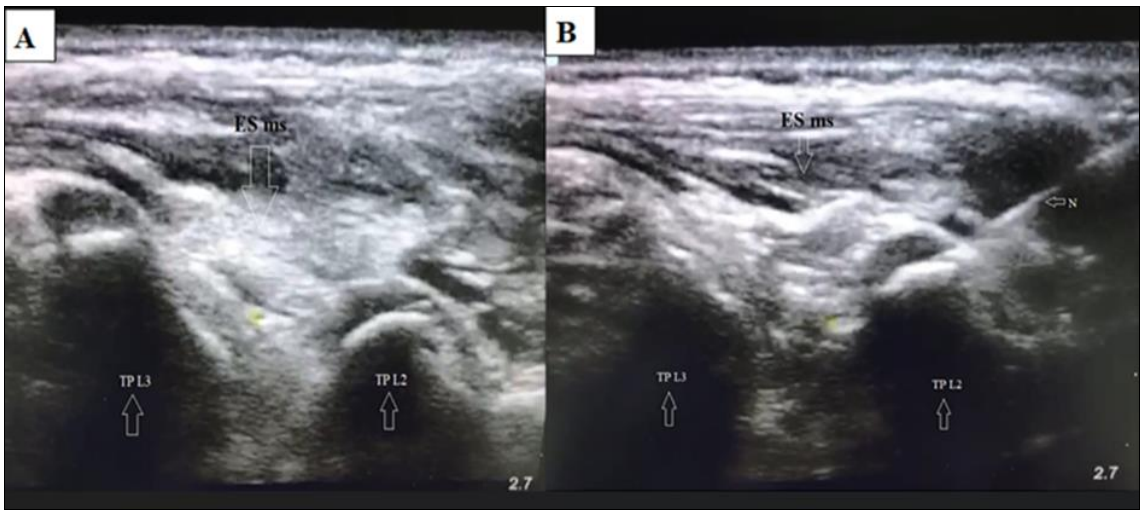

Fig 2: Ultrasound guided ESPB a) image for the transverse process at L2vertebrae (TP L2), b) needle visualization at transverse process (TP L2), ES ms=erector spinea muscle, N=needle, TP L3=transverse process of L3)

All surgical procedures were done by the same surgery team who was qualified and expert in these types of operations.

By the completion of the procedure when the patient obtained adequate tidal volume, a mixture of 0.01 mg/kg atropine and 0.04 mg/kg neostigmine was taken to oppose the impact of the muscle relaxants and extubating was performed then the patient was transferred to the recovery room. Shooting of the hemodynamic parameters (elevate in heart rate (HR) or mean arterial pressure (MAP))) during surgery over 20% from the baseline would mean failure of block performance and necessitated administration of intravenous (IV) opioid analgesic in the form of fentanyl (1 µg/kg).

The participants were admitted to Post-Anesthesia Care Unit (PACU). IV administration of 15 mg/kg paracetamol if FLACC score (Face, leg, activity, cry, consolability) between 2 and 4 within time interval of 6 hours with maximum daily dose 60mg/kg. Tramadol (Amriya Pharma)1 mg/kg (IV) in case of FLACC score > 4 at the initial 24 h following surgery.

Postoperatively, FLACC scale was assessed as primary outcome but time to first rescue analgesia, total analgesic consumption, success rate of the block, block performing time, complications occurrence (Bradycardia (HR less than 65 b/ min) Hypotension (MAP decreased by ≥ 20 % from the baseline reading), local anesthetic systemic toxicity (LAST)) and degree of parents' satisfaction (3-point scale; 1= unsatisfied, 2= neither satisfied nor unsatisfied, 3= satisfied) were secondary out come

Statistical analysis

The Statistical Programme for Social Sciences, Version 25

(IBM Inc., Chicago, IL, USA) was used to conduct the statistical study. Histograms and the Shapiro-Wilks normality tests were utilised to examine the quantitative data' distribution. Utilizing the F test and the post hoc (Tukey) test, parametric data were reported as mean and standard deviation (SD) and compared across the three groups. Non-parametric data were presented as median and interquartile range (IQR), and they were compared using the Mann-Whitney (U) test and analysed utilising the Kruskal-Wallis test. Categorical data were statistically analysed using the Chi-square test and presented as frequency and percentage. Statistical significance was defined as a two-tailed, P value ≤ 0.05.

Results

Thirty people failed to satisfy the qualifying requirements for this study's 148 participants, while 13 individuals declined to take part. The remainder of 105 individuals were divided into three groups, each with 35 individuals. The 105 participants were all followed up and statistically analysed. Figure 3.

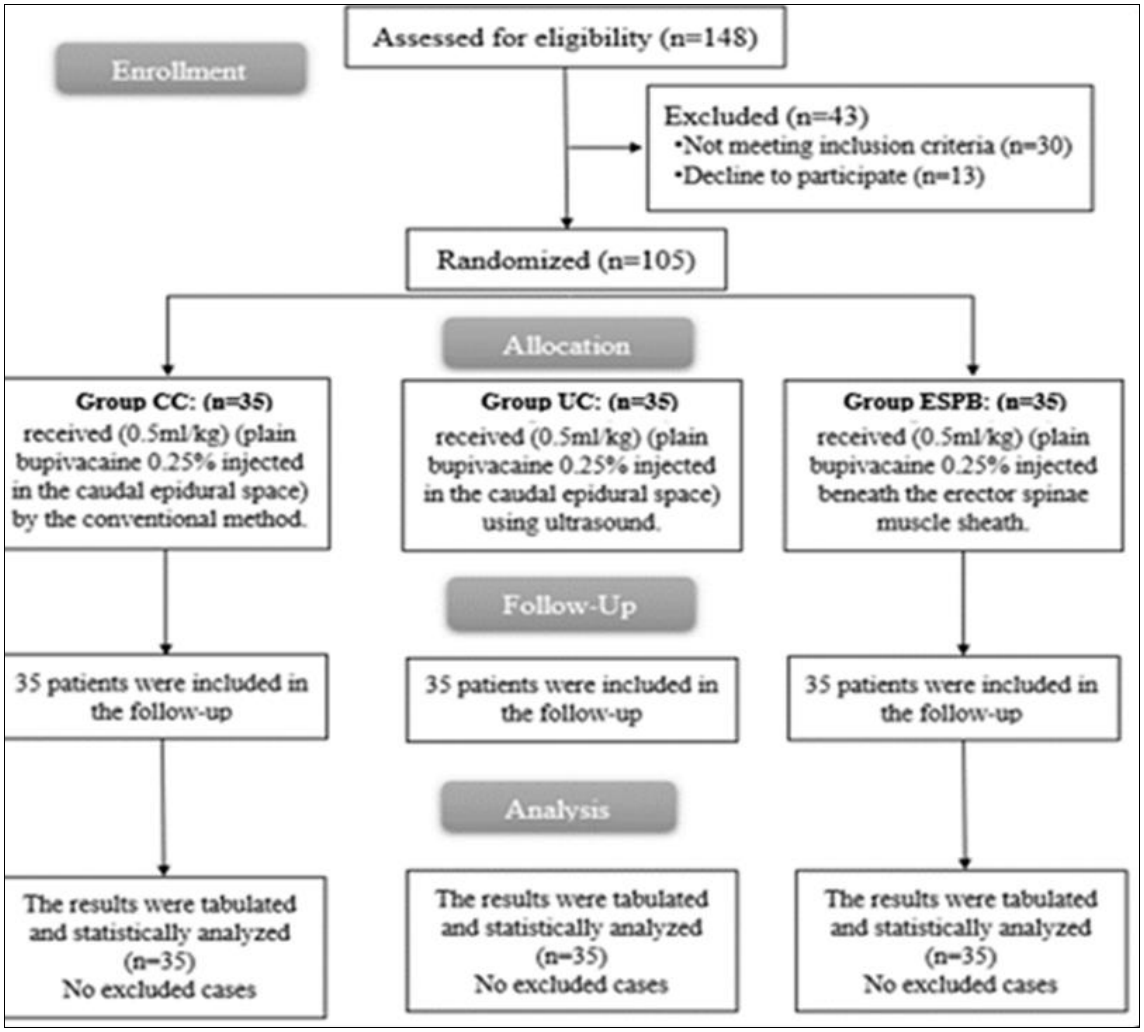

Fig 3: CONSORT flowchart of the enrolled patients

The demographic data were insubstantially variation among groups. Table 1

Table 1: Patient's demographic data among the three groups.

		Group CC (n = 35)	Group UC (n = 35)	Group ESPB (n = 35)	P value
Age (years)		6.83 ± 2.31	6.51 ± 2.24	7.46 ± 2.06	0.196
Sex	**Male**	20 (57.1%)	14 (40%)	17 (48.6%)	0.889
	Female	15 (42.9%)	21 (60%)	18 (51.4%)	
Weight(kg)		28.29 ± 8.37	27 ± 9.26	31.29 ± 10.02	0.143
Height (m)		1.10 ± 0.14	1.07 ± 0.15	1.16 ± 0.16	0.060
BMI (kg/m^2)		22.99 ± 2.02	22.75 ± 1.8	22.61 ± 2	0.715
Type of hip Pathology	DDH	37 %	31 %	29 %	0.629
	Septic arthritis	33 %	34 %	37 %	
	Perth's disease	13 %	22 %	20 %	
	Slipped capital femoral epiphysis	17 %	13 %	14 %	
Surgical duration(min)		90.71 ± 16.4	91.66 – 17.58	86.97± 18.66	0.501

Data are presented as Mean ± SD or frequency (%). BMI: Body mass index, DDH: Developmental dysplasia of the hip.

Intraoperatively, the HR and MAP were insubstantially variation between the three groups. Postoperative HR and MAP were insubstantially various at PACU, 2, 6, 12, 18 and 24 hours and were significantly decreased in group ESPB contrasted to group CC and group UC at 4h (P_2 =0.017, P_2 = 0.01 respectively) and UC group at 4h (P_3 =0.029, P_3 = 0.031respectively) with significant increase in group ESPB compared to group CC at 8h (P_2 =0.012, P_2= 0.004 respectively) and UC group at 8h (P_3 =0.033, P_3=0.006 correspondingly). Figure 4.

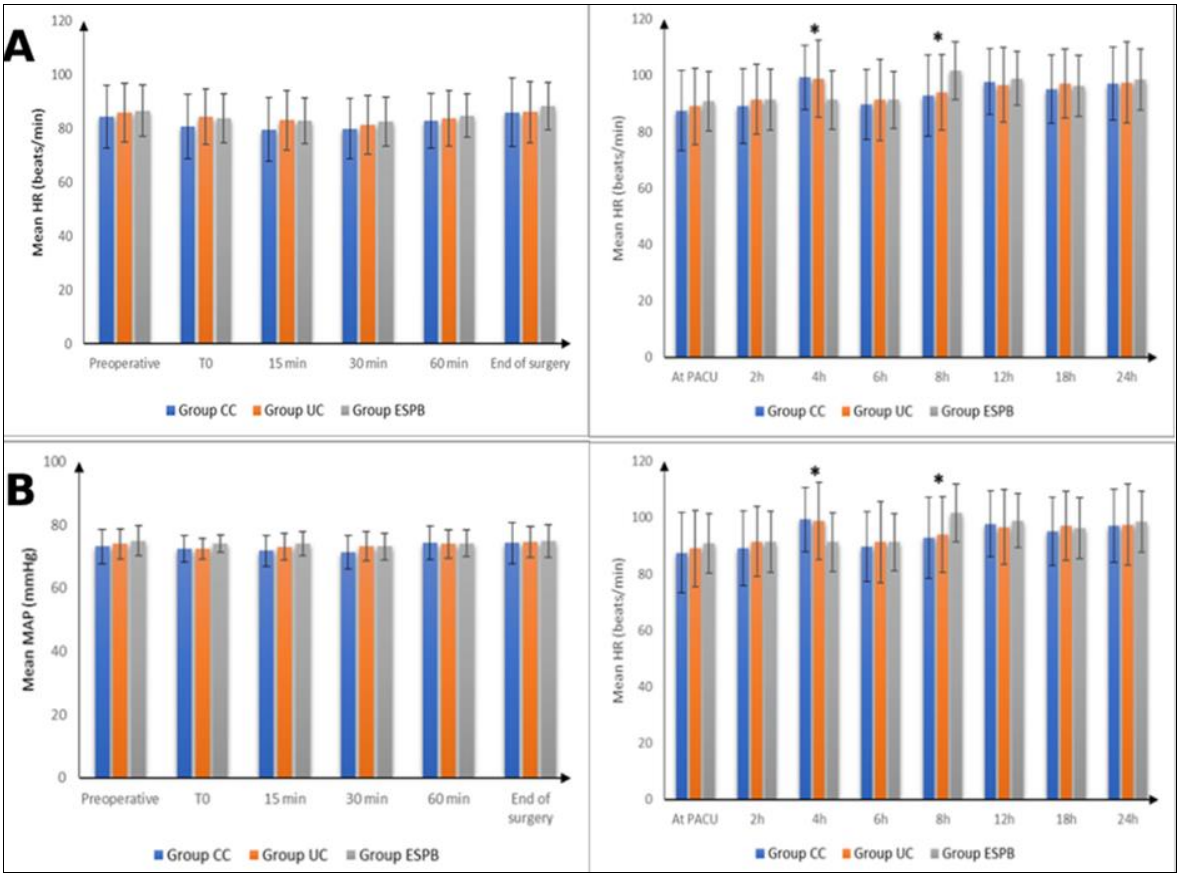

Fig 4: Heart rate (HR) and mean arterial pressure (MAP) among the three groups (A) intraoperative (B) postoperative

FLACC (Face, Legs, Activity, Cry, Consolability) scale was insignificantly different at PACU, 2, 6, 12, 18 and 24 hours with significant decrease in ESPB group than CC group at 4h (P2<0.001) and UC group at 4h (P3<0.001) but was substantially increased in group ESPB than group CC at 8h (P2<0.001) and UC group at 8h (P3<0.001). Figure 5.

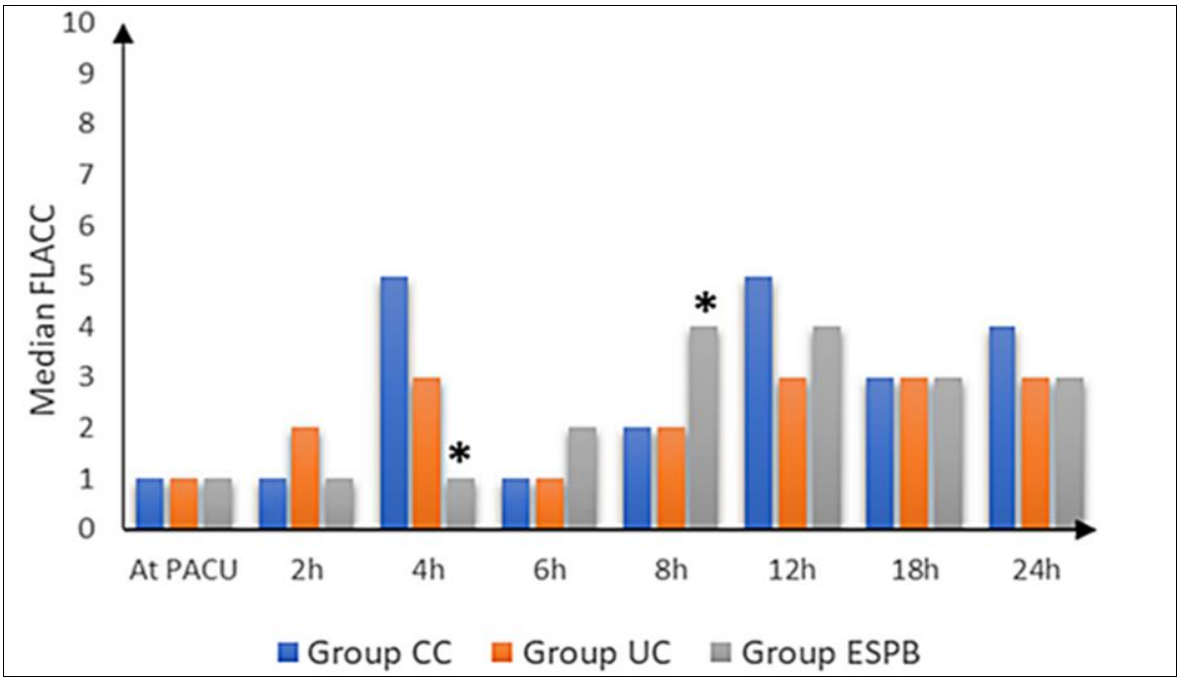

Fig 5: Face, Legs, Activity, Cry, Consolability (FLACC) scale changes among the three groups

Time to the first rescue analgesic demand was substantially longer in group ESPB than groups CC and UC (P2<0.001, P3 <0.001 respectively) and was insignificantly different between groups CC and UC**.** Total tramadol consumption was significantly lower in group ESPB than groups CC and UC (P2<0.001, P3< 0.003 correspondingly) and was insubstantially various among groups CC and UC. Total paracetamol consumption, success rate and block performing time, were insignificantly various among the three groups. Table 2.

Table 2: The analgesic data among the participants under the study

		Group CC (n = 35)	Group UC (n = 35)	Group ESPB (n = 35)	P-value
Time to first rescue analgesic hour		4.29 ± 1.18	4.54 ± 1.17	8.77 ± 2.25	*p* <0.001* P1 = 0.776, P2 <0.001*, P3 <0.001*
Total tramadol Consumption mg		68.06 ± 23.31	61.69 ± 30.61	39.69 ± 28.21	*p*<0.001* P1 = 0.599, P2 <0.001*, P3 = 0.003*
Total paracetamol Consumption mg		777 ± 314.66	735.86 ± 401.12	922.71 ± 282.63	0.055
Block performing time min		3.31 ± 0.76	3.74 ± 0.78	3.51 ± 0.66	0.055
Success rate	Successful	32 (91.4%)	33 (94.3%)	33 (94.3%)	0.858
	Unsuccessful	3 (8.6%)	2 (5.7%)	2 (5.7%)	

Data are presented as Mean ± SD or frequency (%). * *p*<0.05 was statistically significant. P1: P value between groups CC and UC, P2: P value between groups CC and ESPB, P3: P value between groups UC and ESPB.

Side effects and parents' satisfaction were insubstantially variation between the three groups. Table 3.

Table 3: Side effect and patients' satisfaction among the participants under the study

		Group CC (n = 35)	Group UC (n = 35)	Group ESPB (n = 35)	P-value
Side effects	Bradycardia	2 (5.7%)	2 (5.7%)	1 (2.9%)	0.796
	Hypotension	2 (5.7%)	1 (2.9%)	1 (2.9 %)	0.758
	PONV	3 (8.6%)	2 (5.7%)	1 (2.9%)	0.588
	Urinary retention	2 (5.7%)	1 (2.9%)	0 (0%)	0.357
	LAST	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Parents' satisfaction	Unsatisfied	3 (8.6%)	2 (5.7%)	2 (5.7%)	0.766
	Neither satisfied nor unsatisfied	5 (14.3%)	4 (11.4%)	2 (5.7%)	
	Satisfied	27 (77.1%)	29 (82.9%)	31 (88.6%)	

Data are presented as Mean ± SD or frequency (%). PONV: postoperative nausea and vomiting LAST: Local anesthetic toxicity. * *p*< 0.05 was statistically significant.

Discussion

Numerous advantages of regional anaesthesia have been demonstrated, including quicker recovery times, increased functional status, a reduction in post-operative vomiting and nausea, and shorter hospital stays. [17]. Caudal block is still a feasible choice for postoperative analgesia, although it does have some limitations, including the bilateral motor and sensory blocking that may prevent early postoperative ambulation and may delay physical rehabilitation.

Ultrasound-guided ESPB is a technique of peri-paravertebral regional anaesthesia in which local anaesthetic has been noticed from the point of injection towards 3 vertebral levels cranially and 4 levels caudally. [18]. ESPB is supposed to have epidural spread and block the posterior, anterior, ventral, and lateral abdominal and thoracic walls by blocking the ventral and dorsal rami of the abdominal and thoracic spinal nerves and to promote visceral analgesia [18, 19].

Our study demonstrated that there was insubstantial difference among the three groups as regard HR, MAP intraoperative but there was an early significant rise in HR and MAP postoperatively in caudal groups compared to ESPB. FIACC score was significantly higher after 4 hours in both caudal groups compared to ESPB lead to early rescue analgesia demand in caudal block either CC or UC compared to ESPB so tramadol consumption in patients who received ESPB was significant less than patients who received CC or UC, Since ultrasound preparation time was not taken into account when evaluating block performing time, it was comparable across groups and parents' satisfaction was insignificantly different among the three groups.

Our results are supported by Mostafa *et al*. [20] who reported that intraoperative MAP and HR were smilar between control and ESP block group but MAP and HR values for 1st 2 hours postoperative were reduced in the ESP block group than the control group. Abd Ellatif and Abdelnaby [21]. Who noted that the MAP and HR were insignificantly different at all measurements between QLB and ESPB groups. Similar to our findings, Salim *et al*. [22] who observed that the intraoperative MAP and HR were insubstantially various among caudal and QLB groups. But the postoperative HR and MAP were substantially increased in caudal block group than anterior QL block group at 6 and 8h, postoperative morphine consumption in the first 24 h was substantially reduced in anterior QL group contrasted to caudal group moreover patient satisfaction score was insignificantly different between both groups. A recent randomized clinical trial by Abdelrazik *et al*. [23] revealed that although both groups were fewer than the control

group, the early postoperative FLACC rating was reduce in the ESB group compared to the CB group. Our findings are supported by Abduallah *et al.* [24] who reported that the use of ESPB considerably increased the time it took for the initial demand for rescue analgesia if contrasted with the control group. Moreovere Gupta *et al.* [25] found that FLACC was insignificant difference at 2 hours compared to FLACC at PACU in case of chest wall tumor excision received the ESP block. However, FLACC was significantly higher at 6, 12, 18 and 24 hours as compared to FLACC at PACU.

Abdelrazik *et al.* [23] observed that The ESB group had lower analgesia overall than the CB group. Lower abdominal surgery is less invasive than hip surgery, which might account for the little discrepancy with our findings. Ciftci *et al.* [26] found that In comparison to the sham block group, consumption of fentanyl postoperatively was substantially reduced in the ESPB group ($p< 0.001$).

Our findings are consistent with Tulgar *et al.*'s findings [27] that the control group's consumption of tramadol over the first 12 hours was considerably greater than that of the L-ESPB and QLB-T groups.

Our results are supported by Abd Ellatif and Abdelnaby [21]. Who noted that the block's performance time in ESPB group was 5.64±0.66 min since ESPB is an easy block. Moreover, Moustafa *et al.* [28] noticed that Compared to the paravertebral block group, the ESPB group's mean time to conduct the regional anaesthesia procedure was much shorter. In the current research, bradycardia, hypotension, PONV and urinary retention were insubstantially various between the three groups. LAST didn't occur in any patient.

In agreement with our findings, Abduallah *et al.* [24] concluded that no substantial variation was existed between ESPB and control groups as regard complications. In contrast to our findings, Narasimhan *et al.* [29] stated that there were no complications in his study, and this may be because of the limited sample size in both groups PVB and caudal.

In the present research, parents' satisfaction was insubstantially varied among the three groups. Even though the patients receiving ESPB had lower postoperative consumption of tramadol and an improved pain score, this could be clarified through the subjective nature of individual satisfaction, which was influenced by additional variables than just pain.

Abduallah *et al.* [24] and El-Maghraby *et al.* [30] who concluded that the satisfaction of parents was insubstantial among the ESPB and control groups.

The study had some limitations such as the sample size in a single centre was rather small. For a brief period, there was not much patient follow-up. The limited duration of analgesia is due to single injection techniques rather than using catheter insertion technique. Further studies with different additives, concentrations and volume of local anesthetics, are required.

Conclusions

In cases undergoing pediatric hip surgery, US-ESP block produced adequate analgesia that was comparable to CC and UC blocks with prolonged postoperative analgesia and less postoperative opioid consumption with more stable hemodynamic and low side effects.

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Conflict of interests: None to be declared.

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