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Original Article

Comparison of ultrasound-guided pudendal nerve block and caudal epidural block for postoperative analgesia in children undergoing hypospadias repair: A randomized controlled trial

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Abstract

Objectives: This study aims to determine whether ultrasound-guided pudendal nerve block (USG-PNB) provides improved postoperative analgesia compared to caudal epidural block (CEB) in children undergoing hypospadias repair.

Patients and methods: This prospective, randomized, parallel-group, double-blind comparative trial included 40 male children (mean age: 5.92±2.73 years; range, 2 to 12 years) with American Society of Anesthesiologists physical status I or II who were scheduled to undergo hypospadias repair under general anesthesia between March 2023 and January 2024. Participants were randomly allocated (1:1) to either the PNB group, receiving ultrasound-guided PEB (0.3 mL/kg^{-1} of 0.25% bupivacaine), or the CEB group, receiving CEB (1 mL/kg^{-1} of 0.25% bupivacaine) following induction of anesthesia. The primary outcome was the proportion of patients requiring additional analgesia within the first 24 h after surgery. Secondary outcomes included postoperative pain scores and total 24-h analgesic consumption.

Results: In the first 24 postoperative hours, 80% of children in the PNB group required rescue analgesia compared to 15% in the CEB group (p<0.001). Pain scores were significantly higher in the PNB group at 12 and 18 h but did not differ between groups at 0 h, 30 min, 6 h, or 24 h. Total postoperative analgesic requirement was also significantly greater in the PNB group (p<0.001).

Conclusion: In pediatric patients undergoing hypospadias repair, CEB provided longer-lasting postoperative analgesia, reduced analgesic requirements, and greater surgeon satisfaction compared to USG-PNB. Although previous studies have reported favorable outcomes with nerve stimulator-guided PNB, only limited evidence supports improved analgesia with USG-PNB. Since bilateral blockade is required, and the block is technically challenging when performed with ultrasound alone, the success rate may be enhanced by combining ultrasound with nerve stimulator guidance. In our view, USG-PNB should be reserved for high-volume centers with substantial expertise in this technique to ensure reliable analgesia, optimize operating room efficiency, and conserve theatre time.

Keywords: Caudal epidural block, hypospadias, postoperative analgesia; pudendal nerve block.

Regional anesthesia is frequently combined with general anesthesia (GA) in children to provide perioperative analgesia and reduce opioid requirements.[1] Among these techniques, caudal epidural block (CEB) remains the most widely used. However, peripheral nerve blocks are associated with fewer side effects than neuraxial techniques and are increasingly being adopted, particularly with the availability of ultrasound, which has made them more feasible, safer, and reliable.

The pudendal nerve, arising from the sacral plexus (ventral rami of S2-S4), provides motor and sensory innervation to the pelvic floor, perineum, and external genitalia.[1,2] Pudendal nerve block (PNB) at this level achieves analgesia of these regions and, when combined with GA, may serve as an effective component of multimodal perioperative

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analgesia in children undergoing hypospadias repair. Despite these advantages, PNB remains underutilized, likely due to technical difficulty, perceived risk of injury to critical structures, and limited training opportunities. Consequently, caudal blocks continue to be more commonly employed.[3]

Because the pudendal nerve is a mixed nerve, a nerve stimulator can be used to facilitate its precise localization. Several earlier studies have compared nerve stimulator-guided PNB (NSG-PNB) with caudal epidural block (CEB) in children undergoing hypospadias repair, with mixed results. With the advent and widespread availability of ultrasound, ultrasound-guided PNB (USG-PNB) may offer improved accuracy and higher success rates. We hypothesized that USG-PNB would provide superior postoperative analgesia, with a lower proportion of children requiring additional analgesics within the first 24 h compared to CEB. Hence, the aim of this study was to compare the analgesic efficacy of USG-PNB and CEB in pediatric patients undergoing hypospadias repair, using the proportion of patients requiring additional analgesia within the first 24 h after surgery as the primary outcome measure.

PATIENTS AND METHODS

This randomized, parallel-group, double-blind, comparative trial was conducted with children with American Society of Anesthesiologists (ASA) physical status I or II scheduled for hypospadias repair at Maulana Azad Medical College and associated Lok Nayak Hospital between March 2023 and January 2024. Exclusion criteria were severe developmental or communication disabilities affecting pain assessment, allergy to study drugs, and contraindications to CEB or PNB, including bleeding or coagulation disorders, vertebral abnormalities, neurological disorders, and local infection at the injection site. Forty-six patients were assessed for eligibility. Four patients declined participation, and two did not meet the inclusion criteria; one had a dimple at the base of the spine, and one had local infection at the caudal block site. Forty male children (mean age: 5.92±2.73 years; range, 2 to 12 years) were enrolled and randomly allocated to the CEB and PNB groups, with 20 patients in each group. No patient was lost to follow-up (Figure 1). Written informed consent was obtained from parents or legal guardians of all participants, and verbal assent was additionally obtained from children older than seven years. The study protocol was approved by the Maulana Azad Medical College and Associated Hospitals Ethics Committee (Date: 29.08.2022, No: F.1/IEC/MAMC/MD/MS (92/04/2022/232), and the trial was prospectively registered with the Clinical Trials Registry of India (CTRI/2022/12/048187). The study was conducted in accordance with the principles of the Declaration of Helsinki. The manuscript followed the CONSORT (Consolidated Standards of Reporting Trials) guidelines for randomized controlled trials.

On the morning of surgery, children were randomly assigned in a 1:1 ratio to one of two study groups: the PNB group or the CEB group. The randomization sequence was generated using a computer-based random number table. Group allocation was performed by opening a sealed, opaque envelope immediately before surgery by an anesthesiologist not otherwise involved in the trial. On the day of surgery, each child (or the child's parent/guardian) selected one of the sealed envelopes under the supervision of the investigator.

A standardized anesthetic technique was used for all patients. Children were fasted according to the ASA guidelines and premedicated with oral midazolam 0.5 mg/kg administered 30 min before surgery. In the operating room, standard monitoring was applied, including electrocardiography, noninvasive blood pressure (BP) measurement, and pulse oximetry. General anesthesia was induced with either intravenous propofol 2-3 mg/kg or inhaled sevoflurane, followed by intravenous fentanyl 1 µg/kg and vecuronium. A ProSeal laryngeal mask airway (Teleflex Medical, Morrisville, NC, USA) of appropriate size was inserted, and anesthesia was maintained with oxygen in nitrous oxide and sevoflurane. All patients received intravenous dexamethasone 0.1 mg/kg. Thereafter, children underwent either PNB or CEB according to group allocation.

The assigned block (PNB or CEB) was performed after induction of GA by an anesthesiologist not involved in subsequent intraoperative care or postoperative assessment. Parents, surgeons, and personnel responsible

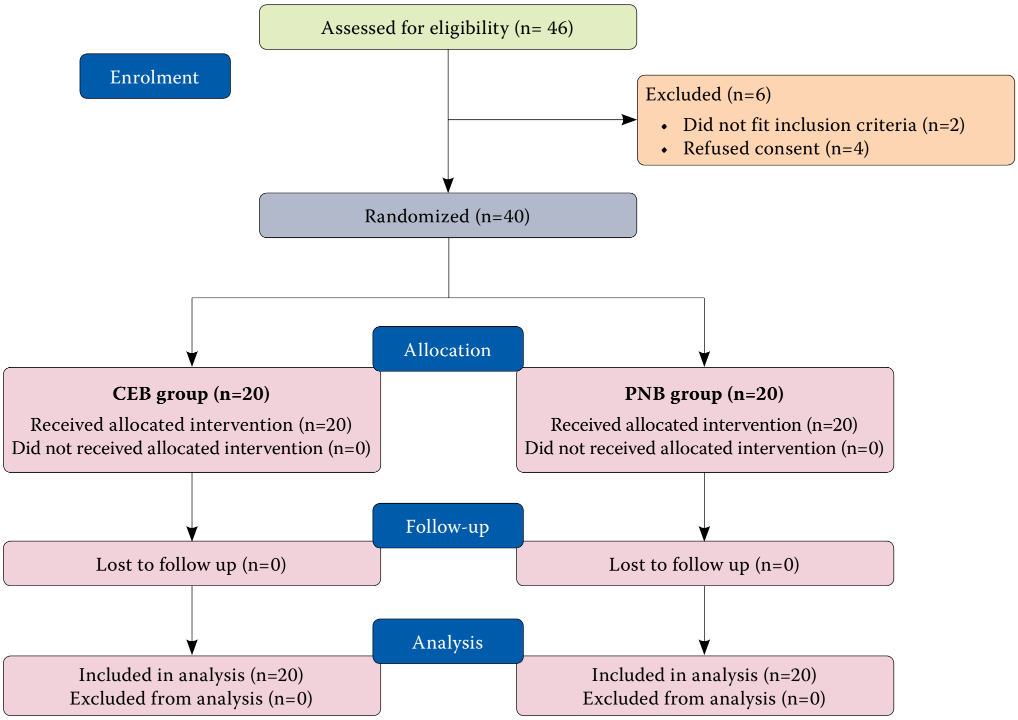

Figure 1. Consolidated Standards of Reporting Trials flowchart of subject enrolment.

PNB: Pudendal nerve block; CEB: Caudal epidural block.

for data collection remained blinded to group allocation. To maintain double blinding, all children underwent aseptic preparation at both block sites, and adhesive bandages were applied to the caudal and pudendal regions regardless of the block performed.

All blocks were performed by an anesthesiologist experienced in ultrasound-guided regional anesthesia. Children in the PNB group underwent the block in the lithotomy position with an assistant supporting the knees. Two injection points were identified at the 3- and 9-o'clock positions, approximately 2 to 2.5 cm lateral to the anus. Ultrasonography was performed in the transverse plane using a curvilinear transducer to visualize the ischium forming the lateral body of the sciatic notch. The probe was then moved caudally until the ischium appeared straighter and transitioned into the ischial spine. At this level, the pudendal artery and nerve were identified medial to the ischial spine (Figure 2). A total of 0.3 mL/kg^{-1} of 0.25% bupivacaine was injected, divided equally between the left and right sides. Children in the CEB group received CEB in the left lateral decubitus position with 1 mL/kg^{-1} of 0.25% bupivacaine. The time required for block performance, from skin preparation and draping to completion of injection, was recorded.

Intraoperatively, BP and heart rate (HR) were recorded at predefined intervals: prior to block performance (T0), prior to incision (T1), 2 min after incision (T2), 10 min after incision (T10), 20 min after incision (T20), and subsequently at regular intervals. Following surgical incision, an increase in HR or mean arterial pressure (MAP) of >20% above baseline was first managed by ensuring adequate anesthesia depth. If the response persisted, it was considered indicative of inadequate analgesia, and intravenous fentanyl 0.5 μg/kg was administered. The total intraoperative fentanyl requirement was recorded.

Toward the end of surgery, all patients received intravenous paracetamol 15 mg/kg. After reversal of neuromuscular blockade and once the child was awake, the ProSeal laryngeal mask airway was removed, and the patient was transferred to the postanesthesia care unit (PACU).

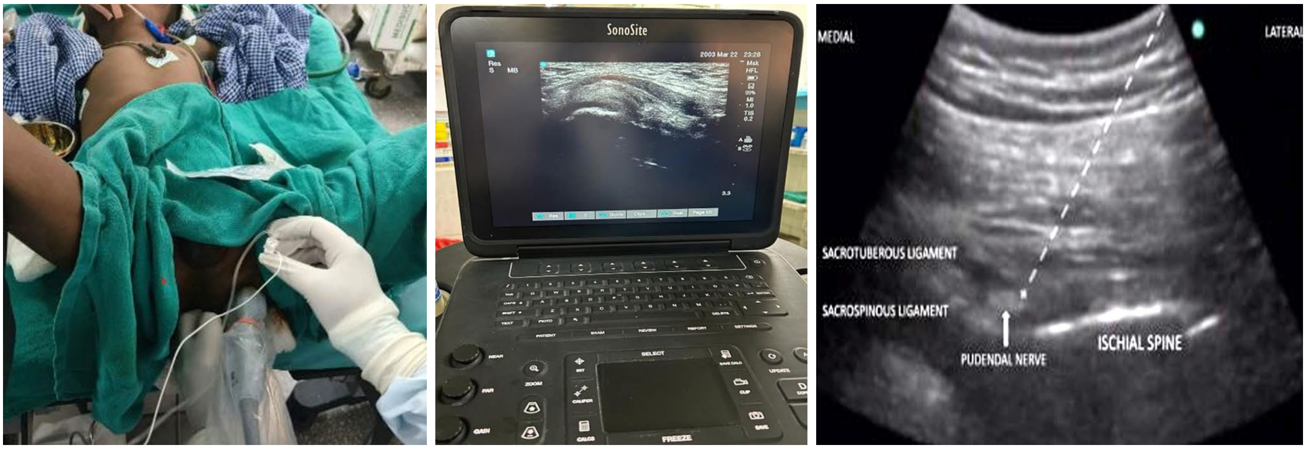

Figure 2. Ultrasound-guided pudendal nerve block image.

Postoperative pain was evaluated using the modified Objective Pain Scale (OPS) developed by Hannallah and Broadman.[3-5] This scale is based on five variables: mean arterial BP, movement, agitation, crying, and position of the child. These variables were assessed with three grades (0= none; 1= moderate; 2= severe) to give a cumulative score ranging from 0 to 10 points (Table 1).

Scores were assessed on arrival in PACU, after 30 mins, and then every 6 h till 24 h postoperatively. If the OPS pain score was 2 to 3, paracetamol syrup or tablet (15 mg/kg) was given to the child. If the OPS pain score ≥4, an injection of tramadol 1 mg/kg with ondansetron 0.1 mg/kg was administered. Time to requirement of first postoperative analgesic and consumption of additional analgesia over 24 h were noted.

Motor block was assessed in the PACU and then every 30 mins till complete motor recovery by using a modified 4-point Bromage scale (0= flexion of knees and feet; 1= flexion of knees; 2= movement of feet only; 3= no movement of knees or feet).[5] Younger children who could not move their legs on command were stimulated by tapping or a gentle pinch on the legs and feet. Both parents' and surgeons' satisfaction were assessed after 24 h using a 3-point Likert scale (1= unsatisfied; 2= partially satisfied; 3= satisfied).[5] Surgeons' satisfaction was based on the overall intraoperative and postoperative experience of the surgeon. Parents' satisfaction was based on their child's comfort and activity. Any complications such as pain or swelling at the injection site were noted.

The primary outcome was the proportion of patients requiring additional analgesia within the first 24 h after surgery. The secondary outcomes included postoperative pain scores and the total postoperative analgesic consumption during the first 24 h.

TABLE 1

The modified objective pain scale

Parameters	None (0 point)	Moderate (1 point)	Severe (2 points)
MAP	±10% preoperative value	>20% preoperative value	>30% preoperative value
Movement	No movement	Restless	Vigorous thrashing
Agitation	Calm or asleep	Mildly agitated	Extremely agitated
Crying	No crying	Crying but consolable	Crying and inconsolable
Position	Normal posture	Flexing legs & thighs	Holding hands to the neck

MAP: Mean arterial pressure; Pain scores interpretation; 0-1 mild pain, 2-3 mild pain, ≥4 moderate to severe pain.

TABLE 2
Characteristics of included studies

	PNB group (n=20)		CEB group (n=20)		
Variables	n	Mean±SD	n	Mean±SD	*p*
Age (year)		5.92 ± 2.6		5.92±2.9	1.000*
2-5	11		10		
6-9	7		6		0.673
10-12	2		4		
Weight (kg)		19.55±8.07		17.42±6.03	0.351*
Height (cm)		115.62±15.08		115.35±16.81	0.957*
ASA class					
I	20		20		-
II	0		0		

PNB: Pudendal nerve block; CEB: Caudal epidural block; SD: Standard deviation; * Independent t test, + Using χ^2 test; ASA: American Society of Anesthesiologists.

Statistical analysis

Based on an earlier study,[5] sample size calculations assumed postoperative analgesic requirement of 20% in the PNB group and 70% in the CEB group, with an alpha of 0.05 (two-sided) and 80% power. The z-approximation yielded n≈12 per group; an approach based on Cohen's h yielded n≈15 per group; and an exact (Fisher exact test) calculation required n=18 per group. To allow for potential dropouts, we recruited 20 patients per group. Data were entered into Microsoft Excel (Microsoft Corp., Redmond, WA, USA) and analyzed using IBM SPSS version 25.0 software (IBM Corp., Armonk, NY, USA). Continuous parametric data were presented as mean ± standard deviation, while nonparametric data were presented as median with interquartile range. Categorical variables were expressed as numbers and percentages. Comparisons between the two groups were performed using the independent t-test for continuous parametric data, the Wilcoxon rank-sum test for nonparametric data, and the chi-square test for categorical variables. A two-sided p-value <0.05 was considered statistically significant.

RESULTS

The two groups were comparable with respect to demographic characteristics (Table 2). All procedures were performed using the Snodgrass technique. The majority of patients underwent subcoronal or distal hypospadias repair, while the remainder had mid-shaft or proximal hypospadias repairs. Older children underwent secondary urethroplasty. All patients had a urinary catheter placed at the end of surgery, which was maintained for four to five days. The duration of surgery and intraoperative fentanyl requirements were similar between groups. The volume of local anesthetic administered was significantly lower in the PNB group compared to the CEB group. However, the time required to perform bilateral PNB was significantly longer than that required for CEB (Table 3).

Within the first 24 h postoperatively, additional analgesia was required in 80% of patients in the PNB group compared to 15% in the CEB group (p<0.001; Table 3). Postoperative pain scores were significantly higher in the PNB group at 12 and 18 h after surgery, while scores were comparable between groups at 0 h, 30 min, 6 h, and 24 h (Table 3, Figure 3). The requirement for additional postoperative analgesia with paracetamol was also higher in the PNB group (p<0.001; Table 3, Figure 4). No patient in either group required second-line rescue analgesia with tramadol.

Hemodynamic parameters differed between groups. In the CEB group, HR and MAP were lower from T1 to T80 (Figures 5, 6), systolic BP was lower from 20 to 90 min, and diastolic BP was lower from T1 to T80 (Figure 7).

TABLE 3
Intraoperative and postoperative data

	PNB group (n=20)					CEB group (n=20)					
Variables	n	%	Mean±SD	Median	IQR	n	%	Mean±SD	Median	IQR	*p*
Duration of surgery (min)			72±15.07					74.5±18.2			0.639*
Time to perform block (min)			20.05±4.66					5.85±1.22			<0.001*
Volume of local anesthetic (mL)			5.87±2.4					15.07±4.65			<0.001*
Additional intraoperative fentanyl (mcg)			2.65±5.12					0.77±3.46			0.183*
Modified OPS											
0 h				1.00	0.25-1.00				0.50	0-1.00	0.081†
30 min				0	0-0				0	0-0	0.429†
6 h				0	0-1.00				0	0-0	0.052†
12 h				2.00	0-2.00				0	0-0	0.002†
18 h				1.00	1.00-1.00				0	0-0	0.001†
24 h				0	0-0				0	0-0	0.799†
Patients requiring additional analgesia in first 24 h	16	80				3	15				<0.001*
Number of doses of paracetamol in the first 24 h											
0 doses	4					17					
1 dose	12					3					<0.001‡
2 doses	3					0					
3 doses	1					0					
Surgeon satisfaction score											
1	2					0					
2	5					0					0.014‡
3	13					20					
Parent satisfaction score											
1	2					0					
2	4					1					0.102‡
3	14					19					

PNB: Pudendal nerve block; CEB: Caudal epidural block; SD: Standard deviation; IQR: Interquartile range; OPS: Objective pain score; * Using Independent t test; † Using Mann-Whitney nonparametric test; ‡ Using χ^2 test.

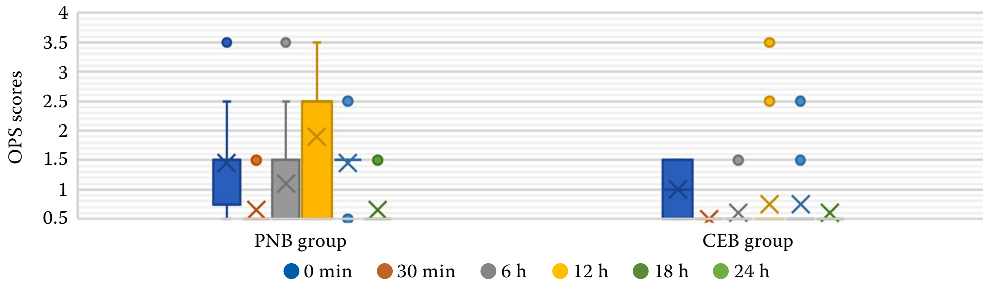

Figure 3. Box-and-whisker plot of modified OPS scores.

PNB: Pudendal nerve block; CEB: Caudal epidural block; OPS: Objective pain score.

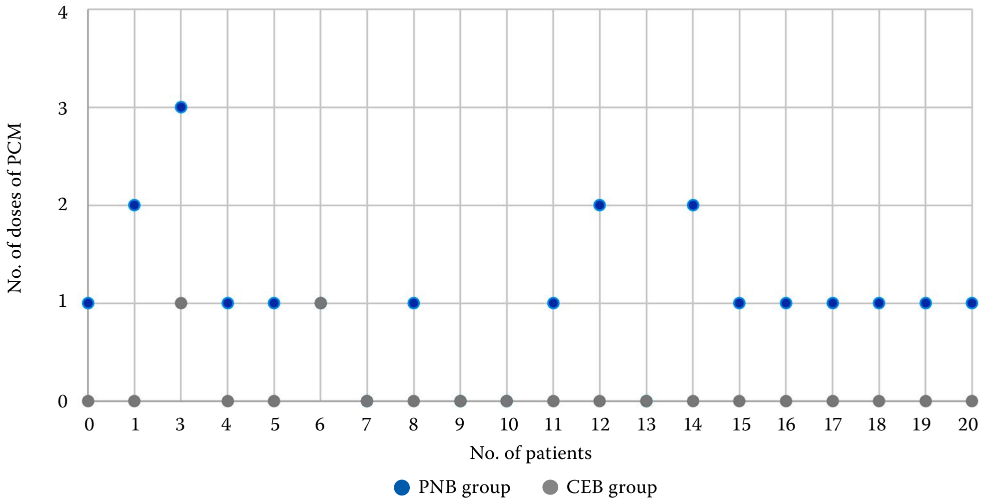

Figure 4. An X-Y scatter diagram showing distribution of patients based on doses of paracetamol required in the study groups.

PNB: Pudendal nerve block; CEB: Caudal epidural block.

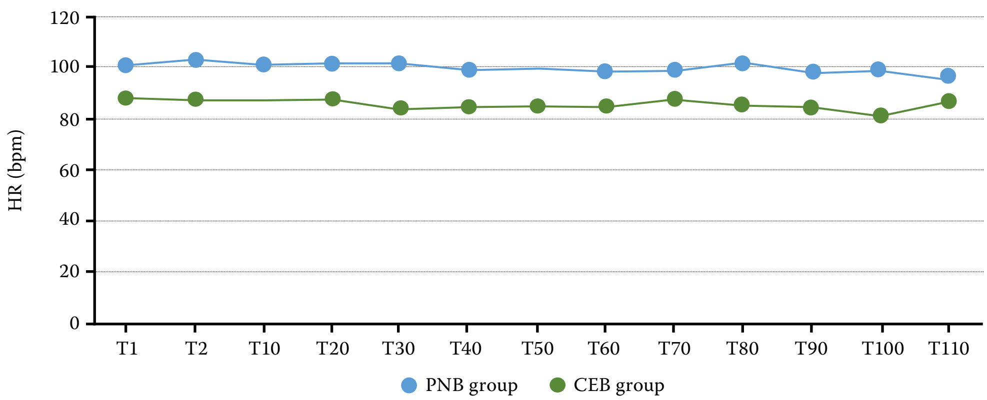

Figure 5. The HR was significantly lower in the CEB group from T1 to T80. Values were obtained using an independent t-test.

HR: Heart rate; PNB: Pudendal nerve block; CEB: Caudal epidural block.

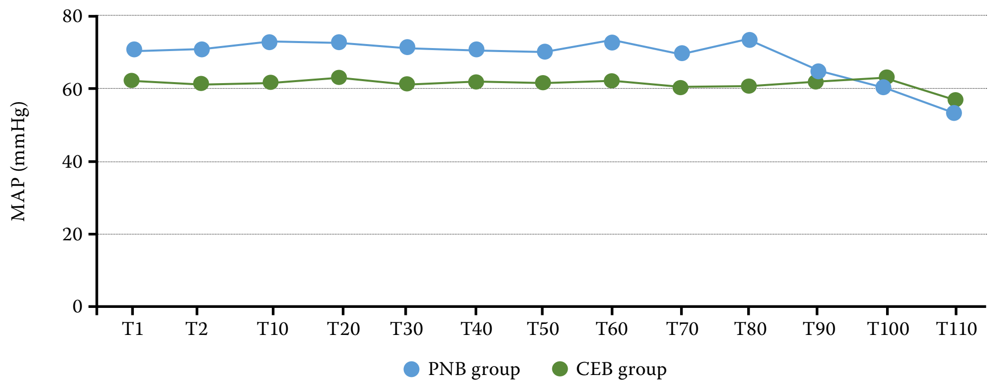

Figure 6. The MAP was significantly lower in the CEB group from T1 to T80 (80 min after administration of the block).

MAP: Mean arterial pressure; PNB: Pudendal nerve block; CEB: Caudal epidural block. Values were obtained using an independent t-test.

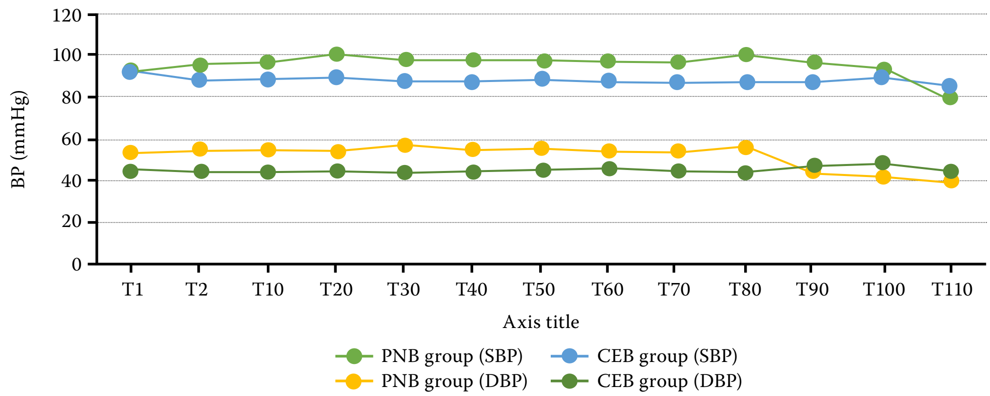

Figure 7. The systolic BP was significantly lower in the CEB group from 20 min to 90 min after the block and the diastolic BP was significantly lower from T1 to T80. Values were obtained using an independent t-test.

BP: Blood pressure; PNB: Pudendal nerve block; CEB: Caudal epidural block; SBP: Systolic blood pressure; DBP:Diastolic blood pressure.

Surgeons' satisfaction scores were higher in the CEB group, whereas parent satisfaction scores were comparable between groups (Table 3). No patient experienced postoperative motor blockade or complications such as pain or swelling at the injection site. Since all patients were catheterized, urinary retention could not be assessed.

DISCUSSION

In this study, 80% of children in the PNB group compared to 15% in the CEB group required additional analgesia within the first 24 h postoperatively. Pain scores were significantly higher in the PNB group at 12 and 18 h, while scores were comparable between the two groups at 0 h, 30 min, 6 h, and 24 h. Similarly, the requirement for additional postoperative analgesia with paracetamol was greater in the PNB group.

Caudal anesthesia is widely used as a safe and reliable component of multimodal analgesia for a variety of pediatric surgical procedures. It is simple, technically easy to perform, reduces the surgical stress response, and decreases the requirement for systemic analgesics.[6] While caudal analgesia provides effective pain relief after hypospadias repair, concerns have been raised regarding potential complications, including motor blockade, urinary retention, intravascular injection, penile engorgement, and urethrocutaneous fistula formation.[7,8] Recent studies have further examined the association between CEB and postoperative surgical complications in hypospadias repair,[3,9] and peripheral nerve blocks, such as penile nerve block or PNB, have been suggested to provide longer-lasting analgesia with fewer complications.[9-11]

Pudendal nerve block provides analgesic blockade of the skin, subcutaneous tissue, and musculature of the external genitalia, perineum, anal canal, and skin around the anus, making it a useful component of multimodal analgesia in hypospadias surgery. The injection site for PNB is relatively distant from the pubic and penile regions, which may reduce the risk of contamination and infection. Unlike CEB, PNB is less likely to cause penile engorgement, urinary retention, or lower extremity weakness. It can also be administered in older children or in those with spinal anomalies where caudal anatomy may be unfavorable. While most previous studies have employed NSG-PNB, the increasing availability of point-of-care ultrasonography and growing familiarity with peripheral nerve blocks make USG-PNB an attractive alternative.

Most previous studies evaluating CEB for postoperative analgesia have used a volume of 1.0 mL/kg.[5,12,13] Although a dose of 0.5 mL/kg is generally sufficient to provide intraoperative analgesia for hypospadias surgery, higher volumes are associated with longer postoperative analgesia. For instance, a median time of 4 h to first rescue analgesia was reported with 0.5 mL/kg of 0.25% bupivacaine combined with 1 μg/kg of fentanyl.[14] Since we did not use any adjuvants in our trial, we selected a volume of 1.0 mL/kg of 0.25% bupivacaine for CEB to ensure prolonged postoperative analgesia. For PNB, many earlier studies used a volume of 0.3 mL/kg^{-1} of 0.25% bupivacaine,[1,5,15] while others have used 0.5 mL/kg^{-1}.[13,16] Many investigators have also incorporated additives such as clonidine[5,16] or fentanyl[1] to prolong analgesia. These studies reported effective postoperative analgesia in children undergoing hypospadias repair, with clonidine associated with a longer duration of analgesia compared to fentanyl. These findings suggest that incorporating additives such as clonidine or fentanyl can enhance the analgesic efficacy of PNB, and the choice of additive may depend on the desired duration of analgesia and clinical context. However, further research is needed to establish optimal dosing regimens and to evaluate the safety profile of these combinations in pediatric populations. Based on these considerations, we elected to use 0.3 mL/kg^{-1} of 0.25% bupivacaine for PNB and 1 mL/kg^{-1} of 0.25% bupivacaine for CEB without any additives in our study. The lower drug volume used in PNB may be advantageous by reducing the risk of local anesthetic systemic toxicity; however, it may also contribute to the shorter duration of analgesia observed with this technique.

The principles of ERAS (Enhanced Recovery After Surgery) in children suggest that scheduled acetaminophen (paracetamol) or nonsteroidal anti-inflammatory drugs form the backbone of postoperative analgesia. Some form of regional anesthesia is strongly encouraged intraoperatively to reduce postoperative opioid needs. Intravenous dexamethasone 0.1 mg/kg in pediatric patients undergoing regional analgesia may also reduce the need for oral analgesics required after surgery.[17] Standardized, age-appropriate tools for pain assessment should guide rescue medication, and opioids are reserved for rescue use and not given routinely. Initially a weak opioid such as oral tramadol or codeine, where permitted, should be used. For severe pain, stronger opioids (e.g., morphine, fentanyl, and hydromorphone) or patient-controlled analgesia or nurse-controlled analgesia may be appropriate for older children. In line with this, all children received some form of regional anesthesia and intravenous dexamethasone 0.1 mg/kg during surgery. For rescue analgesia, if the OPS pain score was 2 to 3, paracetamol syrup or tablet (15 mg/kg) was given to the child. If the OPS pain score was ≥4, an injection of tramadol 1 mg/kg with ondansetron 0.1 mg/kg was administered.

Earlier studies on NSG-PNB reported a prolonged duration of postoperative analgesia with PNB.[5,13,14,18] However, when comparing USG-PNB with CEB, several investigators found comparable results,[1,12,19,20] while only Kasem et al.[1] recently reported that USG-PNB provided superior analgesia over CEB after hypospadias repair. A recent review of regional anesthesia techniques for hypospadias surgery concluded that PNB generally offers better analgesia in terms of pain scores, but when scheduled postoperative analgesics are used, CEB may provide comparable pain relief.[3] Specifically, two studies demonstrated PNB to be superior to CEB,[5,13] whereas one study showed comparable efficacy between the two when nonsteroidal analgesics were administered postoperatively.[12] Hecht et al.,[19] using USG-PNB, found no significant difference in intraoperative opioid or postoperative opioid and nonopioid analgesic requirements, while other investigators reported higher average analgesic consumption with CEB during the first 24 h after surgery.[1,5,13,14] Recently, Sridharan et al.,[16] using ultrasound and PNS-guided PNB, found a longer-lasting pain relief, significantly lower pain scores, and a reduced need for postoperative analgesics in the PNB group. In contrast, using only ultrasonographic guidance, our study found that postoperative pain and analgesic consumption was significantly higher in the PNB group.

There are several possible explanations for the differences between our findings and those reported in the literature. Some investigators have added adjuvants such as clonidine[5,16] or fentanyl[1] to prolong the duration of the block, whereas we did not use any adjuvant. In addition, concurrent administration of intravenous dexamethasone is well known to significantly prolong the duration of postoperative analgesia provided by CEB,[21,22] and all our patients received intravenous dexamethasone. While most trials have compared a dose of at least 0.5 mg/kg dexamethasone with placebo,[22] even a lower dose of 0.25 mg/kg combined with CEB has been shown to extend analgesia and reduce postoperative pain and analgesic consumption.[23] We administered 0.1 mg/kg, which is the standard practice in our institution. In contrast, the effect of intravenous dexamethasone on peripheral nerve blocks in children remains unclear. Joe et al.[24] reported that intravenous dexamethasone 0.5 mg/kg did not enhance the duration of PNB in infants and children aged six to 36 months undergoing hypospadias repair. This may partly explain why caudal analgesia in our study lasted longer, while the duration of analgesia with PNB was shorter.

In our study, although PNB was performed by an anesthesiologist experienced in ultrasound-guided nerve blocks, the procedure was relatively time-consuming. For a successful PNB, the internal pudendal artery and pudendal nerve must be identified; however, the nerve itself is often difficult to visualize due to its small caliber. Bellingham et al.[25] reported that even with an experienced operator, the pudendal nerve could be identified in only 57% of cases. Thus, a deep understanding of pudendal nerve anatomy and its anatomical variations appears to be crucial for consistent success with USG-PNB. It is also possible that in some of our patients, the local anesthetic was not deposited precisely at the target site, which may have contributed to the shorter duration of analgesia observed. This technical difficulty and variability in block success may partly explain why CEB, which is technically simpler and more reliable, provided superior and more consistent analgesia in our trial.

In our study, the mean time required to perform PNB was 20.05±4.66 min compared to 5.85±1.22 min for CEB. Similarly, Ahmed et al.[1] reported that PNB (8.16±0.9 min; range, 6 to 10 min) took significantly longer to administer than CEB (6.24±1.01 min; range, 4 to 8 min). In addition to the longer performance time, the surgical team expressed dissatisfaction with PNB as it delayed surgical preparation and provided inadequate postoperative analgesia in a substantial proportion of children. The anesthesiologists also considered PNB to be technically tedious and less user-friendly compared to the relatively simple and reliable CEB.

The intraoperative fentanyl requirement was comparable between the two groups. However, MAP and HR were significantly lower in the CEB group during the initial 80 min. This finding is consistent with previous studies, which have shown that CEB provides greater intraoperative hemodynamic stability, likely reflecting attenuation of the surgical stress response.[26]

Previous studies[14,27] have reported a significant increase in penile volume following CEB. Although we did not measure penile volume objectively, the surgeons did not report any cases of penile engorgement. Postoperative motor block may occur after caudal anesthesia depending on the concentration of local anesthetic and timing of assessment. In our study, no patient in the CEB group exhibited motor weakness or other postoperative complications. The incidence of urinary retention could not be evaluated, as all patients were catheterized during surgery.

This study had some limitations. The sample size may have been insufficient to detect significant differences in some secondary outcomes. It was conducted at a single center, which may limit generalizability. We did not combine nerve stimulator guidance with USG-PNB, a technique that may have improved block success rates. Additionally, no adjuvants were used in either block. Although the doses of local anesthetic were consistent with those recommended in previous studies, the PNB group received a significantly lower total volume of bupivacaine, which may have contributed to the shorter duration of analgesia and could introduce potential bias related to local anesthetic effect.

In conclusion, in pediatric patients undergoing hypospadias surgery, USG-PNB was time-consuming and yielded inconsistent results. In contrast, CEB significantly prolonged postoperative analgesia, reduced the need for rescue analgesics, and enhanced surgeon satisfaction compared to USG-PNB. Both techniques were safe with no major adverse effects. However, PNB proved technically challenging under ultrasound guidance, requiring considerable expertise and time; its success may be improved by combining ultrasound with nerve stimulator guidance.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

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