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Comparision of Success Rate of Ultrasound-Guided Versus Landmark Technique for Caudal Block in Children

Prabhakar Dahal[1,*], Ravi Ram Shrestha[2], Anuj Jung Karki[3]

Abstract

Background: *Caudal block is one of the most widely used epidural techniques in children, and this study compares its success when performed using ultrasound guidance versus the traditional landmark method.* ***Methods:*** *Forty-six children aged seven years or younger, classified as ASA I–II and undergoing surgery under general anesthesia with caudal analgesia, were enrolled and randomly assigned to either the landmark group (Group C, n = 23) or the ultrasound group (Group U, n = 23). Demographics, overall success rate, first-attempt success, number of needle punctures, time to achieve a successful block, and complications – such as dural puncture, vascular puncture, and subcutaneous bulge – were recorded and compared.* ***Results:*** *Both groups were demographically similar. First-attempt success was significantly higher with ultrasound (82.6%) than with the landmark technique (47.83%). Overall success rates were comparable between groups (91.30% in Group C vs. 95.65% in Group U). The time required to achieve a successful block was also similar. Vascular puncture and subcutaneous bulge occurred slightly more often in the landmark group, though the differences were not statistically significant. No dural punctures occurred in either group.* ***Conclusion:*** *In children aged 0–7 years, ultrasound guidance improves first-attempt success for caudal epidural blocks, while overall success, procedure time, number of punctures, and complication rates remain similar to the landmark technique.*

Keywords: Caudal epidural block, Landmark technique, Pediatric anesthesia, Regional anesthesia, Ultrasound-guided anesthesia, Vascular puncture

INTRODUCTION

Caudal block is the most commonly used epidural analgesia technique in children because it is simple and easy to perform [1]. First described for pediatric cystoscopy by Meredith Campbell in 1933 [2], it has since become a cornerstone of pediatric regional anesthesia. Large North American data sets confirm its safety, with only a few serious complications reported among 10,633 epidurals – one permanent neurological deficit, two epidural abscesses, one post–dural puncture headache, and one case of cauda equina syndrome [3, 4]. When combined with general anesthesia, caudal block provides excellent intra- and postoperative analgesia for genitourinary, digestive, orthopedic, and lower abdominal procedures [1], and it reduces stress hormone levels such as epinephrine, norepinephrine, cortisol, and growth hormone [5–7]. Neonates also benefit through reduced opioid use, less sedation, and earlier extubation [8]. Anatomically, the sacral hiatus is a U- or V-shaped opening formed by incomplete fusion of the sacral arches and bordered by the sacral cornua, with the

***Author for Correspondence**
Prabhakar Dahal
E-mail: dahal.drprabhakar@gmail.com

[1]MBBS & MD, Department of Anaesthesia and Critical Care, University Hospital of North Tees, Hardwick Road, Stockton on Tees, United Kingdom.
[2]Chief Consultant, Department of Anaesthesia and Critical Care National Academy of Medical Sciences, Bir Hospital, Kathmandu, Nepal.
[3]Senior Consultant, Department of Anaesthesia and Critical Care and Pain Medicine, National Academy of Medical Sciences, Bir Hospital, Kathmandu, Nepal.

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sacrococcygeal membrane covering it. In children, the dural sac usually ends about 27.9 ± 8.6 mm from the hiatus in males and 33.2 ± 11.5 mm in females, and the caudal space depth near the membrane averages 4.7–5 mm [9]. The skin-to-sacrum distance ranges from 10–39 mm in children aged 2 months to 7 years [10], making a 25 mm needle generally safe and sufficient to reach the epidural space without risking dural puncture (Figure 1) [1].

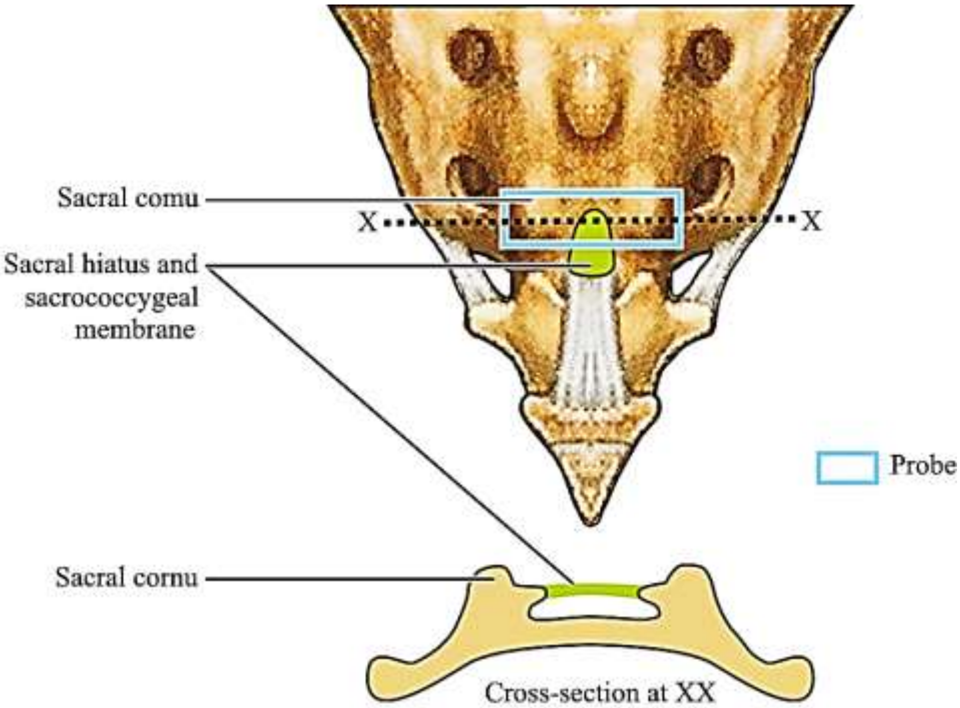

Figure 1. Sacral hiatus and sacral cornua anatomy.

As children grow, the angle of the sacrum changes and the sacral hiatus becomes harder to locate – and may even close – making caudal anesthesia more challenging and less suitable in those older than 6–7 years [11]. At the same time, epidural fat becomes more compact, limiting the spread of local anesthetics. In the traditional landmark technique, the needle is inserted at a 60–80° angle until the "pop" of the sacrococcygeal ligament is felt, then redirected to 20–30° and advanced a few millimeters into the sacral canal. However, anatomical variations of the sacral hiatus and sacral cornua significantly affect success, with reported success rates around 75% in children [12] and failure rates of 3–11%, especially after age seven [13]. Failures often stem from difficulty identifying the hiatus, passing a narrow canal, or advancing the needle in children with a small anterior–posterior sacral diameter [11–13]. Risks include dural and vascular puncture, which may occur when the dural sac ends unusually low or when conditions like sacral meningocele or perineural cyst extend downward [14, 15]. Such complications can lead to intravascular injection, systemic toxicity, total spinal anesthesia, or problems like soft tissue bulging and intra-osseous injection (Figure 2–4) [1].

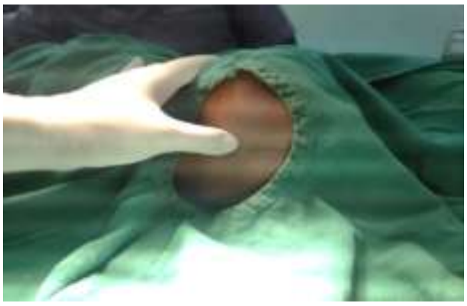

Figure 2. Landmark for caudal block procedure in lateral position: palpation of sacral hiatus.

Figure 3: Inserting needle into sacral hiatus at around 60^0.

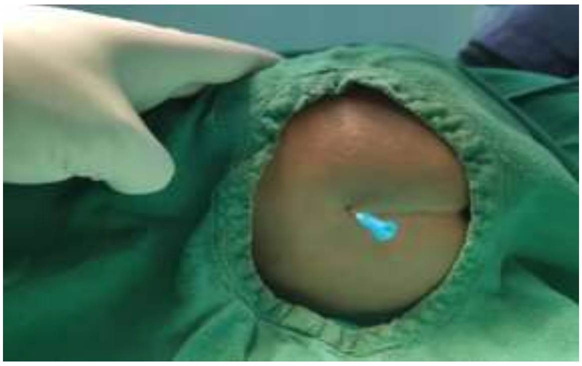

Figure 4: Inserting needle further into sacral canal at around 30^0.

Ultrasound-guided caudal blocks are especially advantageous in children due to the incomplete ossification of their bony structures. This makes it easier to clearly visualize the sacral anatomy, including the position of the sacral hiatus in relation to the end of the dural sac, as well as the spread of the local anesthetic. Shin and associates [16] found that prior anatomical study of the sacral region with ultrasound made it easier to identify the sacral hiatus and determine the level of dural sac [1]. Roberts and associates [17] demonstrate the usefulness of ultrasound imaging with a test dose of saline to confirm the location of the needle during the caudal block. According to the authors, the displacement of the dura mater during the injection of saline is an indicator of a successful block. They found ultrasound-guided caudal blocks successful with a sensitivity of 96.5%, a specificity of 100%, and a positive predictive value of 100% (Figure 5).

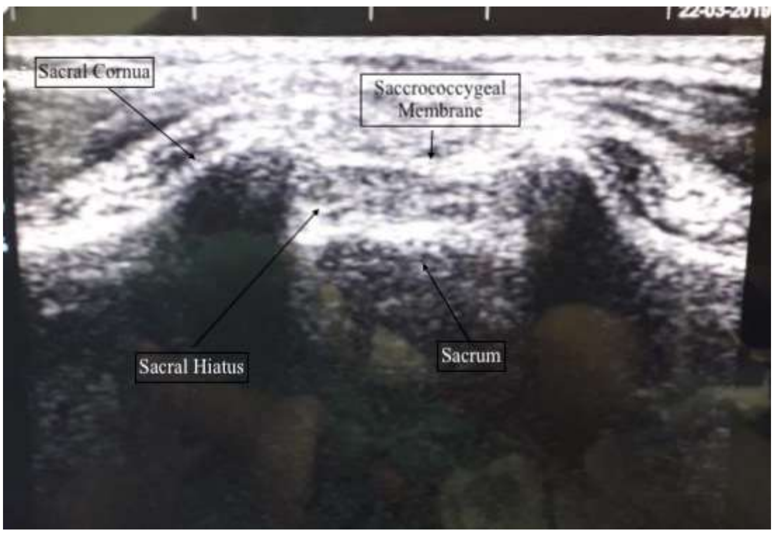

Figure 5. Transverse view of sacral cornua and sacral hiatus.

First puncture success rate of caudal block via landmark technique ranges from 60%–66.2% [18–21]. Complications of caudal block via landmark technique, like vascular puncture and subcutaneous bulge, are 12%–19% and 6%–12% respectively [18–21]. One of the techniques to improve success rate and to decrease complications is the use of ultrasound. First puncture success rate of caudal block via ultrasound guidance ranges from 80%–93%, and the complications like subcutaneous bulge is 0% and the vascular puncture is 1.5%–6% [18–21]. This shows that caudal block via ultrasound will help to increase success rate and decrease complications. This study aims to know the success rate and complications of two different techniques of caudal block, i.e., landmark vs. ultrasound guided in the pediatric population.

LITERATURE REVIEW

Karaca O et al. (2019) [18] conducted a large, randomized study in 275 children aged 6 months to 6 years comparing ultrasound-guided caudal blocks with the traditional landmark technique. Both groups had similar overall success rates, but ultrasound performed much better on the first attempt – 92.5% versus 66.2%. Children in the conventional group needed more needle punctures and experienced more complications, including blood aspiration and subcutaneous bulging, especially among those under 16 kg and younger than 6 years. In contrast, no complications were seen in the ultrasound group. The authors concluded that ultrasound guidance, particularly using a longitudinal view, leads to fewer punctures, fewer complications, and a higher first-attempt success rate in pediatric caudal blocks.

Ahiskalioglu A et al. (2017) [19] ran a randomized controlled trial in Turkey comparing ultrasound-guided caudal blocks with the traditional landmark technique in 134 children aged 5–12 undergoing circumcision. Both groups received the same anesthetic mixture, and researchers recorded procedure time, success rates, number of punctures, first-attempt success, and complications. Overall block success and procedure time were similar between the two techniques, but ultrasound clearly improved first-attempt success (80% vs. 63%). It also resulted in far fewer complications: vascular puncture and subcutaneous bulging were much more common with the traditional method. The authors noted some limitations – mainly that younger children were not included and that postoperative analgesia wasn't assessed – but still recommended ultrasound guidance because it reduces complications and improves first-attempt accuracy in pediatric caudal blocks.

Wang LZ et al. (2012) [20] conducted a randomized study in 140 children (newborn to 6 years old) undergoing inguinal hernia surgery to compare traditional caudal block with an ultrasound-guided sacral hiatus approach. Both groups received the same dose of ropivacaine, but in the ultrasound group, the injection was given as soon as the needle pierced the sacrococcygeal ligament under ultrasound visualization. Although the overall success rates were similar between the two groups, ultrasound guidance resulted in a much higher first-attempt success rate (92.8% vs. 60%), a shorter procedure time, and significantly fewer complications. Vascular punctures and subcutaneous bulges were far more common in the traditional technique. The authors concluded that ultrasound-guided hiatus injections are easier to perform and safer, offering a more reliable caudal block for pediatric surgery.

Liu JZ et al. (2012) [21] compared ultrasound guidance with the traditional landmark method and the swoosh test for caudal blocks in 102 children aged 1 month to 8 years undergoing urologic or perineal surgery. Patients were randomly assigned to either the ultrasound group or the control group. Ultrasound or surface landmarks were used to locate the sacral hiatus, and both groups received local anesthetic after successful needle placement. The ultrasound group clearly performed better: they needed fewer puncture attempts, had a much shorter procedure time, and had higher first-attempt and overall success rates (90.4% and 100%) compared with the control group (66% and 92%). Ultrasound was also far more reliable than the swoosh test in confirming correct placement (98% vs. 62%). Overall, ultrasound guidance proved more accurate, efficient, and dependable than the traditional approach.

Erbuyun K et al. (2014) [22] reviewed 78 children aged 2–10 undergoing urologic surgery to compare ultrasound-guided caudal blocks with the standard landmark technique. They looked at procedure time, ease of performing the block, postoperative pain control, need for extra analgesia, and complications. The only real difference they found was that the standard method was a few seconds faster, which they felt wasn't clinically important. Everything else – success rates, number of attempts, and complications such as block failure, bleeding, or accidental dural puncture – was similar between the two groups. They concluded that while both methods are safe and effective, ultrasound is especially useful when sacral anatomy is hard to identify by palpation.

OBJECTIVES

General Objective

To compare success rate of ultrasound guided versus landmark technique for caudal block in children.

Specific Objectives

- To compare success rate between two groups.
- To compare the success rate at first puncture between the two groups.
- Comparing the number of needle punctures for successful block between the two groups.
- To compare the time required for performing the block between the two groups.
- To compare the complications of the technique between the two groups.
    - Vascular puncture
    - Dural puncture
    - Subcutaneous bulge

A successful block was defined as absence of any blood or cerebrospinal fluid in the aspirate as well as there was no subcutaneous bulge after the administration of the local anesthetics irrespective of any number of attempts.

The success rate at first puncture was defined as reaching the sacral canal or sacral hiatus with a single needle orientation on the first puncture without any withdrawal from the skin.

The time required for performing the block was defined as the period between the time of start of palpation to termination of the local anaesthetic administration in landmark technique, while the time required for performing the block in ultrasound guided block was the time from the ultrasound probe placement in sacral region to termination of drug administration.

METHODOLOGY

- *Type of Study:* Prospective observational comparative study
- *Place of Study:* Operation theater. Kanti Children's Hospital, Maharajgunj Kathmandu, Nepal
- *Duration of Study:* March 2019 to May 2019.

Sample Size

- On the basis of study by *Wang LZ, et al [20]*
- Successful first puncture in ultrasound = 92.8%
- Successful first puncture in conventional method =60%
- Considering ultrasound is better than landmark technique by additional 35% in our study group

- P = (92.8 + 60) / 2 = 76.4
- Q = 100- P = 100-76.4 = 23.6
- z_{α} = 1.96 (95% confidence interval) and Z_{β}= 0.84 (power 80%).

So,

$N = 2 \times (z_{\alpha} + Z_{\beta})^2 \times P \times Q/D^2$

- $= 2 \times (1.96 + 0.84)^2 \times 76.4 \times 23.6/35^2$
- $= 15.68 \times 76.4 \times 23.6/35^2$
- = 23
- i.e. 23 in each group.

- N = the number of patients in each group,
- Z_{α} = constant at given alpha error
- Z_{β}= constant at givens beta error
- SD = standard deviation,
- D = difference between two groups

Inclusion Criteria
- Patient posted for elective surgery under general anesthesia with caudal block as analgesia for intraoperative and postoperative pain management.
- Patient of either sex from neonate to 7 years of age.
- ASA physical status I and II.

Exclusion Criteria
- Refusal by patient's guardian.
- History of hypersensitivity to local anesthetic.
- Children with severe systemic disease (e.g. acute liver failure, acute renal failure).
- History of neurological or spine disorder (e.g. Myelomeningocele, open spina bifida), meningitis, and intracranial hypertension.
- Coagulation disorder.
- Skin lesion at the site of injection.

PROCEDURAL DETAILS
After receiving approval from the ethics committees, informed consent was taken from each child's guardian, and standard fasting guidelines were followed. Forty-six children were randomly assigned to either the landmark caudal block group (C) or the ultrasound-guided group (U) using sealed opaque envelopes. In the operating room, baseline vitals were recorded, anesthesia was induced with either propofol or sevoflurane depending on the child's cooperation, and the airway was secured. All caudal blocks were performed under full anesthesia with the child positioned in the lateral knee-chest position. In the landmark group, the sacral cornua and sacral hiatus were identified by palpation, and a 20/22 G needle was advanced until the "pop" of the sacrococcygeal ligament was felt, then guided into the sacral canal before injecting local anesthetic. In the ultrasound group, the sacral hiatus was visualized using a 5–12 MHz linear probe, and the needle was inserted at the marked site using an out-of-plane approach, again advancing after the ligament "pop." In both groups, injections were given only after negative aspiration, with monitoring for complications. A block was considered successful if no blood or cerebrospinal fluid was aspirated and no subcutaneous bulge occurred. Procedure time, first-attempt success, and complications such as vascular or dural puncture were recorded.

RESULTS
In this study, the demographic characteristics of patients were comparable between the two groups, with no significant differences in age, sex distribution, weight, or ASA status (Table 1). Details related to caudal block performance are summarized in Table 2, which shows that although the overall success rates were similar, the success at the first puncture was significantly higher in Group U. The distribution of the number of punctures required for a successful block is presented in Table 3. Complications associated with the caudal block were low in both groups and are outlined in Table 4.

Table 1. Demographic data of patients.

Variables	Group C (N=23)	Group U (N= 23)	p value
Age (months) Mean ± SD	26.35 ± 22.50	27.74 ± 30.03	0.861[a]
Sex (Male/Female)	15/8	14/9	0.760[c]
Weight (kg) Mean ± SD	9.87 ± 4.32	10.72 ± 5.10	0.546[a]
ASA I/II	22/1	20/3	0.608[b]

Table 2. Caudal block details.

Variables	Group C (N=23)	Group U (N=23)	p value
Overall success rate (n, N%)	21, (91.30)	22, (95.65)	1.000[b]
Success at first puncture (n, N%)	11, (47.83)	19, (82.60)	**0.**029[b]
Time for successful block (sec) Mean ± SD	117.14 ± 52.22	114.23 ± 32.38	0.828[a]

[a]*Independent sample t-test,* [b] *Fisher's Exact test,* [c] *Chi-square test*

Table 3. Number of punctures for successful block.

		Group C	Group U
Number of Punctures for Successful Block	1	11	19
	2	6	3
	3	3	0
	4	1	0

Table 4. Complications of caudal block.

Variables	Group C (N= 23)	Group U (N= 23)	p value
Vascular puncture	7	3	0.284[b]
Dural Puncture	0	0	
Subcutaneous Bulge	2	1	1.000[b]

[b] *Fisher's Exact test*

DEMOGRAPHIC DATA OF THE PATIENTS

Age Distribution

The mean age of patients in landmark technique is 26.35 ± 22.50 months and in ultrasound group is 27.74 ± 30.03 months. There was no statistically significant difference in mean age between these two groups as the *p*-value is 0.861 (Table 5).

Table 5. Age distribution between two groups.

	Group C	Group U	p value
Age (months) Mean ± SD	26.35 ± 22.50	27.74 ± 30.03	0.861[a]

[a] *Independent sample t Test*

Sex Distribution

Number of male and female in group C (Landmark technique) were 15 and 8 respectively and in group U (Ultrasound Guided) were 14 and 9 respectively. The sex distribution was not statistically significant between the group ($p = 0.760$) (Table 6).

Table 6. Sex distribution between two groups.

		Group C	Group U	p value
Sex	Male	15	14	0.760[c]
	Female	8	9	

[c] *Chi-square test*

Weight Distribution

The mean weight of patients in Group C (Landmark technique) was 9.87 ± 4.39 kg; Group U (Ultrasound Guided) was 10.72 ± 5.10 kg. There was no statistically significant difference in mean weight between the two groups as the *p*-value was 0.546 (Table 7).

Table 7. Weight distribution between two groups.

	Group C	Group U	p value
Weight (kg) Mean ± SD	9.87 ± 4.39	10.72 ± 5.10	0.546[a]

[a]*Independent sample t-test*

ASA Distribution

The ASA distribution in both the groups was not statistically significant ($p = 0.608$). Number of ASA I patients in Group C (Landmark Technique) were 22 and in Group U (Ultrasound Guided) were 20. Number of ASA II patients in group C was 1 and group U was 3 (Table 8).

Table 8. ASA distribution between two groups.

		Group C	Group U	p value
ASA	ASA I	22	20	0.608[b]
	ASA II	1	3	

[b] *Fisher's Exact test*

Overall Success Rate

The success rate in Group C (Landmark technique) was 91.30% whereas the success rate in Group U (Ultrasound guided) was 95.65%. There was no statistically significant difference between the overall success rate between two groups ($p = 1.000$) (Table 9).

Table 9. Overall success rate between two groups.

	Group C	Group U	p value
Overall success rate (n, N%)	21, (91.30%)	22, (95.65)	1.000[b]

[b] *Fisher's Exact test*

Success Rate at First Puncture

The success rate at first puncture in Group C (Landmark technique) was 47.83% whereas the success rate at first puncture in Group U (Ultrasound guided) was 82.60%. There was statistically significant difference between two groups in success rate at first puncture as the value of *p* was 0.029 (Table 10).

Table 10. Success rate at first puncture between two groups.

	Group C	Group U	p value
Success rate at first punctura n, N%	11, (47.83)	19, (82.60)	0.029[b]

[b] *Fisher's Exact test*

Number of Needle Punctures for Successful Block

Among the ultrasound group, the successful block in single puncture was 86.36% and success in multiple punctures were 13.64% whereas in conventional method success rate in single punctures was 52.38% whereas success in multiple punctures was 47.62% (Table 11).

Table 11. Number of punctures for successful block between two groups.

		Group C	Group U
Number of Punctures for Successful Block	1	11	19
	2	6	3
	3	3	0
	4	1	0

Time for Successful Block

The mean time for successful block in Group C (Landmark technique) was 117.14 ± 52.22 seconds and in Group U (Ultrasound guided) is 114.23 ± 32.38 seconds. There was no statistically significant difference in time for successful block between two groups (Table 12).

Table 12. Time for successful block between two groups.

	Group C	Group U	p value
Time for successful block (sec) Mean ± SD	117.14 ± 52.22	114.23 ± 32.38	0.828[a]

[a]Independent sample t- test

Vascular Puncture

The vascular puncture between two groups was not statistically significant (p = 0.284). Vascular puncture in Group C (Landmark Technique) was 7, i.e., 30.43%, and in Group U (Ultrasound Guided) were 3, i.e., 13.04% (Table 13).

Table 13. Vascular puncture between two groups.

		Group C	Group U	p value
Vascular Puncture	Yes	7	3	0.284[b]
	No	16	20	

[b] Fisher's Exact test

Dural Puncture

The dural puncture was not seen in any of the two groups.

Subcutaneous bulge

The subcutaneous bulge between two groups was similar and was not statistically significant (p = 1.000). Subcutaneous bulge in Group C (Landmark Technique) was 2, i.e., 8.70%, and in Group U (Ultrasound Guided) it was 1, i.e., 4.35% (Table 14).

Table 14. Subcutaneous bulge between two groups.

		Group C	Group U	p value
Subcutaneous Bulge	Yes	2	1	1.000[b]
	No	21	22	

[b] Fisher's Exact test

DISCUSSION

This study showed that both ultrasound-guided and traditional landmark techniques for caudal blocks work equally well overall. They take roughly the same amount of time and have similar complication rates. However, the critical difference lies in the first attempt: ultrasound made it much more likely to achieve successful block on the first try. This is attributed to ultrasound allowing direct visualization of the sacral hiatus, ligaments, and epidural space, which provides substantial assistance in patients with challenging anatomy.

Other studies have also found that ultrasound improves accuracy and reduces issues such as vascular puncture – especially when using the in-plane technique, where the needle remains visible throughout the procedure. In this study, complications were similar between the two groups, but previous research indicates ultrasound can reduce them significantly. Overall, both methods are clinically viable, but ultrasound provides a more reliable first pass and assists in avoiding procedural errors, especially in complex cases.

CONCLUSION

This study concluded that in the pediatric age group 0–7 years, the use of ultrasound in caudal epidural anesthesia increases the success rate at the first attempt, though the overall success rate, number of needle punctures for successful block, procedure time, and complications were similar in both groups.

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