BMC Anesthesiology

RESEARCH

Open Access

Ultrasonography-guided catheter-over-needle insertion for caudal epidural catheter placement in adults: technical considerations

Pei Zhang[1], Hongzhou Chen[1], Keqiang Yu[2], Xia Ran[3], Rurong Wang[1*] and Jing Wu[2]

Abstract

Background Caudal epidural analgesia significantly reduces acute pain after anorectal surgery; however, caudal epidural catheter placement (CECP) remains challenging, and the safety of real-time ultrasonography-guided CECP is uncertain. This study aimed to evaluate the success rate and related complications of real-time ultrasonography-guided CECP and describe the technical considerations.

Methods This prospective, single-center observational study included 233 patients catheterized in the left lateral decubitus position. The sacral hiatus was palpated and then confirmed using ultrasonography. A catheter-over-needle was inserted through the sacrococcygeal ligament under real-time ultrasonographic guidance, the metallic needle was withdrawn through the outer sleeve, and the epidural catheter was placed through the outer sleeve into the sacral canal epidural space. The primary outcome was the success rate of CECP; several surgical variables, the incidence of related complications, and improvement measures were also assessed.

Results CECP through the sacral hiatus was successful in 231 patients. The sacral canal depth at the hiatus apex, the mean distance between the sacral cornua, and the distance from the skin to the inferior margin of the sacrococcygeal ligament were 5.07 ± 1.38, 8.00 ± 1.94, and 14.24 ± 4.18 mm, respectively. The sacral canal depth was > 3 mm in 94.4% of patients. No complications, such as epidural hematoma, dura puncture, and intraspinal infection during postoperative epidural catheter utilization, occurred.

Conclusion Ultrasonography-guided CECP through the sacral hiatus is a simple, feasible, safe, and effective technique for postoperative anorectal analgesia. Additionally, caudal epidural analgesia manages severe pain after anorectal surgery. Therefore, this technology merits comprehensive clinical application.

Trial Registration number No. ChiCTR 2,000,038,918.

Keywords Ultrasonography, Epidural catheter, Catheter-over-needle, Caudal block, Intraspinal infection, Subcutaneous tunnel, Postoperative pain, Anorectal surgery

*Correspondence:
Rurong Wang
wangrurong@scu.edu.cn
[1]Department of Anesthesiology, West China Hospital, Sichuan University, Chengdu, Sichuan 610041, China
[2] Institute of Integrated Traditional Chinese and Westen Medicine, West China Hospital, Sichuan University, Chengdu, Sichuan, China
[3]Department of Anesthesiology, Chengdu Shangjin Nanfu hospital, Chengdu, Sichuan, China

Background

Caudal block is widely used in clinical practice for perioperative anesthesia and postoperative pain management [1]. It was initially introduced as a landmark-based, blind technique; however, the success rate was only 68–75% by experienced physicians[1]. Recently, ultrasonography has increasingly been used to guide caudal block, improving its success rate to 100% [1–3].

Given the advantages of simple operation and the limited complications of the caudal block, this technology has been widely used in anorectal surgery [4]. The single caudal epidural block can meet the needs of both anorectal surgery and post-surgery short-term analgesic treatment. However, due to the particularity of perianal anatomy, severe and prolonged pain after anorectal surgery is experienced, which is exacerbated by postoperative dressing changes and defecation [5–6]. Therefore, a long-lasting and effective analgesic method after anorectal surgery is required.

Epidural analgesia has become a widely practiced analgesic technique worldwide, and caudal block could provide reliable intraoperative and postoperative pain relief for patients undergoing anorectal surgery [7–10]. However, the single caudal epidural block is primarily used in clinics, with limited literature reporting the technically challenging placement of the epidural catheter through the sacral hiatus.

Generally, a Tuohy needle is used for epidural catheter placement; however, this is only suitable for the thoracolumbar epidural catheter and not for placement through the sacral hiatus [11]. Due to the considerable anatomical variation of the sacral hiatus, some patients have a relatively narrow sacral hiatus [12], which may cause caudal epidural catheter placement (CECP) failure. Moreover, because the sacral hiatus is close to the anus, the possibility of intraspinal infection should be considered and strictly prevented [13]. Other complications of caudal epidural analgesia include hematoma, direct nerve trauma, catheter prolapse, and catheter blockage [7–9].

Therefore, using the catheter-over-needle technique, this study investigated the feasibility of ultrasonography-guided CECP through the sacral hiatus into the caudal epidural space. The feasibility, safety, efficacy, and related complications associated with this method were evaluated to address critical clinical challenges in perioperative and postoperative pain management in anorectal surgery.

Methods

Study design and patient recruitment

A prospective, single-anonymized, observational design was employed. The study protocol was conducted following the principles of the Declaration of Helsinki, approved by the Clinical Trial Ethics Committee of Chengdu Shangjin Nanfu Hospital (No. 2019042504), and registered with the Chinese Clinical Trial Center (No. ChiCTR 2000038918). All participants signed an informed consent form before enrollment. After the clinical trial registration, the patients were enrolled from October 2020 to December 2023. The manuscript follows the relevant CONSORT guidelines.

This study included adult patients (age > 18 years) who underwent anorectal surgery (mixed hemorrhoid, complex anal fistula, or perianal abscess) and required patient-controlled epidural analgesia at Chengdu Shang Jin Nanfu Hospital. Patients with a body mass index of < 30 kg/m^2 and the American Society of Anesthesiologists (ASA) grade of I–III were eligible for inclusion. The exclusion criteria were as follows: allergies to local anesthetics, neurological or psychiatric disorders, history of sacrococcygeal region infection, coagulopathy, anticoagulant or antiplatelet medication use, immunocompromised status, and sacral canal stenosis.

Protocol for CECP

Before CECP, intravenous access to upper limbs and routine monitoring measures (pulse oximetry, electrocardiogram, and noninvasive blood pressure) were established. Following preparation, the patients were placed in the left lateral position, and oxygen was administered via the nasal catheter at a rate of 2 L/min. A single experienced anesthesiologist then performed all CECPs under ultrasound guidance.

A palpable dimple between two sacral cornua was considered a sacral hiatus, making a "+" mark. A linear-array ultrasound transducer (5–12 MHz; Mindray 7, Shenzhen, China) was placed transversely on the "+" mark. The ultrasound transducer scanned the sacral hiatus. We identified the bilateral sacral cornua as the two hyperechoic structures from the ultrasonic transverse views. There are two band-like hyperechoic structures: the superficial one is the inferior sacrococcygeal ligament, and the deep one is the dorsal surface of the sacral bone. The hypoechoic region between these structures was then identified as the sacral cavity. The ultrasound transducer was scanned cephalomedially, and the apex of the sacral hiatus was recognized when the two band-like structures suddenly disappeared (Fig. 1A). In the apex of the sacral hiatus in the ultrasonic transverse view, the distance between the two band-like structures (depth of the sacral canal [line a]), distance from the skin to the inferior margin of the sacrococcygeal ligament (line b), and distance between the bilateral cornua (line c) was measured (Fig. 1A). The transducer was subsequently rotated 90° to obtain a longitudinal view of the sacral canal (Fig. 1B), in which the dorsal sacrococcygeal ligament was identified, and its thickness was measured (line d).

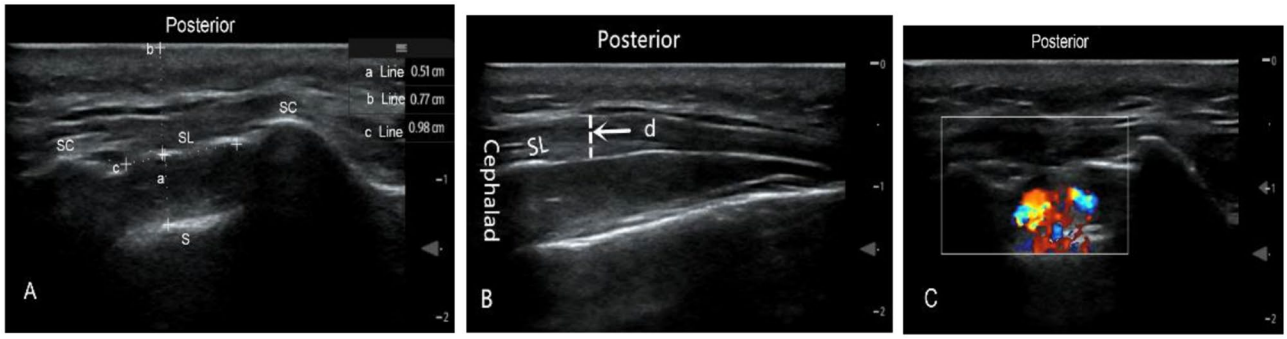

Fig. 1 Ultrasound image of the sacral canal. (**A**) Transversal ultrasound image of the sacral canal; (**B**) Longitudinal ultrasound image of the sacral canal; (**C**) ultrasound Doppler image. Measurement of the distance between the two band-like structures (depth of the sacral canal at the apex of the sacral hiatus [line a]), distance from the skin to the inferior margin of the sacrococcygeal ligament (line b), and distance between the bilateral cornua (line c) and the dorsal sacrococcygeal ligament thickness (line d) were obtained. (**C**) Unidirectional flow on color Doppler shows ropivacaine injection into the sacral canal. SC: Sacral cornua; SL: sacrococcygeal ligament; S: Sacral base

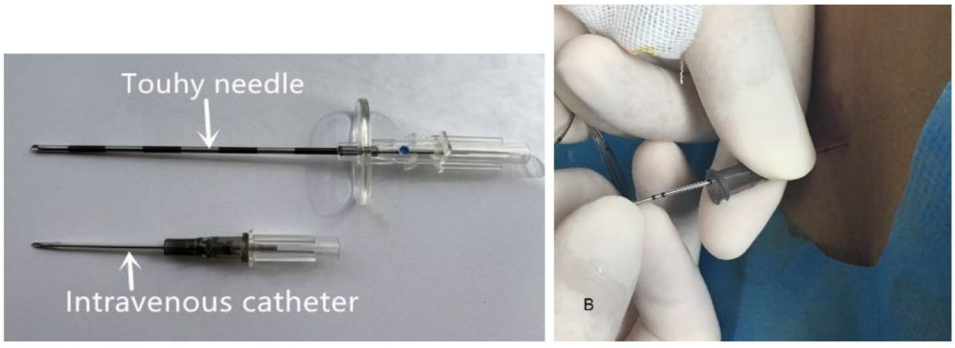

Fig. 2 CECP flow chart. (**A**) 16-gauge sterilized biosafety intravenous catheter; (**B**) Epidural catheters pass through the outer sleeve of the intravenous catheter

After identification and evaluation of the sacral hiatus by ultrasound, the transducer was covered with a sterile plastic protective sleeve. Strict disinfection was applied around the puncture site, and a towel was laid. After local infiltration of 1% lidocaine into the intended site of the needle entry, under the guidance of real-time ultrasound, a 2-mL syringe with a 23-gauge needle was slowly advanced into the sacral hiatus using the out-of-plane approach until the needle tip passed through the sacrococcygeal ligament in the sonographic transverse view. Meanwhile, the characteristic "pop" was detected, and the loss of resistance technique was used to inject normal saline into the sacral canal, as observed on the ultrasound Doppler image (Fig. 1C), indicating a successful caudal block. Subsequently, we slowly administered 0.5% ropivacaine (16 mL for men and 14 mL for women) and closely monitored the patients' response during administration [14–15]. If the patient experienced adverse reactions, such as dizziness, tinnitus, and pulse or consciousness changes, the drug injection was immediately terminated, and symptomatic treatment was initiated.

After administration, the caudal epidural block was repeated at the original puncture site using a 16-gauge catheter-over-needle under out-of-plane ultrasound guidance. This catheter-over-needle was substituted for the 16-gauge (1.7 mm) sterilized biosafety intravenous catheter (V4251709-03, B. Braun Melsungen AG, Penang, Malaysia) (Fig. 2A), which was inserted into the sacral hiatus under the sonographic transverse view, after advancing the metallic guide needle through the dorsal sacrococcygeal ligament. We then slowly withdrew the metallic needle and retained the outer sleeve, through which a multi-orifice epidural catheter was threaded in the cephalad direction. The catheter was then advanced until approximately 11 cm of the epidural catheter entered the outer sleeve (6 cm in the caudal epidural space) and stopped. Intravascular and subarachnoid intubation was excluded by epidural catheter aspiration, and a 3-mL test dose of 2% lidocaine was administered.

A subcutaneous tunnel secured the catheter; the first 2 cm ran to the right hip and then turned to the cephalad, with a length of 3 cm. The remaining length of the epidural catheter extended beyond the waist, and the epidural catheter connector remained in the lower abdomen, with the catheter adequately fixed by adhesive tape.

A transparent dressing was applied over this area near the anus, providing waterproofing.

Evaluation of the sacral block effect

Fifteen minutes after CECP, we punctured the patient around the anus using a blunt needle. If the patient reported no pain and could not control the anus autonomously, the effect of the caudal epidural block was considered satisfactory; in contrast, if the patient experienced pain around the anus and could voluntarily control it, indicating caudal block failure, an appropriate drug dose was administered through the catheter. After a satisfactory caudal epidural block was achieved, 0.5 ug/kg of dexmedetomidine was administered intravenously for 10–15 min. Additionally, 30 mg of propofol was administered intravenously at the beginning of the surgery to aid rapid sleep. When necessary, 2–4 mg/kg/h of propofol was administered intravenously to maintain the Ramsay score at 4–6 points. After surgery, the patient returned to the post-anesthetic care unit (PACU) for observation and was connected to an epidural pump.

Postoperative analgesia and follow-up

The nursing staff collected data regarding dexmedetomidine and propofol administrations, local anesthetic administration, related complications, ultrasonography measurements, and any redirections or reinsertions of the needle. Postoperative epidural analgesia was instituted with an infusion of 0.2% ropivacaine with 0.4 μg/mL sufentanil at 3 mL/h; these were adjusted at the attending anesthesiologist's discretion. The infusion was continued postoperatively, and the patient or acute pain team decided to discontinue according to the patient's pain degree. If the epidural was not "working," 10 mL of 1% lidocaine was injected through the epidural catheter to confirm the correct positioning of the epidural catheter. If the patient's perianal pain is significantly relieved, the epidural catheter is correctly positioned and can be continued. If the patient's perianal pain is not relieved, the catheter has been displaced, and the use is terminated. Switch to medication for analgesia, such as intravenous NSAIDs(Non-steroidal anti-inflammatory drugs) (+ possibly opioids) or oral NSAIDs, or apply lidocaine cream around the perianal area.

Table 1 Demographic data

Demographics	Number of Patients(*N* = 233)
Age(y)	38.6 ± 10.3(19–65)
Male	128(54.9%)
Weight(kg)	64.37 ± 12.62(40–120)
Height(cm)	166.06 ± 7.93(140–190)
BMI(kg/m2)	23.2 ± 3.4(16.2–37.0)
ASA	
I	100
II	133
III	0
Types of Surgery	
Hemorrhoids	139(59.6%)
Anal fistula	60(25.8%)
Perianal abscess	34(14.6%)
Ultrasound measurement(mm)	
Sacral fissure depth	5.07 ± 1.38(1.5–9.9)
Skin to the sacral canal	14.24 ± 4.18(7.5–28.2)
Medial spacing of sacral cornu	8.00 ± 1.94(3.4–12.3)
SL thickness	4.38 ± 1.00(1-7.1)
Sacral fissure depth(mm)	
< 2.0	1(0.4%)
2.0–3.0	12(5.2%)
>3.0	220(94.4%)

Values are mean ± SD, number (proportion) where appropriate. SL: Sacrococcygeal ligament

Outcomes

The primary outcome was the success rate of CECP. The secondary outcomes were: (1) the depth of the sacral canal at the apex of the sacral hiatus; (2) distance from the skin to the sacrococcygeal ligament inferior margin; (3) distance between the bilateral sacral cornua; (4) thickness of the sacrococcygeal ligament; (5) the number of skin punctures (e.g., reinsertion after complete needle withdrawal); (6) first-pass success rate (the catheter placement was successful on the first needle pass and first skin puncture); (7) related complications, such as dura puncture, epidural hematoma, accidental catheter shear, and intravascular or intrathecal local anesthetic injection; and(8) incidence of postoperative intraspinal infection and epidural catheter prolapse.

Statistical analysis

Data are expressed as the mean and standard deviation, median and interquartile range, or number and percentage, as appropriate. All data were analyzed using SPSS, version 25.0 (IBM Corp., Armonk, NY, USA).

Results

Data were collected from 233 patients (median age, 38.6 ± 10.3 years; 54.9% male) (Table 1). All patients were classified as ASA Grade I or II. Concerning the type of surgery, 59.6%, 25.8%, and 14.6% of the patients underwent surgery for mixed hemorrhoids, anal fistulas, and perianal abscesses, respectively (Table 1).

In the transverse ultrasonic view of the sacral hiatus at the apex, the mean depth of the sacral canal, distance from the skin to the inferior margin of the sacrococcygeal ligament, and distance between the bilateral sacral cornua were 5.07 ± 1.38, 14.24 ± 4.18, and 8.00 ± 1.94 mm, respectively. In the longitudinal view, the mean thickness of the sacrococcygeal ligament was 4.38 ± 1.00 mm. Notably, 220 (94.4%) patients had a sacral canal depth at the

sacral hiatus apex of > 3.0 mm, and only one patient had a depth of < 2 mm (Table 1).

Table 2 presents the outcomes of ultrasound-guided CECP. All patients underwent out-of-plane ultrasound-guided skin puncture for needle advancement; however, catheterization was unsuccessful three times in two patients. Overall, 231 patients underwent successful CECP through the sacral hiatus, with a success rate of 99.1%. Among these patients, the first-, second-, and third-pass success rates were 77.7% ($n = 181$), 12.8% ($n = 30$), and 8.6% ($n = 20$), respectively. Regarding complications, six patients had high resistance during CECP; no patient showed intravascular catheter placement, and one patient showed epidural catheter shear during the creation of the subcutaneous tunnel, resulting in catheter replacement.

Epidural use was continued for 4 postoperative days. Notably, there was no spinal infection and no neurological complications; moreover, patients with regular use of postoperative epidural analgesia reported adequate analgesia.

Table 2 Outcome parameter

Procedural variables	Number of patients ($N = 233$)
Successful CECP	231(99.1%)
Number of successful CECP, n (%)	
Fist	181(77.7%)
Second	30(12.8%)
Third	20(8.6%)
Regarding complications	
High resistance	6(2.6%)
Intravascular catheter	0(0%)
Epidural catheter shear	1(0.4)
Infectious	0(0%)
Neurological complications	0(0%)

Number (proportion) where appropriate.CECP: Caudal epidural catheter placement

Discussion

This study demonstrated that the catheter-over-needle in real-time ultrasound-guided CECP can be used for most patients undergoing anorectal surgery, with a high first-pass success rate. Our results corresponded with those of previous studies showing that successful CECP is associated with the ultrasound-guided puncture technique and the sacral canal depth [1 12 16]; CECP becomes challenging if the sacral canal depth is < 2 mm [17].

We performed CECP through the sacral hiatus for postoperative continuous analgesia rather than a single caudal block. The success of the caudal block was closely related to the puncture technique, sacral hiatus' anatomical variation, and volume and concentration of local anesthetics [17–18]. For example, when the sacral hiatus depth is < 1.6 mm, the sacral block success rate is low [11219–20]. In the present study, we found that when the volume and concentration of local anesthetic infusion were fixed, its injection into the sacral canal to achieve caudal block was possible, granted the sacral hiatus was not entirely closed. However, the success of caudal epidural catheterization was closely related to the sacral canal depth and puncture technique [21].

Therefore, we investigated the influence of changes in caudal epidural catheterization tools and ultrasound-guided puncture technology on CECP success while considering the sacral hiatus' anatomical variations. Accordingly, 94.4% of patients with a sacral canal depth of > 3 mm could effectively undergo continuous sacral block if the anesthesiologist was skilled in puncture and applying traditional puncture technology. However, with improved puncture technology and catheter placement tools, patients with a > 2-mm sacral canal depth could effectively undergo CECP, with first- and second-pass success rates of 77.7% and 12.8%, respectively. Notably, only one patient in this study had a < 2 mm sacral canal depth and, therefore, could not undergo continuous caudal epidural analgesia; however, in the case of incomplete closure, adequate analgesia could still be achieved through a successful caudal block.

In clinical settings, the 16-gauge Tuohy needle is currently the most commonly used epidural puncture needle. It is used for thoracic and lumbar epidural catheterization, with a 1.7-mm outer diameter and 80-mm handle length; however, its handle is too long and inconvenient, which has certain limitations for sacral canal catheterization [11]. Since the sacral hiatus is only covered by skin, subcutaneous fat, and sacrococcygeal ligament, the distance between the skin and sacral canal is small (vertical distance: 14.24 ± 4.18 mm), and there is significant variation in sacral hiatus.

Therefore, the 16-gauge intravenous catheter was identified as more suitable for caudal epidural catheterization [18]. This intravenous catheter has a 50-mm total length and comprises an outer sleeve of 1.6 mm diameter and a metallic guide needle of 32 mm length. The outer sleeve is made of polyurethane, an elastic material; its tip is of relatively small size and rounded, without a bevel, which does not easily damage the epidural catheter or blood vessels of the caudal epidural space during the procedure [18]. The metallic guide needle can guide the outer sleeve through the sacrococcygeal ligament into the sacral canal [18]; withdrawing the metallic guide needle and maintaining the outer sleeve provides a passageway for the epidural catheter into the caudal epidural space. Compared with the Tuohy needle [11], this 16-gauge intravenous catheter is smaller, lighter, more flexible, and more conveniently navigates the epidural catheter into the caudal epidural space [18]. One disadvantage is that the metallic guide needle's bevel is too long; once the metallic guide needle passes through the sacrococcygeal ligament,

the outer sleeve cannot pass through. During each operation, we needed to align the outer sleeve's tip with the metallic guide needle's tip to ensure both pass through the sacrococcygeal ligament. Therefore, this technique is simple and suitable for most patients.

Ultrasound imaging—a valuable tool for previewing the sacral hiatus anatomy and visualizing needle advancement—can identify the sacral hiatus, evaluate the sacral canal, and reduce the risk of caudal epidural catheterization failure [119–20]. In the present study, the sacral hiatus was identified in all patients, and its closure was not observed in any patient. Fortunately, in the present study, most patients had a > 2-mm sacral canal depth and were suitable for CECP.

Previously, the caudal epidural block was performed under in-of-plane ultrasound guidance in the prone position [1 19], whereas our study used out-of-plane ultrasound guidance for catheterization in the lateral decubitus position. During the caudal block procedure, it is more convenient for patients to change from a supine to a lateral than to a prone position[1]. Additionally, the lateral position enables a more effective transition to the supine position for urgent treatment if the patient experiences local anesthetic poisoning. Furthermore, when the patient is in the lateral decubitus position, their knees are pulled close to their chests to expose the sacral hiatus more clearly, making caudal block and catheter insertion easier [22–23].

However, in the lateral decubitus position, fixing the ultrasound probe at the sacral hiatus puncture site is complex [19]. Moreover, the average vertical distance between the skin and sacral epidural space is 14.24 ± 4.18 (7.5–28.2) mm [2, 5, 12], while the intravenous catheter's needle handle is only 30 mm. Our study chose out-of-plane rather than in-plane ultrasound guidance to overcome these challenges. Out-of-plane ultrasound guidance has the following advantages: minor procedural trauma, short puncture distance, simple operation process, and ability to be used with various types of puncture needles (long or short), thus making caudal epidural block and catheterization more straightforward, accurate, and successful [1822–23]. Although the complete needle trajectory could not be seen on the ultrasound image under real-time out-of-plane ultrasound guidance, the needle tip remained visible when it passed through the sacrococcygeal ligament. We also used the loss of resistance technique with saline to ensure intravenous catheter insertion into the sacral canal space [18].

The S2–S5 segments innervate the perianal tissue [5]; therefore, during the caudal block, the tip of the epidural catheter must reach the S2 segments. Previously, Senoglu et al. analyzed adult sacrococcygeal magnetic resonance images and found most dural sacs terminated in the S1–S2 segments [22 24], and the distance between the dural sac termination level and the sacral hiatus was approximately 40–50 mm [22]. However, when the patient assumes the lateral decubitus position, dural sac termination will shift to the cephalic side, and the distance between the sacral hiatus and the dural sac termination will increase, reducing the risk of local anesthetic poisoning or total spinal anesthesia due to accidental entry of the epidural catheter into the subarachnoid space [7]. Consistent with our findings, Afshan et al. found that a depth of 50 mm was most appropriate for epidural catheter placement (ECP) [25], and Königsrainer et al. found that 30–40% of adequately placed catheters move outwards within the epidural space over time [26]. Therefore, we limited the catheter insertion depth to 50–60 mm, meeting the need for adequate analgesia. Additionally, we used subcutaneous tunneling techniques to prevent the epidural catheter's outward movement [27].

Cesur et al. reported that the quality of epidural anesthesia could be improved, and the risk of catheter-related complications could be decreased by administering local anesthetics through the epidural needle before epidural catheterization [28]. Therefore, we completed the caudal block before CECP to ensure the epidural catheter's smooth placement into the caudal epidural space without entering the subarachnoid or intravascular space [7]. After successful catheterization, we routinely injected 3 mL of 2% lidocaine through the epidural catheter as the 'test dose' to confirm whether the catheter had accidentally entered the subarachnoid or intravascular space, as recommended in previous studies [18 29]. Thus, we found no cases of catheter insertion in the subarachnoid or intravascular space.

Due to the sacral hiatus' proximity to the anus, CECP through the sacral canal has posed considerable challenges to postoperative nursing, especially regarding caudal epidural infection [7 13 30]. Previously, Bomberg et al. found that using a subcutaneous tunnel to fix a thoracic epidural catheter can significantly reduce the incidence of epidural catheter infection [27]. Considering infection prevention was essential for quality control in our study, we also used the subcutaneous tunnel method for epidural catheter fixation [27 31]. However, because CECP through the sacral hiatus is prone to bending and blockage due to the position of the sacral hiatus at the lowest site of physiological bending, we chose to extend the subcutaneous tunnel to one side of the body before turning in a cephalic direction to avoid epidural catheter blockage [21].

Due to patients requiring traditional Chinese medicine fumigation after surgery, the postoperative puncture sites are easily contaminated, posing further challenges to postoperative nursing [7]. Therefore, we chose breathable and high-viscosity adhesive tape to fix the epidural catheter and added a layer of watertight transparent adhesive

close to the anus to avoid the adhesive tape being polluted when encountering water. Additionally, the adhesive tape used to fix the epidural catheter was quickly replaced if it was accidentally contaminated.

Postoperatively, we found the patient's degree of pain was high on the first postoperative night and at the first dressing change [5]; therefore, according to the recommendations of previous studies [7 30 32], epidural analgesia was administered for 4 days postoperatively for pain relief. If patients requested the extension of epidural analgesia, we limited the duration to 1 week to prevent intraspinal infection [30]. However, further research is required regarding how long caudal epidural analgesia can be continuously used.

In the present study, the epidural catheter was accidentally scratched by the tip of the metallic guide needle while creating the subcutaneous tunnel in one (0.4%) patient. Subsequently, the method was improved by using the left thumbnail to fully protect the epidural catheter during subcutaneous tunnel creation [31], resulting in no further accidents. Postoperatively, we found no patients had an epidural abscess or meningitis, possibly related to strict compliance with the inclusion criteria, rigorous aseptic operation, limitation of the epidural catheter duration [13], use of a subcutaneous tunnel for epidural catheter fixation, and waterproof prevention of contamination [7].

There are some limitations to our study. First, all CECPs were performed by one anesthesiologist, and the efficiency of all placements was similar. Therefore, further research is required to investigate the effect of the anesthesiologists' experience level on this method's efficacy. Second, patients with sacral canal stenosis or closure may be unsuitable for this technique for postoperative analgesia; nonetheless, the incidence of postoperative analgesia in patients with sacral canal stenosis or closure was low. Third, this method was unsuitable for pain relief in superobese patients because their sacrococcygeal subcutaneous fat is generally thick and requires a more extended handle of the catheter-over-needle. Currently, our institution only has an intravenous needle with a 30-mm handle length, which cannot meet the requirements for patients with extreme obesity.

Conclusions

We found that our technique of ultrasound-guided CECP through the sacral hiatus for caudal epidural analgesia for anorectal surgery is feasible, safe, and effective. It also reduces the incidence of related complications and infection. Moreover, learning to use the catheter-over-needle for CECP is relatively easy, and this technique alleviates severe pain after anorectal surgery and allows painless dressing changes and defecation. Therefore, this technique provides a new technical solution for integrating perioperative anesthesia and postoperative pain treatment and merits comprehensive clinical application.

Abbreviations

ASA	American Society of Anesthesiologists
CECP	caudal epidural catheter placement
ECP	epidural catheter placement
PACU	post-anesthesia care unit

Acknowledgements

We acknowledge all staff who helped perform this study.

Author contributions

Each author is expected to have made substantial contributions to the conception and design of the work. The acquisition, analysis, and interpretation of data were performed by Z.P., R.X., C-HZ, and Y-KQ; Z.P. C-HZ and Y-KQ performed the creation of new software used in work; Z.P. and W-RR have drafted the work or substantively revised it; Z.P. W.J. and W-RR wrote the main manuscript text, and Z.P. prepared all figures; All authors reviewed the manuscript.

Funding

This research was supported by the Science and Technology Department of Sichuan Province [NO: 2023YFS0100].

Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

The study protocol was conducted according to the principles of the Declaration of Helsinki and was approved by the Clinical Trial Ethics Committee of Chengdu Shangjin Nanfu Hospital (No. 2019042504). This trial is registered with the Chinese Clinical Trial Center (No. ChiCTR 2000038918). All participants provided written informed consent for participation.

Consent for publication

not applicable.

Competing interests

The authors declare no competing interests.

Received: 9 October 2024 / Accepted: 1 January 2025
Published online: 01 April 2025

References

1. Kao S-C, Lin C-S. Caudal epidural block: an updated review of anatomy and techniques. BioMed Res Int. 2017;2017:9217145.
2. Nikooseresht M, Hashemi M, Mohajerani SA, Shahandeh F, Agah M. Ultrasound as a screening tool for performing caudal epidural injections. Iran J Radiol. 2014;11:e13262.
3. Chen CP, Wong AM, Hsu CC, Tsai WC, Chang CN, Lin SC, et al. Ultrasound is a screening tool for proceeding with caudal epidural injections. Arch Phys Med Rehabil. 2010;91:358–63.
4. Siddiqui ZI, Denman WT, Schumann R, Hackford A, Cepeda MS, Carr DB. Local anesthetic infiltration versus caudal epidural block for anorectal surgery: a randomized controlled trial. J Clin Anesth. 2007;19:269–73.
5. Ceulemans A, De Looze D, Van de Putte D, Stiers E, Coppens M. High postoperative pain scores despite multimodal analgesia in ambulatory anorectal surgery: a prospective cohort study. Acta Chir Belg. 2019;119:224–30.
6. Ba-bai-ke-re M-M-T-JA, Huang H-G, Re W-N, Fan K, Chu H, Ai E-H-T, et al. How can we improve patients' comfort after Milligan-Morgan's open haemorrhoidectomy? World J Gastroenterol. 2011;17:1448–56.
7. Bos EME, Hollmann MW, Lirk P. Safety and efficacy of epidural analgesia. Curr Opin Anaesthesiol. 2017;30:736–42.
8. Hawkins JL. Epidural analgesia for labor and delivery. N Engl J Med. 2010;362:1503–10.

9. Block BM, Liu SS, Rowlingson AJ, Cowan AR, Cowan JA, Wu CL. Efficacy of postoperative epidural analgesia: a meta-analysis. JAMA. 2003;290:2455–63.
10. Wheatley RG, Schug SA, Watson D. Safety and efficacy of postoperative epidural analgesia. Br J Anaesth. 2001;87:47–61.
11. Nath S, Koziarz A, Badhiwala JH, Alhazzani W, Jaeschke R, Sharma S, et al. Atraumatic versus conventional lumbar puncture needles: a systematic review and meta-analysis. Lancet. 2018;391:1197–204.
12. Kim YH, Park HJ, Cho S, Moon DE. Assessment of factors affecting the difficulty of caudal epidural injections in adults using ultrasound. Case Rep Pain Res Manag. 2014;19:275–79.
13. Christie IW, McCabe S. Major complications of epidural analgesia after surgery: results of a six-year survey. Anesthesia. 2007;62:335–41.
14. Zhang P, Chang H, Yang T, Fu Y, He X, Li J, et al. Study on MEV90 of 0.5% ropivacaine for US-guided caudal epidural block in anorectal surgery. Front Med (Lausanne). 2022;9:1077478.
15. Li X, Li J, Zhang P, Deng H, Yang M, He H, et al. The minimum effective concentration (MEC90) of ropivacaine for ultrasound-guided caudal block in anorectal surgery. A dose-finding study. PLoS ONE. 2021;16:e0257283.
16. Trinh A, Hashmi SS, Massoud TF. Imaging anatomy of the vertebral canal for trans-sacral hiatus puncture of the lumbar cistern. Clin Anat. 2021;34:348–56.
17. Nakahashi M, Uei H, Hoshino M, Omori K, Igarashi H, Tokuhashi Y. Anatomical evaluation of the sacral hiatus using ultrasound imaging: factors that inhibit needle insertion during caudal epidural block procedures. Pain Pract. 2020;20:55–61.
18. Oh D. The influence of ultrasound-guided technique using a catheter-over-needle on the incidence of accidental intravascular injection during caudal block-A retrospective case series study. Med (Kaunas). 2021;57:1–7.
19. Kim DH, Park JH, Lee SC. Ultrasonographic evaluation of anatomic variations in the sacral hiatus: implications for caudal epidural injections. Spine. 2016;41:E759–63.
20. Park GY, Kwon DR, Cho HK. Anatomic differences in the sacral hiatus during caudal epidural injection using ultrasound guidance. J Ultrasound Med. 2015;34:2143–48.
21. Munro C, Baliga S, Shepherd J, MacEachern CF. Anatomical study of the human sacral hiatus and implications for successful caudal epidural injection. Surgeon. 2021;19:e103–6.
22. Jeon JY, Jeong YM, Lee SW, Kim JH, Choi HY, Ahn Y. The termination level of the dural sac relevant to caudal epidural block in lumbosacral transitional vertebrae: a comparison between sacralization and lumbarization groups. Pain Phys. 2018;21:73–82.
23. Park SJ, Yoon KB, Shin DA, Kim K, Kim TL, Kim SH. The influence of needle insertion depth on epidural spread and clinical outcomes in caudal epidural injections is a randomized clinical trial. J Pain Res. 2018;11:2961–67.
24. Senoglu N, Senoglu M, Ozkan F, Kesilmez C, Kızıldag B, Celik M. MRI's level of termination of the dural sac and its clinical relevance in caudal epidural block in adults. Surg Radiol Anat. 2013;35:579–84.
25. Afshan G, Chohan U, Khan FA, Chaudhry N, Khan ZE, Khan AA. Appropriate length of epidural catheter in the epidural space for postoperative analgesia: evaluation by epidurography. Anesthesia. 2011;66:913–18.
26. Königsrainer I, Bredanger S, Drewel-Frohnmeyer R, Vonthein R, Krueger WA, Königsrainer A, et al. Audit of motor weakness and premature catheter dislodgement after epidural analgesia in major abdominal surgery. Anesthesia. 2009;64:27–31.
27. Bomberg H, Kubulus C, Herberger S, Wagenpfeil S, Kessler P, Steinfeldt T, et al. Tunneling of thoracic epidural catheters is associated with fewer catheter-related infections: a retrospective registry analysis. Br J Anaesth. 2016;116:546–53.
28. Cesur M, Alici HA, Erdem AF, Silbir F, Yuksek MS. Administration of local anesthetic through the epidural needle before catheter insertion improves the quality of anesthesia and reduces catheter-related complications. Anesth Analg. 2005;101:1501–05.
29. Guay J. The epidural test dose: a review. Anesth Analg. 2006;102:921–29.
30. Rosero EB, Joshi GP. Nationwide incidence of serious complications of epidural analgesia in the United States. Acta Anaesthesiol Scand. 2016;60:810–20.
31. Sakai W, Tachibana S, Chaki T, Nakazato N, Horiguchi Y, Nawa Y, et al. Safety of an improved pediatric epidural tunneling technique for catheter shear. Paediatr Anaesth. 2021;31:770–7.
32. Sethna NF, Clendenin D, Athiraman U, Solodiuk J, Rodriguez DP, Zurakowski D. Incidence of epidural catheter-associated infections after continuous epidural analgesia in children. Anesthesiology. 2010;113:224–32.

Publisher's note