Turk Neurosurg 36(2):254-263, 2026
DOI: 10.5137/1019-5149.JTN.48568-25.3

Original Investigation
Spine and Peripheral Nerves

Received: 07.02.2025
Accepted: 17.06.2025
Published Online: 04.03.2026

Effects of Caudal Epidural Pethidine on Pain Control and Early Mobilization after Posterior Spinal Instrumentation: A Randomized Controlled Trial

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ABSTRACT

AIM: To evaluate the effects of administering pethidine (also known as meperidine), a long-acting narcotic analgesic, via the caudal epidural route at the conclusion of posterior lumbar instrumentation (PLI) surgery on postoperative pain control, and early mobilization of patients.

MATERIAL and METHODS: The cases included in this prospective study (n=48) were randomly divided into two groups, ensuring similar gender and age distributions and uniformity regarding lumbar pathologies requiring surgery. In the first group, 20 mL of sodium chloride (0.09%) solution containing pethidine chloride (0.5 mg/kg) was administered via a caudal epidural block before the patients were awakened from anesthesia. The control group consisted of cases in which the caudal epidural block was not performed using pethidine or any other pharmaceutical/pharmacological agent. Visual analog scale (VAS) pain assessments were performed in both groups preoperatively, postoperatively, and 24, 48, and 72 hours after awakening and recovery. Oral feeding at the sixth postoperative hour and mobilization at the eighth postoperative hour were evaluated in all cases. The data obtained were statistically analyzed with a significance level of α=0.05.

RESULTS: The VAS scores of cases administered with pethidine via a caudal block were found to be significantly lower at all measurement times compared with those without a caudal epidural block ($p < 0.05$). The need for analgesic medication in terms of dosage and duration was lower in the pethidine group during the postoperative period. Both groups began oral feeding at the sixth postoperative hour. The cases in the pethidine group were mobilized with ease at the eighth postoperative hour, whereas those without a caudal epidural block with pethidine could only be mobilized as early as the 24th postoperative hour.

CONCLUSION: Administering pethidine via a caudal epidural block before awakening at the conclusion of PLI surgery may provide benefits in postoperative pain control and early mobilization.

KEYWORDS: Analgesics, Caudal epidural block, Meperidine, Pethidine, Postoperative pain

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INTRODUCTION

Spinal deformities, degenerative spine diseases, traumas causing instability in the spine, infectious pathologies, and spinal tumors often require posterior lumbar surgical approaches using implants, such as screw–rods or plates. These approaches are generally referred to as posterior lumbar instrumentation (PLI) procedures (23). They are inherently associated with significant tissue damage and inflammation; thus, effective pain management in the postoperative period is critical.

Inadequate pain control can prolong hospital stay, delay rehabilitation, and negatively affect surgical outcomes. Delayed mobilization and uncontrolled pain negatively affect patients' quality of life and recovery process (15). They may increase the risk of side effects or adverse events due to the use of multiple medications for pain control (polypharmacy) (13). They can also lead to long-term opioid use, increasing the risk of addiction and healthcare costs. Lumbar and caudal epidural blocks can be applied in the postoperative period to prevent such situations, reduce long-term complications, and improve quality of life (6).

Various medical and conservative treatment modalities are used in postoperative pain management, such as oral or parenteral and/or externally administered nonsteroidal anti-inflammatory drugs (NSAIDs) and oral or systemic opioid analgesics (11). Targeted application of local anesthetics alone or in combination with steroids may also be preferred (14).

An epidural block is usually performed by administering pharmacological agents, such as opioids, steroids, local anesthetics, or hyaluronidase, to the area of neural compression under imaging guidance (22). However, a caudal epidural block aims to relieve pain by injecting medication into the epidural space through the sacral hiatus and targeting the nerves affected by pain signals. The main difference between a caudal block and other types of epidural blocks is the target area of the injection. The sacral hiatus is an important anatomical landmark for the application of caudal epidural blocks (20).

In caudal epidural injections, agents administered with a higher fluid volume may dilute and remove inflammatory mediators from the epidural space, providing clinically significant results. However, there is no direct evidence that administered drugs penetrate more effectively anterior to the nerve roots (36). Analgesia and inflammation can be reduced by administering local anesthetics (26) (e.g., bupivacaine, lignocaine, and ropivacaine), steroids (12) (e.g., betamethasone), or opioids (5) (e.g., morphine) to this area.

Pethidine (meperidine) is an opioid analgesic that acts on mu-opioid receptors in the central nervous system. The use of pethidine in caudal blocks acts directly on spinal opioid receptors, blocking pain signals from the lower body regions to the brain. The caudal approach can provide more localized and effective pain control than systemic applications because it allows the drug to be delivered closer to the surgical site in the lumbar region.

The literature has evaluated the effectiveness of caudal epidural morphine or bupivacaine administration in postoperative pain and neuroendocrine stress response in pediatric patients (35). In addition, a recent pediatric patient study compared sacral hiatus injection with conventional sacral canal injection and ultrasound-guided injections for caudal epidural blocks (1). However, there is no high-quality evidence in the literature on the use of pethidine-containing caudal epidural blocks administered via the sacral hiatus before patients wake up at the end of PLI procedures in adults.

This study aimed to evaluate the effects of a pethidine caudal epidural block via the sacral hiatus route on postoperative pain, nutrition, and mobilization compared with cases without a caudal block at the end of PLI surgery. The data obtained are considered to make a significant contribution to the literature in this field.

MATERIAL and METHODS

This prospective study was conducted with the approval of the Giresun University Faculty of Medicine Local Ethics Committee (Approval No: E-53593568-771-238738897, dated March 18, 2024). The same neurosurgeon from the Department of Neurosurgery Clinic performed surgery on all of the cases included in the study. Informed consent was obtained from all participants.

The sample size was determined using "G*Power (version 3.1.9.4)" (9,10). According to the sample calculation, reaching the required number of cases was determined as the primary endpoint of the study. Estimated power was 0.80, alpha (margin of error): 0.05, effect size was 0.4. Accordingly, the sample size was determined as 48 for the chi-square test. Between March 19, 2024, and August 31, 2024, 48 patients aged 31–83 years were included. The researcher responsible for the statistical analysis of the data was blinded to which group received pethidine. Additionally, none of the subjects knew whether they had been given pethidine or not.

Inclusion and Exclusion Criteria

Patients aged 18 years or older scheduled for PLI due to lumbar spinal stenosis, lumbar spondylolisthesis, spinal instability, lumbar spinal deformity, degenerative disc disease, or lumbar fractures with at least 3 months of persistent pain not responding to medical or conservative treatments and presenting with back pain, unilateral or bilateral leg pain, neurological deficits, or neurogenic claudication were included in the study. Patients with pethidine allergies, infections, or bleeding disorders at the surgical site, sacral spine malformations incompatible with a caudal epidural blockade, diabetes mellitus, cardiovascular diseases, alcohol consumption, or a history of smoking were excluded. The remaining 48 patients were randomly assigned to two equal groups. To perform randomization, blocks were created before starting the study, which included equal numbers of participants according to the needs of the study, such as gender, age, and severity of disease. The participants in the blocks were then randomly assigned to the treatment and control groups.

Group 1 consisted of patients who received pethidine blocks (n = 24), while Group 2 (the control group) included patients who did not receive pethidine or any other pharmaceutical blocks

(n = 24). The patients' age, gender, height, weight, American Society of Anesthesiologists physical status classification (I–II), diagnoses, surgical types, and postoperative analgesic dosages and durations were recorded in a Microsoft Office Excel file.

Operation and Caudal Epidural Block

A standard endotracheal general anesthesia induction procedure was applied to all patients. For patients undergoing PLI with diagnoses such as lumbar spinal stenosis, lumbar spondylolisthesis, lumbar spinal instability, lumbar degenerative deformity, and lumbar spinal trauma, pethidine was administered via the caudal epidural route at the end of the surgery only to patients in Group 1 before they were awakened.

Using fluoroscopy, a lateral view was obtained to display the anatomical boundaries of the sacral canal. The caudal canal appeared as a translucent layer posterior to the sacral segments under fluoroscopy. The median sacral crest appeared as an opaque line posterior to the caudal canal, while the sacral hiatus typically presented as a translucent opening at the base of the caudal canal. The coccyx could be observed articulating with the inferior surface of the sacrum. The caudal epidural block was performed by entering a 22-gauge Quincke spinal needle through the sacral hiatus under fluoroscopic guidance, followed by the administration of a contrast agent. The correct placement was confirmed by observing the distribution of the contrast agent in the epidural space. In Group 1, a mixture of pethidine and 20 mL of physiological serum was injected epidurally into the sacral hiatus caudal at a rate of 0.5 mL per second under fluoroscopic guidance. As the caudal block was not applied to the cases in Group 2, which was called the control group, no pharmacological agent, including saline, was injected (Figure 1).

After the caudal epidural block, a sterile sticker was applied to the needle insertion site. The patients were transferred to the ward after extubating and awakening.

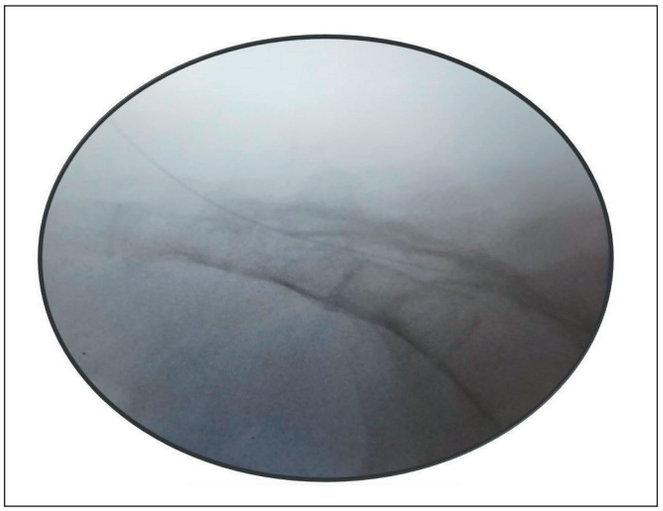

Figure 1: Demonstrative image of caudal epidural pethidine application under guidance using a mobile C-arm system (fluoroscopy).

Pain and Mobilization Assessment

Pain intensity was assessed using a visual analog scale (VAS). In both the control and experimental groups, all patients were assessed for postoperative mobilization beginning at the eighth hour. The assessment included activities such as turning from one side to the other in bed, sitting at the bedside, standing up at the bedside, and walking in the patient's room. The evaluation was conducted using a patient mobility scale that measured the level of pain and difficulty experienced during these activities.

Postoperative analgesia. Intravenous paracetamol (3 × 1 g/day) and tenoxicam (2 × 20 mg/day) were administered to each patient according to the standard analgesia protocol. Intravenous 0.5 mg/kg tramadol and/or intramuscular 100 mg pethidine was planned to be administered as rescue analgesia if the patients had a VAS score > 4.

Statistical Analysis

The Minitab program was used for the statistical evaluation of the data obtained. A one-way analysis of variance was applied to compare the groups. Descriptive statistics were presented as mean ± standard deviation (SD), minimum, and maximum values. For all statistical analyses, a P value of less than 0.05 was considered statistically significant.

RESULTS

The patients who received a pethidine block had instrumented a minimum of three and a maximum of five levels. In patients without a block, instrumentation was applied to a minimum of three and a maximum of seven levels. The body mass index of all groups was found to be 18.5–24.9 kg/m^2. The case data are summarized in Table I.

Group 1 represents the cases in which a caudal epidural block was applied with pethidine, while Group 2 represents the cases in which no caudal epidural medication was applied.

No statistically significant correlation was observed between the groups in terms of age or the number of instrumented levels and pain (p>0.05).

When comparing the preoperative and postoperative VAS scores of Group 1 (pethidine administered) and Group 2 (control), statistically significant differences were found between the groups at the 0th hour (F-Value: 89.81; p-value: 0.00), the 24th hour (F-Value: 68.16; p-value: 0.00), the 48th hour (F-Value: 28.21; p-value: 0.00), and the 72nd hour (F-Value: 13.10; p-value: 0.00) (Figure 2, Figure 3).

In addition, the patients without a caudal epidural block achieved mobilization earliest on the first postoperative day (n=14), while 10 patients were mobilized at the 48th hour. Patients who received caudal epidural pethidine required fewer doses and durations of analgesic medication postoperatively compared with those who did not.

A postoperative analgesia protocol was established for the patients in each group using intravenous paracetamol (3 × 1 g/day), tenoxicam (2 × 20 mg/day), and intravenous 0.5 mg/

Table I: Comparison of Demographic and Other Data of Cases with or without Caudal Epidural Block with Pethidine

Groups	Variable	Sex	Mean ± SD	Min	Max
With pethidine	Age (year)	M	54.27 ± 11.70	31	71
		F	61.15 ± 9.76	41	72
Without pethidine		M	63.75 ± 10.29	48	83
		F	55.25 ± 8.42	41	69
With pethidine	Preoperative VAS	M	8.818 ± 0.982	7	10
		F	8.769 ± 0.725	8	10
Without pethidine		M	9.000 ± 0.739	8	10
		F	8.750 ± 0.866	8	10
With pethidine	Postoperative VAS (immediately)	M	1.273 ± 0.467	1	2
		F	1.462 ± 0.519	1	2
Without pethidine		M	3.750 ± 0.965	2	5
		F	3.583 ± 1.084	2	5
With pethidine	Postoperative VAS (24-hour)	M	1.545 ± 0.688	1	3
		F	1.385 ± 0.506	1	2
Without pethidine		M	3.250 ± 0.965	2	5
		F	3.333 ± 0.778	2	4
With pethidine	Postoperative VAS (48-hour)	M	1.455 ± 0.522	1	2
		F	1.462 ± 0.660	1	3
Without pethidine		M	2.667 ± 0.985	1	4
		F	3.000 ± 1.044	1	4
With pethidine	Postoperative VAS (72-hour)	M	1.273 ± 0.467	1	2
		F	1.462 ± 0.660	1	3
Without pethidine		M	2.250 ± 0.622	1	3
		F	2.167 ± 1.030	1	4

SD: *Standard deviation,* ***Min:*** *Minimum,* ***Max:*** *Maximum, and,* ***VAS:*** *Visual analog scale.*

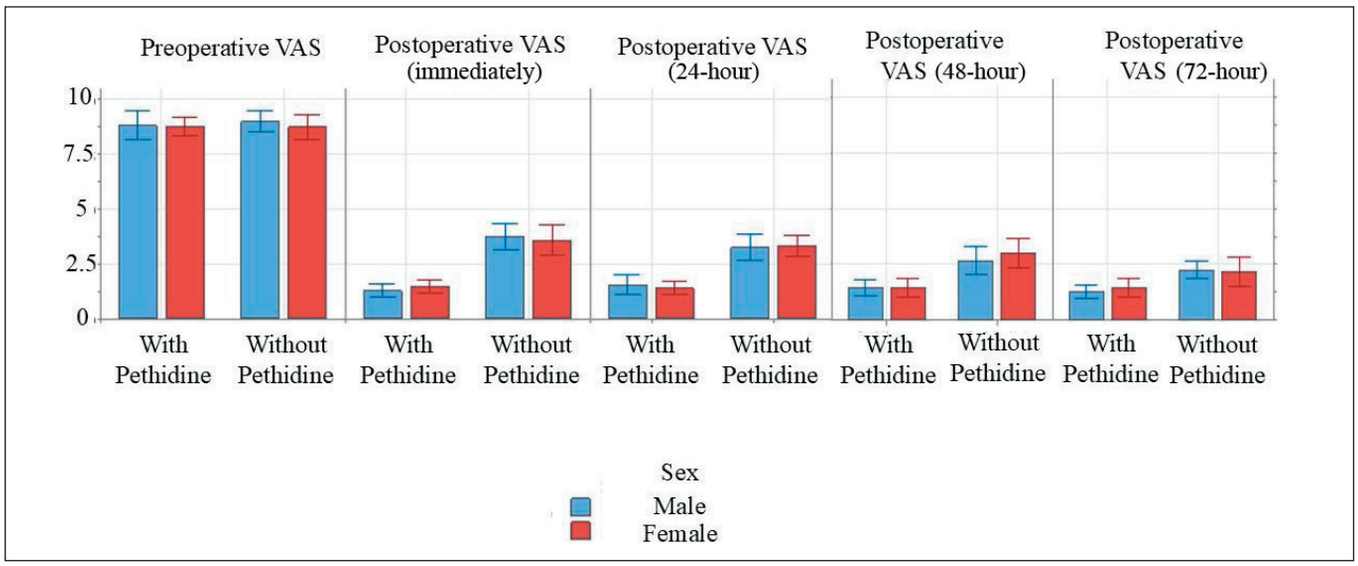

Figure 2: Comparison of intergroup VAS scores by gender between patients who underwent a caudal epidural block with pethidine and those who did not.

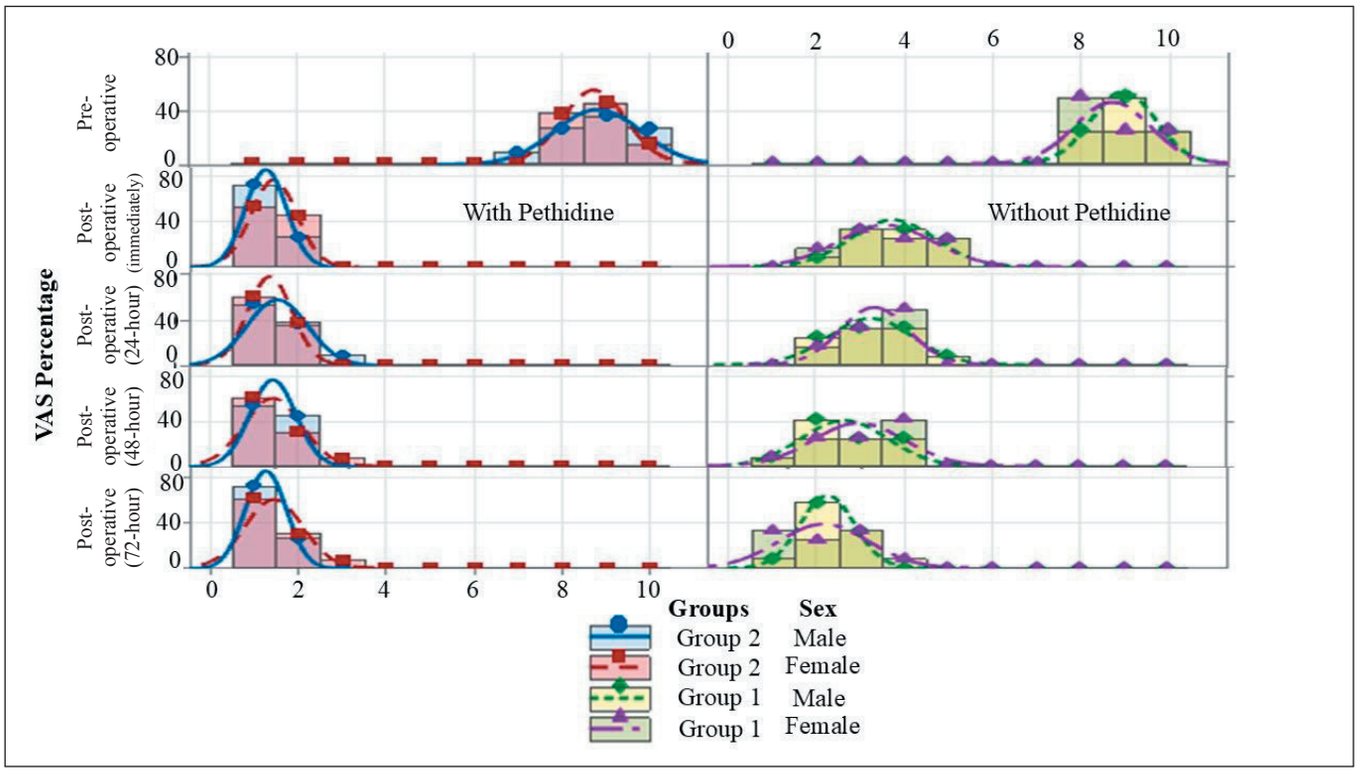

Figure 3: Interval plot of intergroup VAS scores by gender of patients who underwent a caudal epidural block with pethidine versus those who did not receive any caudal epidural block.

kg tramadol and/or intramuscular 100 mg pethidine for rescue analgesia when necessary.

None of the patients who underwent caudal epidural block required rescue analgesia, and no drug-related side effects or adverse events were observed in any patient in this group. In patients without a caudal epidural block, side effects were noted in those who received intramuscular pethidine for analgesia. Among the patients who did not receive caudal epidural block, seven received intravenous tramadol, and eight received intramuscular pethidine as rescue analgesia. The side effects observed in these cases are presented in Table II.

The patients who received caudal epidural pethidine were observed to mobilize easily by the eighth hour, whereas those without an epidural block and pethidine achieved mobilization earliest on the first postoperative day (n=14). Ten patients were mobilized by the 48th hour due to analgesia-related delays.

Table II: Postoperative Opioid-Related Side Effects

Side effects	Number of patients
Confusion, perception disorders, mood changes	2
Vertigo, euphoria	2
Insomnia, headache	1
Tremors	2
Miosis	1

DISCUSSION

PLI, which is a surgical treatment applied for pathologies such as lumbar spinal stenosis, lumbar spondylolisthesis, lumbar spinal instability, lumbar degenerative deformity, and lumbar spinal trauma, can cause uncontrolled pain and difficulty in mobilization during the postoperative period. As a result, satisfactory outcomes may not be achieved in these patients (31).

Epidural space infiltrations are classified as caudal, transforaminal, and interlaminar. The injection method depends on the type of pain and the surgeon's preference. The caudal epidural block, an epidural anesthesia method administered through the sacral hiatus, has become a fundamental element in pediatric and adult anesthesia, particularly for procedures involving the lower abdomen, perineum, and lower extremities. Especially after lumbar spinal instrumentation surgeries, failed back surgery syndrome is observed at a notable rate. In such cases, epidural caudal injections are often preferred for pain control (24). Studies have reported the positive effects of transforaminal epidural injections and caudal epidural injections combined with an erector spinae plane block during and after lumbar spinal fusion surgeries on postoperative pain control, patient satisfaction, and early mobilization (30).

Pethidine is an opioid analgesic increasingly studied within the context of caudal epidural anesthesia due to its unique properties, including local anesthetic effects and complementing traditional agents such as bupivacaine or lidocaine (2).

Effective pain management after PLI is essential to accelerate recovery, facilitate early mobilization, and reduce the risk of complications. However, it is evident that creating and applying a general analgesia protocol is challenging for many surgical procedures. A caudal epidural block administered through the sacral hiatus is frequently used by neurosurgeons and pain specialists due to its high reliability. In this procedure, an imaging method should be employed to achieve high accuracy in needle placement. In our study, fluoroscopy was used for this purpose (7).

Given the complex nature of PLI as a spinal surgical intervention and the severe postoperative pain pattern, a multimodal approach combining different classes of analgesics is widely applied for postoperative pain management (28). This strategy enhances analgesic effectiveness by targeting various pain pathways while minimizing the side effects associated with higher doses of single agents.

Morphine, hydromorphone, fentanyl, and oxycodone are the most commonly used opioid analgesics. However, the use of these analgesics is associated with significant side effects, such as constipation, emesis, sedation, and risks of dependency or tolerance. Thus, there are notable limitations and risks, such as the need for titration and monitoring (17). For this reason, adjuvant therapies, including non-opioid analgesics, are increasingly preferred in multimodal pain management due to their ability to reduce opioid consumption and associated side effects.

Adjuvant therapies, which integrate various strategies into a consistent multimodal pain management plan, are key to optimizing postoperative pain control while minimizing opioid use. Protocols frequently including NSAIDs, such as ibuprofen and ketorolac, which inhibit cyclooxygenase enzymes involved in prostaglandin synthesis and reduce inflammation and pain, are preferred not only for their analgesic effects but also for their ability to reduce the inflammatory component of postoperative pain (33).

However, their frequent use in spinal surgeries may not be appropriate due to their potential for interfering with osteochondral tissue healing. Acetaminophen, often used as part of a multimodal regimen, provides effective analgesia with a favorable side effect profile, can be administered orally or intravenously, and is particularly beneficial in cases in which NSAIDs are contraindicated. Gabapentinoids are typically initiated preoperatively and continued postoperatively to reduce both acute and chronic pain. Agents such as gabapentin and pregabalin are preferred for alleviating neuropathic pain, which can be a component of postoperative pain following PLI (18). They work by inhibiting calcium channels in the central nervous system, thereby reducing the release of excitatory neurotransmitters (32).

Ketamine, an N-methyl-D-aspartate receptor antagonist, is sometimes used at sub-anesthetic doses to provide analgesia and reduce opioid requirements, particularly in patients with high opioid tolerance or neuropathic pain (29). Corticosteroid drugs can also be used to reduce inflammation and nerve root edema in patients with radicular pain.

The caudal blockade, a type of epidural anesthesia, is effective in treating lower lumbar and sacral pain. Its efficacy is enhanced by the washing effect of high-volume fluid injections combined with the administered agents, which cleanse the inflammatory mediators responsible for pain. As discussed earlier, pethidine, although less commonly used than other local anesthetics, can be utilized in caudal blocks. Although less commonly used for PLI, peripheral nerve blocks, such as lumbar plexus or paravertebral nerve blocks, can be considered part of a multimodal approach, especially for patients with contraindications to epidural or systemic opioids (28).

In this study, cases with a caudal epidural block using pethidine and cases without a caudal epidural block were compared to evaluate the pain and mobilization of patients in the postoperative period following PLI. In the control group, in which caudal blockade was not performed with pethidine or any other drug, performing caudal blockade with saline was not deemed necessary, as the subjects would not know whether caudal blockade was performed under anesthesia.

Pethidine, one of the first synthetic opioid analgesics widely used for treating moderate to severe pain, is typically employed for managing acute pain, such as postoperative pain, pain during childbirth, or pain caused by injuries. However, it is less commonly used for chronic pain treatment because of its potential toxicity stemming from the accumulation of its metabolite—normeperidine. Pethidine primarily acts by binding to mu-opioid receptors, which are G-protein-coupled receptors in the central nervous system. When pethidine binds to these receptors, it inhibits the release of neurotransmitters, such as substance P, which play a role in transmitting pain signals in the spinal cord and brain. This leads to a reduction in pain perception (4).

Epidural pethidine infiltration involves administering pethidine into the epidural space, the area surrounding the spinal cord within the vertebral column. When administered epidurally, pethidine acts on opioid receptors, particularly in the dorsal horn of the spinal cord, blocking the transmission of pain signals. This results in decreased pain perception without causing a complete motor block, a desirable outcome in certain clinical situations, such as childbirth. It can also be used to manage pain following abdominal or lower extremity surgeries.

The advantages of a caudal block with pethidine include effective analgesia, rapid onset, and moderate duration of action. One significant concern regarding the use of pethidine in spinal or epidural applications is its potential neurotoxicity (40). Although pethidine is less associated with neurotoxicity compared with other opioids, adverse neurological effects have been reported, particularly with high doses or prolonged use. Similar to other opioids, pethidine carries a risk of respiratory depression (4), which can be particularly dangerous in the postoperative period. The risk increases when combined

with other central nervous system depressants. As an opioid, pethidine has the potential for abuse and dependency, necessitating careful monitoring, especially in patients requiring prolonged postoperative pain management. The inclusion and exclusion of cases in this study were carried out considering these scientific data.

However, when an opioid, such as pethidine, is administered caudally through the sacral space, its pharmacokinetics differ significantly from systemic administration routes, such as intravenous or oral. When injected via the caudal epidural route, pethidine primarily acts locally on the spinal nerves in the sacral and lower lumbar regions, providing effective regional analgesia. A portion of the drug may be absorbed into systemic circulation through the epidural venous plexus. However, the rate and extent of systemic absorption are generally lower compared with intravenous administration, as the drug accumulates in the localized area where its effects are intended. Unlike oral drugs, which are absorbed through the gastrointestinal system and enter the portal circulation directly (first-pass metabolism), drugs administered via the caudal route do not directly enter the portal circulation. Instead, they are absorbed into the systemic venous circulation and subsequently distributed throughout the body (38).

Once the drug enters systemic circulation, it eventually reaches the liver. Pethidine is primarily metabolized in the liver through the cytochrome p450 enzyme system (CYP2D6, 2C19, and 3A4) (37). It is metabolized into normeperidine and other metabolites, which are less active but may contribute to toxicity, especially with repeated doses.

In a study that evaluated caudal epidural injection in the treatment of lumbosacral nerve pain syndromes in a double-blind manner involving 39 cases, the participants were randomly divided into three groups (3). The researchers administered a combination of 10 mL of 0.09% isotonic sodium chloride, 20 mL of lignocaine (1%), and 1 mL of betamethasone (7 mg) through a caudal epidural injection to the first group. The second group received the same combination without betamethasone through a caudal epidural injection. In the third group, only 1 mL of betamethasone (7 mg) was administered as a superficial injection around the sacral hiatus. In the postoperative period, only tramadol was allowed as an analgesic medication. The cases in all three groups were evaluated at 1, 24, and 48 hours, at the end of the first week, and four weeks after the injections (3). The results showed that while the mobility of the lumbar spine improved in all patient groups, there was no statistically significant difference between the three treatment groups. However, the straight leg raise test results associated with epidural steroid injections were superior to those of steroid injections around the sacral hiatus (3).

Morphine and bupivacaine were used in a study comparing the efficacy of a caudal epidural block with a constant depth of anesthesia in surgical stress response in children who had undergone abdominal and genitourinary surgery in the past using bispectral index analysis. The results indicated that bupivacaine's caudal epidural application was more effective than morphine in reducing intraoperative and postoperative stress responses in children undergoing surgery (35).

In a study involving 90 patients scheduled for surgery below the umbilical level, the ability of epidural morphine administered via the caudal route to alleviate pain was assessed and compared with an intramuscular opioid injection. The cases receiving 4 mg of morphine/10 mL of normal saline via the caudal route were compared with those receiving intramuscular opioids using the VAS (25). The average pain score in the caudal epidural group was significantly lower during the first 12 hours postoperatively, and 38% of the cases required additional intramuscular injections within the first 12 hours. However, in the study, 86% of the patients in the intramuscular group received opioid injections, and although no patient developed respiratory depression due to morphine injection, side effects were more frequent in the intramuscular group than in the epidural group (19).

In a study comparing between caudal epidural bupivacaine with adrenaline and pethidine with adrenaline for operative and postoperative analgesia in infants and children, 25 cases under the age of 12 were evaluated. The study showed that none of the children in either group required parenteral analgesia. However, although the pethidine group experienced longer analgesia and sedation duration, delayed vomiting and urination times could hinder the routine use of pethidine (25).

In another study involving pediatric patients aged 2–5 years who underwent unilateral inguinal hernia surgery, caudal epidural injections of pethidine combined with levobupivacaine were suggested as an effective method for postoperative analgesia duration, pain control, and early mobilization (39).

Eighty-seven cases were evaluated in a study investigating the effect of caudal dexmedetomidine and ketamine in preventing delirium in pediatric patients undergoing congenital inguinal hernia repair. The results showed that patients who received caudal dexmedetomidine had a longer time until the first postoperative analgesia compared with ketamine and reduced postoperative analgesic consumption. Moreover, no significant difference was reported between the two drugs regarding postoperative sedation duration and the incidence of perioperative adverse events (8).

Contrary to the literature, this study found no side effects and/or adverse events, such as delayed vomiting and urinary frequency, in adults receiving caudal epidural pethidine.

In a randomized, double-blind, controlled clinical study analyzing the effectiveness of preemptive analgesia with a single caudal epidural injection in patients undergoing posterior approach surgeries for lumbosacral region pathologies, administering analgesics before the painful stimulus was reported to be more effective than after its onset. It was reported that 82 patients who underwent instrumented or non-instrumented discectomy in the lumbosacral spine through a posterior approach were randomized into a control group (n=40), and a study group (n=42), and patients in the control group received a single caudal epidural injection of 20 mL of normal saline. In the study, a single 20 mL caudal epidural injection containing bupivacaine and tramadol was administered to the patients in the study group, and a single caudal epidural injection with bupivacaine and tramadol was found to be a safe, simple, and

effective method for preemptive analgesia in managing postoperative pain (34).

However, in this study, side effects, such as drowsiness, impaired perception, mood changes, euphoria, insomnia, headache, tremor, and miosis, were observed in cases without a caudal epidural block who received intravenous opioids for postoperative analgesia. The results of this study are consistent with the literature. A caudal epidural block containing pethidine has been shown to significantly improve postoperative pain and mobilization following PLI surgery.

In Ahiskalioglu et al.'s study, a solution of levobupivacaine (0.125%) combined with morphine (10 μg/kg) was administered as caudal epidural injections at a total volume of 0.5 mL/kg. Despite limitations in central neuraxial anesthesia, they recommended using ultrasound in pediatric caudal injections to reduce complications and increase the success rate of the first attempt (1).

However, in another study comparing caudal epidural injections performed under ultrasound guidance with those performed under fluoroscopy, it was suggested that although ultrasound-guided blocks had a higher success rate in the first attempt and required smaller needle sizes, no significant difference in block success was observed between the groups. Moreover, conventional methods have been associated with fewer issues, such as blood aspiration, bone tissue irritation, and subcutaneous bulging (21). In the current study, mobile C-arm fluoroscopy was preferred over ultrasound guidance for caudal epidural injections.

As with all complex surgical interventions, the early mobilization of PLI cases is essential for functional recovery, preventing complications associated with immobilization, and maintaining hemostatic balance. Therefore, assessing the level of activity in postoperative cases and the factors affecting it is crucial.

In summary, the importance of effective postoperative pain management in spinal surgeries, particularly in posterior lumbar instrumentation, cannot be overlooked. It plays a vital role in shortening recovery time, increasing patient satisfaction, and optimizing surgical outcomes. Postoperative pain management after PLI requires a balanced approach that considers the effectiveness, side effects, and impact on the recovery of various analgesics. A multimodal strategy that includes opioid and non-opioid options and regional anesthesia techniques provides the best results in terms of pain control, patient satisfaction, and early mobilization. As research progresses, we believe that new agents or combinations of different pharmaceuticals could further improve postoperative pain management protocols.

As a result, this analytical study, which divided 48 cases into randomized two groups, found no significant statistical relationship between age or the number of instrumented levels and pain ($p<0.05$). Compared with the control group that did not receive a caudal epidural block, those who received a single dose of caudal epidural pethidine had a lower analgesic requirement and postoperative VAS scores ($p<0.05$). Moreover, no patients in the caudal epidural pethidine group required opioid analgesia in the postoperative period. No side effects or adverse events related to the medication were observed in the caudal epidural pethidine group. However, in cases without a caudal epidural block, side effects related to intravenous opioid use were detected in the postoperative period to provide analgesia. The assessment of patient mobilization was made using a patient mobility scale. The cases with caudal epidural pethidine were found to be able to mobilize comfortably and pain-free by the eighth hour, while in the group without a caudal epidural block and pethidine, 58.33% were mobilized on the first postoperative day, and 41.66% were mobilized by the 48th hour at the earliest.

The VAS is based on the patients' ability to understand the scale and their subjective pain experiences, which can introduce variability. It may not be suitable for individuals who struggle to understand the scale concept. At first glance, this can be considered a limitation of our study. However, the VAS has been validated in numerous studies, showing its reliability and correlation with other pain scales, such as the numeric rating scale and the verbal descriptive scale. The VAS is considered the gold standard for pain assessment due to its simplicity and ease of use (16,27).

Limitations

In this study, the cases were of the same ethnicity, and only the effect of a caudal epidural block containing pethidine was investigated. There was no control group consisting of cases receiving normal saline or other opioids or any pharmacological agent through caudal epidural blocks. Instead, cases without any drug-related caudal epidural blocks were compared. This is the main limitation of our study. Future research should include a larger, multi-center study design involving different ethnicities, examining not only the efficacy of pethidine but also the roles and long-term effects of different opioid drugs on caudal epidural blocks for postoperative pain relief. Because, it should be noted that cultural differences in pain perception will affect the results. In summary, this study is limited by its small sample size, single-center design, and use of subjective measures, such as the VAS.

CONCLUSION

Despite the significant literature on the use of opioids in spinal anesthesia, there is limited specific data on the use of pethidine in caudal blocks, especially in the context of spinal surgeries, such as PLI. Most studies have focused on more commonly used opioids, such as morphine or fentanyl. Due to concerns about its side effects, the use of pethidine has declined, and current studies may not fully reflect its efficacy and safety profile in modern surgical settings. Considering the critical role of postoperative pain management in spinal surgery outcomes and the unique properties of pethidine as an analgesic, there is a clear need to evaluate its efficacy and reliability, particularly when administered via caudal blocks. This evaluation could contribute to optimizing postoperative care, improving patient recovery, and potentially redefining analgesic protocols in spinal surgeries. It has been observed that caudal epidural pethidine administered before the

patient wakes up after PLI surgery significantly improves postoperative pain control and mobilization. Based on these results, we believe that caudal epidural pethidine can be safely and effectively used in postoperative pain management following PLI, enabling patients to mobilize earlier.

Declarations

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Availability of data and materials: The datasets generated and/or analyzed during the current study are available from the corresponding author by reasonable request.

Disclosure: The authors declare no competing interests.

This study is an analytical and observational study and does not constitute a clinical trial. Therefore, registration in a clinical trial registry was not required and no clinical trial registration number exists.

AUTHORSHIP CONTRIBUTION

Study conception and design: NeK, IT, IY

Data collection: NeK

Analysis and interpretation of results: NeK, IT, IY

Draft manuscript preparation: TT, SO, NK

Critical revision of the article: NK, IY

Other (study supervision, fundings, materials, etc...): NeK, IY

All authors (NeK, IT, TT, SO, NK, IY) reviewed the results and approved the final version of the manuscript.

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