Preoperative Butorphanol Improves Anaesthesia Outcomes in Patients Undergoing Percutaneous Transforaminal Discectomy: A Single-Centre Study

Ann. Ital. Chir., 2025 96, 4: 496–504
https://doi.org/10.62713/aic.3968

Jinli Che[1,†], Jizheng Zhang[1,†], Jiaming Zheng[2], Xiaohua Sun[1], Wanlu Ren[1]

[1]Department of Anesthesiology, Tianjin Hospital of Tianjin University, 300211 Tianjin, China
[2]West China School of Medicine, Sichuan University, 610207 Chengdu, Sichuan, China

AIM: This study aims to analyze the effect of the preoperative use of butorphanol on patients who underwent percutaneous transforaminal endoscopic discectomy (PTED), providing additional insights into the selection of an anaesthesia regimen for PTED.
METHODS: The medical records of 106 patients who underwent PTED in our hospital from February 2021 to May 2023 were selected for retrospective analysis. The patients were divided into a reference group (n = 56; no preoperative medication) and a research group (n = 50; preoperative intravenous butorphanol) based on whether they were using butorphanol. Moreover, the anaesthesia sedation effects and pain levels at different moments in the two groups were compared.
RESULTS: The Ramsay Sedation Scale (RSS) scores of patients in the research group at Time (T) 1–4 were significantly higher than those of the reference group ($p < 0.001$). At 6 h postoperatively, the numerical rating scale (NRS) scores were significantly higher than preoperative scores in both groups ($p < 0.001$). The NRS scores of patients in the research group were significantly lower than those of the reference group at 6 h postoperatively ($p < 0.001$). Central venous pressure (CVP) and heart rate (HR) levels in the study group were significantly lower than those in the reference group at the T1–T4 stage, while percutaneous oxygen saturation (SpO_2) was significantly higher than that in the reference group ($p < 0.05$). However, no significant differences in respiratory rate and the incidence of intraoperative adverse reactions were observed between the two groups ($p > 0.05$). A significant difference in Iowa Surgery Anesthesia Satisfaction Scale (ISAS) scores exists between the two groups ($p < 0.05$).
CONCLUSIONS: The preoperative use of butorphanol in patients undergoing PTED may effectively enhance intraoperative sedation and reduce postoperative pain.

Keywords: butorphanol; endoscopes; diskectomy; anaesthetics

Introduction

The number of lumbar disc herniation (LDH) cases has been increasing annually [1]. However, chronic low back pain caused by degeneration or herniation of the lumbar discs has a profoundly adverse impact on the daily life of a patient [2]. Percutaneous transforaminal endoscopic discectomy (PTED) is a major surgical procedure for the treatment of LDH and has been used as an alternative to open discectomy [3]. PTED is a minimally invasive technique that reduces the use of general anaesthesia (GA), minimizes damage to the surrounding soft tissues and paravertebral musculature, accelerates wound healing time, reduces spinal instability, and shortens the length of hospital stay [4]. Anaesthesia methods commonly used for this procedure include GA and local anaesthesia (LA) [5]. LA allows communication between the surgeon and the patient to facilitate the assessment of nerve damage through feedback (e.g., lower limb movement), thereby ensuring a high level of safety [6]. In addition, LA has minimal impact on respiratory and circulatory function whilst allowing for early mobility, thereby significantly shortening recovery time, making it the primary method of anaesthesia [7]. However, intraoperative pain is often encountered when resection is performed under LA. In certain events that patients experience intolerable pain, the procedure needs to be paused [8].
Butorphanol is a preoperative sedative analgesic with anti-inflammatory activity and a synthetic agonist-antagonist opioid analgesic that exerts analgesic and sedative effects via κ-opioid receptors without dependence, while reducing emergence agitation (EA) [9,10]. These properties lead us to hypothesize that the preoperative use of butorphanol can mitigate pain in patients undergoing PTED. A randomized controlled trial has also found that 9.07 µg/kg of butorphanol was more effective than sufentanil in gastrointestinal endoscopic sedation and significantly reduced recovery time [11].

Submitted: 16 January 2025 Revised: 12 March 2025 Accepted: 17 March 2025 Published: 10 April 2025
Correspondence to: Wanlu Ren, Department of Anesthesiology, Tianjin Hospital of Tianjin University, 300211 Tianjin, China (e-mail: renwanlumazuike@163.com).
[†]*These authors contributed equally.*

The above-mentioned advantages of butorphanol offers us fresh insights to investigate its capacity in further improving surgical and anaesthesia outcomes by thoroughly exploring and analyzing the effects of preoperative use of butorphanol on patients undergoing PTED.

Information and Methods

General Information

Patients who underwent PTED at Tianjin Hospital of Tianjin University from February 2021 to May 2023 were selected for the study. All patients were informed of all possible clinical outcomes of the different treatments and signed a written informed consent. The study design was approved by the ethics committee of Tianjin Hospital of Tianjin University (approval No.: 20240379). The study was conducted in accordance with the latest edition of the World Medical Association Declaration of Helsinki [12].

Number of patients recruited: 115 cases; Number of patients included: 106 cases; Grouping (and group names): Research group (n = 50), Reference group (n = 56).

Inclusion and Exclusion Criteria

Inclusion Criteria

The inclusion criteria include the following: (1) normal cardiopulmonary, hepatic and renal function and stable vital signs; (2) normal coagulation function; (3) ineffective conservative treatment for more than 6 weeks; and (4) American Society of Anesthesiologists (ASA) classification of I or II.

Exclusion Criteria

The exclusion criteria include the following: (1) hypersensitivity to butorphanol or its components; (2) comorbid severe circulatory and respiratory diseases; (3) lumbar spine infection, tuberculosis and malignancy; (4) pregnancy and breastfeeding; (5) history of lumbar spine surgery and psychiatric disorders; and (6) spinal instability.

Methodology

An intraoperative monitor (model 8000A, Jiangsu Xinrui Medical Technology Co., Ltd., Xuzhou, China) was used for monitoring. The research group was given an intravenous injection of 20 μg/kg of butorphanol tartrate (specifications: 2 mL: 4 mg; Jiangsu Hengrui Pharmaceutical Co., Ltd., Lianyungang, China) 10 min before the operation. The patients in the reference group were given 50 mg flurbiprofen ester injection (State Pharmaceutical License: H20183054; Specification: 5 mL: 50 mg × 5 sticks; Wuhan Daan Pharmaceutical Co., Ltd., Wuhan, China).

The patients were positioned prone for G-arm X-ray fluoroscopy (Geelin500-M, Hefei Jimai Intelligent Equipment Co., Hefei, China) to determine the responsible segmental body surface projection puncture point, puncture point from the intervertebral space midline of 8–15 cm and the horizontal line at an angle of 5°–10°. The specification was decided by the attending surgeon according to the actual situation. Then, 1% lidocaine hydrochloride (national drug permit: H32025054; specification: 5 mL: 0.1 g; Jiangsu Yuexing Pharmaceutical Co., Ltd., Xinghua, China) was used with 0.15% ropivacaine hydrochloride (national drug permit: H20113463; specification: 10 mL: 75 mg; Hebei Yipin Pharmaceutical Co., Ltd., Shijiazhuang, China). The mixture, with a volume of 15–20 mL, was injected through the puncture point into the anaesthetized skin and deep muscle fascia layer by layer through the needle. Fluoroscopy was performed to confirm the position of the needle tip in the intervertebral foramen. Then, the guidewire was inserted, and a surgical incision of approximately 1 cm was cut. The surgical channel was expanded with a soft tissue dilation tube and placed in the working trocar. The light source and imaging system were connected. The spinal endoscope was placed into the working trocar, and the lumbar spine tissue structure was clearly exposed in the water medium. Under the microscope, bipolar radiofrequency tip, nucleus pulposus forceps and visual annular saw were used to clean up the surgical field. The visual annular saw was used to perform the upper articular eminence shaping according to the degree of the upper articular eminence obstructing the view of the vertebral canal in the operation. The working trocar was adjusted, the protruding disc was exposed microscopically, and the protruding nucleus pulposus and part of the annulus fibrosus were removed. Then, the compression materials on the ventral side of the nerve root and the intervertebral foramen were explored and cleaned. The observations under the microscope showed that the nerve root had fallen back, the blood vessels on the surface were congested, and the nerve root and the dural sac resumed autonomous pulsation. After no active bleeding was observed and determined, an absorbable haemostatic sponge was placed, the spinal endoscope and working trocar were taken out, and the working channel was closed. Finally, the skin was sutured. The surgical schematic is shown in Fig. 1.

Observation Indicators

Baseline Data Collection

The baseline data of the two groups, including gender, age, body mass index (BMI), disease duration, ASA classification and time of surgery, were collected and compared.

Comparison of Ramsay Sedation Scale Scores

The Ramsay Sedation Scale (RSS) [13] was used to evaluate the anaesthesia sedation of patients in the two groups at different moments (T1: during positioning; T2: during placement of the working trocars; T3: during the removal of the medulla oblongata; and T4: upon completion of the procedure). It allows a score from 1 to 6: 1 point for anxiety and restlessness, 2 points for having a sense of disorientation and quiet cooperation, 3 points for being responsive to commands, 4 points for being drowsy but responsive to

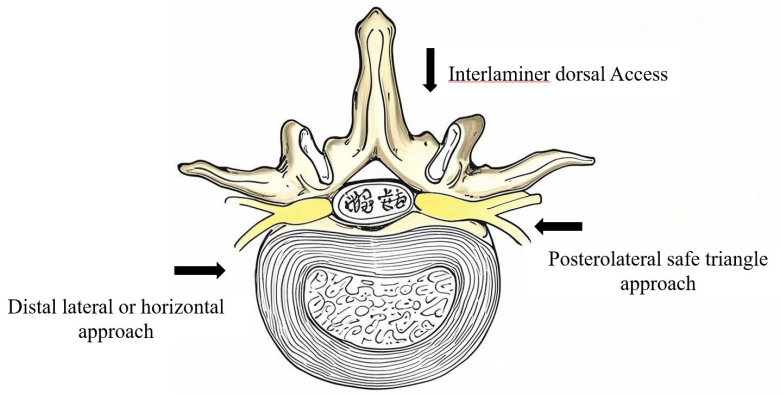

Fig. 1. Schematic diagram of percutaneous transforaminal endoscopic discectomy (PTED) surgery. The figure was plotted using BioRender (v2.0, BioRender Inc., Toronto, ON, Canada).

tapping between the eyebrows or loud auditory stimuli, 5 points for being drowsy and unresponsive to tapping between the eyebrows or loud auditory stimuli; and 6 points for being drowsy and unresponsive to any stimuli. A score of 1 indicates insufficient sedation, scores of 2–4 indicate satisfactory sedation, and a score of 5 or 6 indicates oversedation.

Comparison of Physical Pain Levels

A numerical rating scale (NRS) [14] was used to evaluate the preoperative and 6 h postoperative pain experienced by patients in both groups. The patients were asked to describe the intensity of pain by indicating a number from the range of 0 to 10, with 0 indicating no pain, 0–3 mild pain, 3–7 moderate pain, >7 severe pain, and 10 severe pain.

Monitoring of All Vital Signs

Heart rate (HR), respiratory rate, central venous pressure (CVP) and saturation of percutaneous oxygen saturation (SpO_2) were recorded before anaesthesia (T0), at the time of puncture and positioning (T1), at the time of insertion of the working trocar (T2), at the time of nucleus pulposus removal (T3) and at the time of completion of the operation (T4) in both groups.

Statistics on the Occurrence of Adverse Reactions

The data concerning the occurrence of bradycardia, intraoperative agitation, hypotension, respiratory depression, nausea and vomiting in both groups were compared.

Anaesthesia Satisfaction Survey

After the patient was fully awakened, the patient's level of satisfaction with anaesthesia was investigated using the Iowa Surgery Anesthesia Satisfaction Scale (ISAS) score [15] questionnaire, which consists of 11 questions, each with the six possible answers used in this study. The responses were rated on a scale ranging from –3 to +3. The total score is the mean of the scores for the 11 questions. A fully satisfied patient should score +3 on all questions (after the responses to the 'negative' questions were reversed). The Cronbach's alpha coefficient of the scale is 0.80, indicating good internal consistency.

Statistical Methods

The collected data were analysed and processed using SPSS 26.0 software (64 bit; IBM, Armonk, NY, USA). The categorical variables were expressed as *n* (%), and Pearson's chi-square was used when the sample size was ≥40 and the theoretical frequency was $T \geq 5$. Continuity-corrected chi-square was used when the sample size was ≥40 but the theoretical frequency was $1 \leq T < 5$. If the sample size was <40 or the theoretical frequency was $T < 1$, then Fisher's exact probability method needed to be used instead. The Shapiro–Wilk test was used to determine whether the continuous variables conform to the normal distribution. For the data that do not conform to the normal distribution of the data, the median (interquartile range) was used; the Mann-Whitney *U* test was used for inter-group comparisons. Repeated measures nonparametric tests was used to analyze the clinical indicators at different moments in the two groups of patients, and *post hoc* tests were carried out using Bonferroni's correction method. The difference was statistically significant when $p < 0.05$.

Results

Comparison of the Baseline Information Between the Two Groups

The baseline data of the two groups of patients were collected and compared. The results showed that no significant differences were found between these two groups in terms of age, gender, BMI, duration of illness, salient point, etiology, ASA classification and duration of surgery ($p > 0.05$). A significant difference existed in terms of education and place of residence between the two groups ($p < 0.05$). The details are shown in Table 1.

Table 1. Comparison of the baseline data between the two groups (n [%]), M [P_{25}, P_{75}].

Variable	Research group (n = 50)	Reference group (n = 56)	χ^2/Z	p
Age (years)	56.00 (52.00, 62.00)	56.00 (52.00, 61.00)	–0.154	0.878
Sex			0.026	0.871
Male	26 (52.00)	30 (53.57)		
Female	24 (48.00)	26 (46.43)		
BMI (kg/m^2)	21.70 (20.70, 23.00)	21.80 (20.80, 22.51)	–0.104	0.917
Duration of illness (months)	15.00 (11.00, 20.00)	16.00 (12.00, 19.00)	–0.557	0.578
Etiology			0.172	0.918
Herniated lumbar disk	39 (78.00)	42 (75.00)		
Lumbar spinal stenosis	9 (18.00)	11 (19.64)		
Others	2 (4.00)	3 (5.36)		
Salient point			0.092	0.955
L3-L4	8 (16.00)	10 (17.86)		
L4-L5	23 (46.00)	26 (46.43)		
L5-S1	19 (38.00)	20 (35.71)		
ASA classification			0.132	0.716
Class I	39 (78.00)	42 (75.00)		
Class II	11 (22.00)	14 (25.00)		
Surgical duration (min)	76.00 (59.00, 85.00)	74.00 (57.00, 84.00)	–0.237	0.813
Educational level			12.771	0.002
University	8 (16.00)	14 (25.00)		
Middle school	37 (74.00)	23 (41.07)		
Primary school and below	5 (10.00)	19 (33.93)		
Location of residence			6.660	0.010
Municipalities	12 (24.00)	27 (48.21)		
Countryside	38 (76.00)	29 (51.79)		

ASA, American Society of Anesthesiologists; BMI, body mass index.

Table 2. Comparison of RSS scores at different moments between the two groups of patients (M [P_{25}, P_{75}], points).

Group	n	T1	T2	T3	T4	$F_{groups/number\ of\ measurements/interaction\ value}$	$p_{groups/number\ of\ measurements/interaction\ value}$
Research group	50	2.00 (2.00, 3.00)	3.00 (2.00, 3.00)	2.00 (2.00, 3.00)	2.00 (2.00, 3.00)	111.23/5.86/1.79	<0.001/0.001/0.149
Reference group	56	2.00 (1.00, 2.00) ***	2.00 (1.00, 2.00) ***	2.00 (2.00, 2.00) ***	2.00 (1.00, 2.75) ***		

RSS, Ramsay Sedation Scale. *** denotes $p < 0.001$.

Table 3. Comparison of pain levels at different moments between the two groups (M [P_{25}, P_{75}], points).

Group	Preoperative	6 h postoperative	Z	p
Research group	3.00 (2.00, 4.00)	4.00 (3.00, 5.00)	–5.684	<0.001
Reference group	3.00 (2.00, 4.00)	5.00 (4.00, 6.00)	–7.762	<0.001
Z	–1.645	–3.924		
p	0.100	<0.001		

Table 4. Comparison of intraoperative vital sign indicators between the two groups of patients (M [P_{25}, P_{75}]).

Variable	Group	T0	T1	T2	T3	T4	$F_{groups/number\ of\ measurements/interaction\ value}$	*p*
CVP (mmHg)	Research group	6.80 (6.60, 7.23)	7.00 (6.70, 7.20)	10.35 (8.88, 11.33)	10.95 (9.48, 12.20)	9.05 (8.30, 10.53)	33.697/375.31/4.024	<0.001/<0.001/<0.05
	Reference group	6.70 (6.30, 7.20)	7.50 (7.10, 7.90)***	11.30 (9.93, 12.55)**	11.40 (10.40, 12.75)*	9.70 (8.53, 10.80)*		
HR (cycles/min)	Research group	78.00 (71.00, 81.25)	84.00 (78.00, 89.00)	92.50 (84.75, 99.00)	101.50 (96.50, 107.25)	89.00 (82.50, 98.00)	41.97/199.22/7.27	<0.001/<0.001/<0.01
	Reference group	74.00 (68.00, 80.50)	91.00 (87.00, 96.75)**	97.00 (88.75, 103.00)**	107.50 (96.00, 118.00)**	97.00 (89.00, 101.75)***		
SpO_2 (%)	Research group	97.00 (96.00, 98.00)	94.00 (93.00, 96.00)	95.00 (94.00, 96.00)	93.50 (92.00, 94.25)	97.00 (95.00, 97.25)	195.58/171.49/18.14	<0.001/<0.001/<0.001
	Reference group	97.00 (96.00, 98.00)	93.00 (92.00, 94.00) ***	92.00 (91.00, 93.00) ***	93.00 (92.00, 94.00) **	93.50 (92.00, 95.00) ***		
Respiratory rate (breaths/min)	Research group	16.00 (14.00, 19.00)	17.00 (15.00, 19.25)	19.00 (16.75, 20.00)	17.00 (15.00, 20.00)	16.00 (14.00, 18.00)	2.30/14.05/0.90	0.13/<0.001/0.47
	Reference group	16.00 (14.00, 18.00)	19.00 (16.00, 20.00)	18.00 (16.25, 20.75)	17.00 (16.00, 18.75)	17.00 (14.00, 18.00)		

CVP, central venous pressure; HR, heart rate; SpO_2, percutaneous oxygen saturation; T0, recorded before anaesthesia; T1, at the time of puncture and positioning; T2, at the time of insertion of the working trocar; T3, at the time of nucleus pulposus removal; T4, at the time of completion of the operation;*indicates a significant difference between the groups at the same moment, $p < 0.05$; **indicates a significant difference between the groups at the same moment, $p < 0.01$; ***indicates a significant difference between the groups at the same moment, $p < 0.001$.

Table 5. Comparison of the occurrence of intraoperative adverse reactions between the two groups (*n* [%]).

Group	Bradycardia	Intraoperative agitation	Low blood pressure	Respiratory depression	Nausea	Vomiting	Total incidence
Research group ($n = 50$)	1 (2.00)	0	0	0	1 (2.00)	1 (2.00)	6.00% (3/50)
Reference group ($n = 56$)	0	1 (1.79)	2 (3.57)	1 (1.79)	2 (3.57)	1 (1.79)	12.50% (7/56)
χ^2							0.656
p							0.418

Comparison of RSS Scores

The two groups at different moments were collected and analyzed. The results showed that the RSS scores of the patients in the research group were significantly higher than those of the reference group at T1–T4 ($p < 0.001$). These data are demonstrated in Table 2.

Comparison of Pain Levels

The pain levels of the two groups of patients at different moments were collected and compared. The results showed no significant difference was found in the preoperative NRS scores of these two groups ($p > 0.05$). However, the surgical operation increased their pain levels. Thus, the NRS scores of the patients in both groups were significantly higher than the preoperative ones at 6 h after the operation ($p < 0.001$). The NRS scores of the patients in the research group were significantly lower than those of the reference group at 6 h postoperatively ($p < 0.001$). These data are presented in Table 3.

Comparison of Intraoperative Vital Sign Indicators

Regarding the indicators of intraoperative vital signs, we found no significant differences between the two groups in terms of CVP, HR, SpO_2 and respiratory frequency at the moment of T0 ($p > 0.05$). In comparison, CVP and HR levels in the study group were significantly lower than those in the reference group at the T1–T4 stage, while SpO_2 was significantly higher than that in the reference group ($p < 0.05$). However, no significant difference was found between the two groups in terms of respiratory frequency ($p > 0.05$). These data are shown in detail in Table 4.

Occurrence of Intraoperative Adverse Reactions

Analyzed with SPSS software, the incidence of intraoperative adverse reactions was lower in the research group than in the reference group; however, this difference was not statistically significant ($p > 0.05$). These data are shown in Table 5.

Anaesthetic Satisfaction

The ISAS scores of the two groups of patients do not conform to the normal distribution, as verified by SPSS software. Thus, the data are expressed as M (P_{25}, P_{75}), with the ISAS scores of the research group and the control group as 1.00 (–1.00, 2.00) and 0.00 (–1.00, 1.00), respectively. Comparisons indicate that a significant difference exists in the ISAS scores between the two groups ($Z = –2.295$, $p = 0.022$).

Discussion

Fostering the development and adoption of minimally invasive surgery is the current trend in the surgical field globally. Procedures using spinal endoscopic technology are increasingly gaining traction among neurosurgeons worldwide. Among them, PTED results in minimal damage and has a wide range of indications for the treatment of intervertebral discs, vertebral body and spinal canal diseases. It is also the new spine surgery development trend and an important direction of development.

Despite significant advances in perioperative medicine, a large proportion of patients still experience severe pain during the perioperative period [16]. One study reported that some patients undergoing PTED cannot tolerate the pain during surgery, particularly during the fibrous ring and posterior ligament repair [17]. The intense pain experienced by patients undergoing this type of surgery can be caused by the relatively large diameter of the intervertebral foramen (approximately 8 mm). The foramen magnum may cause a certain degree of compression of the nerve roots during the procedure, which may be more pronounced, particularly in middle-aged and elderly patients with decreased intervertebral height and narrow intervertebral spaces. Furthermore, the surgery itself triggers a stress response in patients. This stress response often exacerbates pain by affecting the levels of various stress-related substances in the body (e.g., cortisol and malondialdehyde (MDA)).

Satisfactory intraoperative analgesia is essential for surgical performance. PTED is performed around the nerve roots. Therefore, patient consciousness and certain motor functions must be maintained to minimize damage to the nerve roots. General anaesthesia (GA) provides complete sedation with analgesia, thereby preventing the patient from perceiving and responding to neuro-injurious stimuli; thus, the use of GA may greatly predispose users to the risk of neurological complications [18]. However, the use of LA alone may not necessarily results in good anaesthetic effect; in particular, this form of anaesthesia is ineffective in controlling pain caused by nerve root traction, trocar placement and posterior longitudinal ligament stimulation, and patients sometimes abandon the procedure because of in-

tolerable pain [19]. Therefore, LA regimens are commonly accompanied by higher dosage of opioid analgesia, which increases the incidence of adverse reactions, such as nausea and vomiting in the perioperative period [20]. Hyperalgesia refers to the measures taken before the start of surgery to block the injury receptors and reduce postoperative pain [21]. The results of one study confirmed the use of suprapubic application of butorphanol combined with ultrasound-guided multipoint block in knee arthroplasty can maintain smooth intraoperative blood flow in patients with good analgesic effects [22]. On the basis of the above studies, we hypothesized that the implementation of preoperative butorphanol in patients undergoing PTED treatment can lead to a good analgesic and sedative effect.

As shown in Table 1, no statistical difference exists between the baseline data of the two groups of patients except for the level of education and place of residence ($p > 0.05$). This study aims to explore the effect of different anaesthesia management protocols on patients who underwent PTED. The level of education and the place of residence of the two groups are not direct determinants. Thus, their variability does not have any effect on the results of the study. The RSS scores of patients in the research group were significantly higher than those of the reference group at T1–T4 ($p < 0.001$). This finding is presumed to be due to the fact that butorphanol, in the presence of μ-receptors *in vivo* without the μ-receptor agonists, prevents nociceptive impulse conduction by mainly agonizing the κ-receptor and hyperpolarizing the membrane potential through the mechanism of G-protein coupling. This scenario leads to a reduction in the release of metamorphic neurotransmitter, such as substance P. It also allows the postsynaptic membrane to hyperpolarize. In the case of μ- and δ-receptors, the dose-dependent analgesic and sedative effects at the spinal level are minimal. In the case of μ-receptor agonists, butorphanol antagonizes μ-receptors whilst agonizing κ-receptors to provide analgesia and sedation. As a result, side effects such as respiratory depression at μ-receptors are reduced or eliminated. This finding is similar to the findings of Reed *et al*. [23].

Our results also showed that the use of preoperative butorphanol can result in a good analgesic effect, as shown in Table 3, where the 6-h postoperative NRS score for the research group was significantly lower than that of the reference group ($p < 0.001$), because butorphanol can reduce the area of myocardial infarction through the action of κ-opioid receptor and adenosine triphosphate–sensitive potassium channels. Butorphanol can also reduce the production of myocardial MDA. MDA is a marker of oxidative stress, and elevated levels of MDA are usually accompanied by the onset and development of pain; thus, the effective inhibition of MDA production is conducive to the reduction of physical pain. Similar results were reported by Calapai *et al*. [24].

Regarding the occurrence of intraoperative adverse reactions, the incidence of intraoperative adverse reactions in patients receiving the butorphanol anaesthesia regimen was not significantly different from the incidence in the reference group, most likely attributed to the small sample size in the current study since the sample size directly affects the validity of the statistical test. Even if real differences existed, they might not be detected by the statistical test because of the low statistical efficacy. Furthermore, some uncontrolled confounding factors in this retrospective study may have affected the results, thereby masking the true between-group differences.

Perioperative anaesthesia services, including perioperative assessment for identifying the risk factors associated with anaesthesia and the surgery, choosing of the type of anaesthesia, and predicting the possible outcomes, are crucial. Being satisfied with perioperative anaesthesia services is defined as the degree to which the patient's expectations are met [25]. The results of the current study showed that the surgical anaesthesia satisfaction of the patients in the research group was significantly higher than that of the reference group ($p < 0.05$), mainly attributed to butorphanol's potent analgesic and sedative effects in the research group. Our analysis revealed that the preoperative use of butorphanol results in remarkable analgesic and sedative effect, which helps alleviate patients' pain and discomfort caused by surgical operations, thereby improving their comfort and satisfaction. This outcome was confirmed in a study by Guo *et al*. [26].

Several limitations of this study should be acknowledged. Firstly, given the fact that it is a retrospective analysis, interpretation of the results could be affected by the quality of the data, bias or confounding effects, as well as the difficulty of controlling for all confounding factors, which may lead to biased results. In addition, the small sample size in this study lowers the chances of detecting true existence of the observed effect, compromising the intrinsic validity of the study and therefore the extrapolation of the results. In light of this limitation, subsequent studies could adopt a randomized controlled trial design and bigger sample size in order to improve the validity and reliability of the results.

Conclusions

The use of preoperative butorphanol is beneficial for patients undergoing PTED surgery. Its application enhances anaesthetic and sedative effects while mitigating postoperative pain. This study provides insights into developing better anaesthesia protocols for PTED.

Availability of Data and Materials

All experimental data included in this study can be obtained by contacting the corresponding author if needed.

Author Contributions

JLC and JZZ designed the research study. XHS and WLR performed the research. JLC, JZZ and JMZ analyzed the data. WLR drafted this manuscript. All authors contributed to important editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

This study obtained approval from Tianjin Hospital of Tianjin University's ethics committee (approval number: 20240379), all patients were informed of all possible clinical outcomes of the different treatments and signed a written informed consent.

Acknowledgment

Not applicable.

Funding

This research received no external funding.

Conflict of Interest

The authors declare no conflict of interest.

References

[1] Basic Research and Transformation Society, Professional Committee of Spine and Spinal Cord, Chinese Association of Rehabilitation Medicine. Guideline for diagnosis, treatment and rehabilitation of lumbar disc herniation. Zhonghua Wai Ke Za Zhi [Chinese Journal of Surgery]. 2022; 60: 401–408. https://doi.org/10.3760/cma.j.cn112139-20211122-00548. (In Chinese)

[2] Zhang AS, Xu A, Ansari K, Hardacker K, Anderson G, Alsoof D, *et al*. Lumbar Disc Herniation: Diagnosis and Management. The American Journal of Medicine. 2023; 136: 645–651. https://doi.org/10.1016/j.amjmed.2023.03.024.

[3] Rapčan R, Kočan L, Witkovsky V, Rapčanová S, Mláka J, Tirpák R, *et al*. Endoscopic discectomy of the herniated intervertebral disc and changes in quality-of-life EQ-5D-5L analysis. Medicine. 2023; 102: e34188. https://doi.org/10.1097/MD.0000000000034188.

[4] Gadjradj PS, Rubinstein SM, Peul WC, Depauw PR, Vleggeert-Lankamp CL, Seiger A, *et al*. Full endoscopic versus open discectomy for sciatica: randomised controlled non-inferiority trial. BMJ (Clinical Research Ed.). 2022; 376: e065846. https://doi.org/10.1136/bmj-2021-065846.

[5] Mooney J, Laskay N, Erickson N, Salehani A, Mahavadi A, Ilyas A, *et al*. General vs Local Anesthesia for Percutaneous Endoscopic Lumbar Discectomy (PELD): A Systematic Review and Meta-Analysis. Global Spine Journal. 2023; 13: 1671–1688. https://doi.org/10.1177/21925682221147868.

[6] Erken HY, Karaeminogullari O, Yilmaz O, Mirel K, Ozer RO. Local Anesthesia and Conscious Sedation Does Not Affect Patient's Mood and Anxiety Levels during Percutaneous Endoscopic Lumbar Diskectomy: A Prospective Study. Journal of Neurological Surgery. Part A, Central European Neurosurgery. 2022; 83: 435–441. https://doi.org/10.1055/s-0041-1739203.

[7] Marhofer P, Hopkins PM. Anaesthesiologists versus surgeons, or regional anaesthesia versus local anaesthesia? British Journal of Anaesthesia. 2020; 124: 126–128. https://doi.org/10.1016/j.bja.2019.10.008.

[8] Verma A, Sharma N, Chilkoti G, Garg PK. Intra-operative pain and patient satisfaction during lichtenstein repair under local anesthesia versus spinal anesthesia: an open-label randomized controlled trial. Hernia: the Journal of Hernias and Abdominal Wall Surgery. 2022; 26: 1089–1094. https://doi.org/10.1007/s10029-022-02561-6.

[9] Meng T, Lin X, Li X, Yue F, Zhang Y, Wang Y, *et al*. Pre-anesthetic use of butorphanol for the prevention of emergence agitation in thoracic surgery: A multicenter, randomized controlled trial. Frontiers in Medicine. 2022; 9: 1040168. https://doi.org/10.3389/fmed.2022.1040168.

[10] Zhang C, Jiang S, Lu Y, Yuan F. Butorphanol tartrate mitigates cellular senescence against tumor necrosis factor -α (TNF-α) in human HC-A chondrocytes. Bioengineered. 2022; 13: 5434–5442. https://doi.org/10.1080/21655979.2021.2024651.

[11] Zhu X, Chen L, Zheng S, Pan L. Comparison of ED95 of Butorphanol and Sufentanil for gastrointestinal endoscopy sedation: a randomized controlled trial. BMC Anesthesiology. 2020; 20: 101. https://doi.org/10.1186/s12871-020-01027-5.

[12] World Medical Association. World Medical Association Declaration of Helsinki: Ethical Principles for Medical Research Involving Human Participants. JAMA. 2025; 333: 71–74. https://doi.org/10.1001/jama.2024.21972.

[13] Gill M, Green SM, Krauss B. A study of the Bispectral Index Monitor during procedural sedation and analgesia in the emergency department. Annals of Emergency Medicine. 2003; 41: 234–241. https://doi.org/10.1067/mem.2003.53.

[14] Farrar JT, Young JP, Jr, LaMoreaux L, Werth JL, Poole MR. Clinical importance of changes in chronic pain intensity measured on an 11-point numerical pain rating scale. Pain. 2001; 94: 149–158. https://doi.org/10.1016/S0304-3959(01)00349-9.

[15] Dexter F, Aker J, Wright WA. Development of a measure of patient satisfaction with monitored anesthesia care: the Iowa Satisfaction with Anesthesia Scale. Anesthesiology. 1997; 87: 865–873. https://doi.org/10.1097/00000542-199710000-00021.

[16] Baca Q, Marti F, Poblete B, Gaudilliere B, Aghaeepour N, Angst MS. Predicting Acute Pain After Surgery: A Multivariate Analysis. Annals of Surgery. 2021; 273: 289–298. https://doi.org/10.1097/SLA.0000000000003400.

[17] Zhang J, Wang X, Cai Z, Kang J, Liu Y, Nie C, *et al*. Analgesic effect of epidural anesthesia via the intervertebral foramen approach in percutaneous transforaminal endoscopic discectomy: a retrospective study. BMC Anesthesiology. 2022; 22: 397. https://doi.org/10.1186/s12871-022-01924-x.

[18] Zhou T, Ma T, Gu Y, Zhang L, Che W, Wang Y. How to predict the culprit segment in percutaneous transforaminal endoscopic surgery under local anesthesia for surgical treatment of lumbar degenerative diseases? Radiologic images or clinical symptoms. Frontiers in Surgery. 2023; 9: 1060318. https://doi.org/10.3389/fsurg.2022.1060318.

[19] Lin W, Ma WT, Xue Y. Low Back Pain Induced by Posterior Longitudinal Ligament Incision in Percutaneous Transforaminal Endoscopic Lumbar Discectomy. Orthopaedic Surgery. 2020; 12: 1230–1237. https://doi.org/10.1111/os.12747.

[20] Fan Y, Gu G, Fan G, Zhu Y, Yang Y, Gu X, *et al*. The effect of preoperative administration of morphine in alleviating intraoperative pain of percutaneous transforaminal endoscopic discectomy under local anesthesia: A STROBE compliant study. Medicine. 2017; 96: e8427. https://doi.org/10.1097/MD.0000000000008427.

[21] Yang DZ, Sin B, Beckhusen J, Xia D, Khaimova R, Iliev I. Opioid-Induced Hyperalgesia in the Nonsurgical Setting: A Systematic Review. American Journal of Therapeutics. 2019; 26: e397–e405. https://doi.org/10.1097/MJT.0000000000000734.

[22] Xuan C, Yan W, Wang D, Li C, Ma H, Mueller A, *et al*. Efficacy of preemptive analgesia treatments for the management of postoperative pain: a network meta-analysis. British Journal of Anaesthesia. 2022; 129: 946–958. https://doi.org/10.1016/j.bja.2022.08.038.

[23] Reed R, Trenholme N, Skrzypczak H, Chang K, Ishikawa Y, Barletta M, *et al*. Comparison of hydromorphone and butorphanol for management of pain in equine patients undergoing elective arthroscopy: a randomized clinical trial. Veterinary Anaesthesia and Analgesia. 2022; 49: 490–498. https://doi.org/10.1016/j.vaa.2022.05.006.

[24] Calapai M, Puzzo L, Bova G, Vecchio DA, Blandino R, Barbagallo A, *et al*. Effects of Physical Exercise and Motor Activity on Oxidative Stress and Inflammation in Post-Mastectomy Pain Syndrome. Antioxidants (Basel, Switzerland). 2023; 12: 643. https://doi.org/10.3390/antiox12030643.

[25] Teshome D, Mulat Y, Fenta E, Hunie M, Kibret S, Tamire T, *et al*. Patient satisfaction and its associated factors towards perioperative anesthesia service among surgical patients: A cross-sectional study. Heliyon. 2022; 8: e09063. https://doi.org/10.1016/j.heliyon.2022.e09063.

[26] Guo F, Sun DF, Feng Y, Yang L, Li JL, Sun ZL. Efficacy and safety of propofol target-controlled infusion combined with butorphanol for sedated colonoscopy. World Journal of Clinical Cases. 2023; 11: 610–620. https://doi.org/10.12998/wjcc.v11.i3.610.