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Research Article

Perioperative factors associated with severe early postoperative pain after single-level lumbar discectomy: A retrospective cohort study

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ABSTRACT

Background: Lumbar disc herniation is a frequent cause of radicular low back pain, and lumbar discectomy remains one of the most commonly performed spinal procedures when conservative treatment fails. Despite advances in surgical technique and perioperative management, postoperative pain—particularly during the early postoperative period—remains clinically relevant. Severe pain within the first 24 hours after surgery may delay mobilization, increase opioid requirements, and complicate recovery. However, perioperative factors associated with severe early postoperative pain following elective single-level lumbar discectomy remain incompletely understood.

Methods: This retrospective cohort study included adult patients undergoing elective single-level lumbar discectomy under general anesthesia. Postoperative pain intensity was assessed using the maximum numeric rating scale score recorded within the first 24 hours. Severe pain was defined as a score $\geqslant$7. Demographic, operative, and analgesic variables, including operative duration, intraoperative opioid exposure (fentanyl equivalents), multimodal analgesia, and rescue opioid use, were analyzed. Univariable and multivariable logistic regression analyses identified factors independently associated with severe early postoperative pain.

Results: Among 322 patients, 78 (24.2%) experienced severe early postoperative pain. Longer operative duration (adjusted odds ratio 1.38 per 10-minute increase), higher intraoperative opioid exposure (adjusted odds ratio 1.29 per 50 microgram increase), absence of multimodal analgesia (adjusted odds ratio 0.46), and post-anesthesia care unit rescue opioid administration (adjusted odds ratio 3.12) were independently associated with severe pain within the first 24 hours.

Conclusions: Severe early postoperative pain after single-level lumbar discectomy is common and is influenced by perioperative factors. Optimizing multimodal analgesia and limiting intraoperative opioid exposure may improve outcomes.

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1. Introduction

Lumbar disc herniation is a common cause of radicular low back pain, and lumbar discectomy remains one of the most frequently performed surgical procedures when conservative treatment fails [1]. Despite advances in surgical technique and perioperative management, postoperative pain continues to be a clinically relevant problem, particularly during the early postoperative period [2].

Pain intensity during the first 24 hours after lumbar discectomy varies substantially among patients. Even

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after technically uncomplicated single-level procedures, postoperative pain may range from minimal discomfort to severe pain requiring additional analgesic interventions [2]. Early postoperative pain is clinically important, as it may delay mobilization, increase opioid requirements, and complicate early postoperative care. Moreover, recent studies have suggested that higher pain intensity in the immediate postoperative period may be associated with poorer functional outcomes after lumbar disc surgery [3].

A number of perioperative factors have been investigated as potential contributors to postoperative pain following spine surgery. Operative duration is often considered a surrogate marker for surgical complexity and tissue trauma and has been included among predictors of postoperative pain intensity in lumbar disc surgery populations [2]. In addition, perioperative analgesic strategy represents a potentially modifiable determinant of postoperative pain. In spine surgery, multimodal analgesia has been widely recommended, with systematic reviews and umbrella reviews consistently reporting improved early pain control and opioid-sparing effects when non-opioid adjuncts are incorporated into perioperative care [4–6]. Studies focusing specifically on lumbar disc surgery frequently assess pain at 24 hours as a key outcome, underscoring the clinical relevance of the immediate postoperative period [7].

The role of intraoperative opioid exposure in postoperative pain control has also been increasingly examined. Experimental and clinical evidence indicates that higher intraoperative opioid requirements do not necessarily result in superior postoperative analgesia and may, in some settings, be associated with opioid-induced hyperalgesia or increased pain sensitivity during early recovery [8–10]. These findings suggest that the relationship between intraoperative opioid administration and postoperative pain is complex and may not be linear.

Despite the growing body of literature on postoperative pain after spine surgery, important gaps remain. Many previous studies have evaluated heterogeneous surgical populations, including multilevel procedures or instrumented operations, limiting procedure-specific interpretation [2,6]. Furthermore, much of the existing literature has focused on mid- or long-term outcomes, while determinants of severe pain within the first 24 hours have received comparatively less attention. Data specifically addressing early severe postoperative pain in patients undergoing elective single-level lumbar discectomy therefore remain limited.

Accordingly, the present study was designed to evaluate perioperative factors associated with severe early postoperative pain following elective single-level lumbar discectomy.

2. Materials and Methods

2.1. Study design and ethical approval

This retrospective cohort study was conducted at a tertiary care center after approval was obtained from the İstinye University Human Research Ethics Committee (Approval Number: 2026/11; Date: 09.01.2026). Due to the retrospective nature of the study and the use of anonymized patient data, the requirement for written informed consent was waived.

2.2. Study population

Adult patients ($\geqslant$18 years) who underwent elective single-level lumbar microdiscectomy under general anesthesia were eligible for inclusion. All procedures were performed using a standard open midline posterior approach.Patients were identified through the hospital electronic medical record system. Only primary procedures were included.

Patients were excluded if they underwent multilevel surgery, procedures involving fusion or instrumentation, emergency operations, revision surgery, postoperative intensive care unit admission, early reoperation, or had missing postoperative pain documentation within the first 24 hours.

2.3. Data collection

Demographic and perioperative data were retrospectively extracted from electronic medical records. Collected variables included age, sex, body mass index, ASA physical status, operated disc level, and operative duration.

Perioperative analgesic variables included intraoperative opioid administration (expressed as fentanyl equivalents), use of multimodal analgesia, requirement for rescue opioid analgesia in the post-anesthesia care unit (PACU), and postoperative patient-controlled analgesia use. Intraoperative analgesia was provided using fentanyl and remifentanil, with cumulative opioid exposure standardized by conversion to fentanyl equivalents. Multimodal analgesia was based on the routine postoperative analgesic protocol of the neurosurgery clinic and consisted of scheduled paracetamol administered every 8 hours during the first 24 hours after surgery. Intravenous tramadol was administered as rescue analgesia when clinically indicated based on postoperative pain assessment.

Postoperative pain intensity was routinely assessed and documented by nursing staff using a standard numeric rating scale (NRS; 0–10) as part of usual postoperative care. All pain scores recorded within the first 24 hours after surgery were reviewed, and the maximum NRS value during this period was used for analysis.

2.4. Outcome measures

Postoperative pain severity was categorized based on the maximum NRS score within the first 24 hours as follows:

- Mild pain: NRS 0–3
- Moderate pain: NRS 4–6
- Severe pain: NRS $\geqslant$7

For regression analyses, pain severity was dichotomized into non-severe pain (NRS 0 – 6) and severe pain (NRS $\geqslant$7).

The primary outcome of interest was the occurrence of severe early postoperative pain within the first 24 hours after surgery.

2.5. Statistical analysis

Continuous variables were assessed for normality and are presented as mean ± standard deviation or median with interquartile range, as appropriate. Categorical variables are presented as number and percentage.

Comparisons between patients with severe and non-severe postoperative pain were performed using the independent samples t-test or Mann–Whitney U test for continuous variables and the chi-square or Fisher's exact test for categorical variables, as appropriate.

Variables showing clinical relevance or a univariable association with severe postoperative pain were entered into a multivariable logistic regression model to identify factors independently associated with severe early postoperative pain. Results are reported as odds ratios with 95% confidence intervals. A two-sided p value <0.05 was considered statistically significant. Statistical analyses were performed using standard statistical software.

3. Results

During the study period, 327 adult patients underwent elective single-level lumbar discectomy. Five patients were excluded due to incomplete postoperative pain data within the first 24 hours. Accordingly, a total of 322 patients were included in the final analysis. Flowchart in Fig. 1 depicts the patient eligibility assessment, exclusions, and formation of the final study cohort. Postoperative pain severity was determined using the maximum numeric rating scale (NRS) score recorded within the first 24 hours after surgery and classified as mild (NRS 0 – 3), moderate (NRS 4 – 6), or severe (NRS ⩾7).

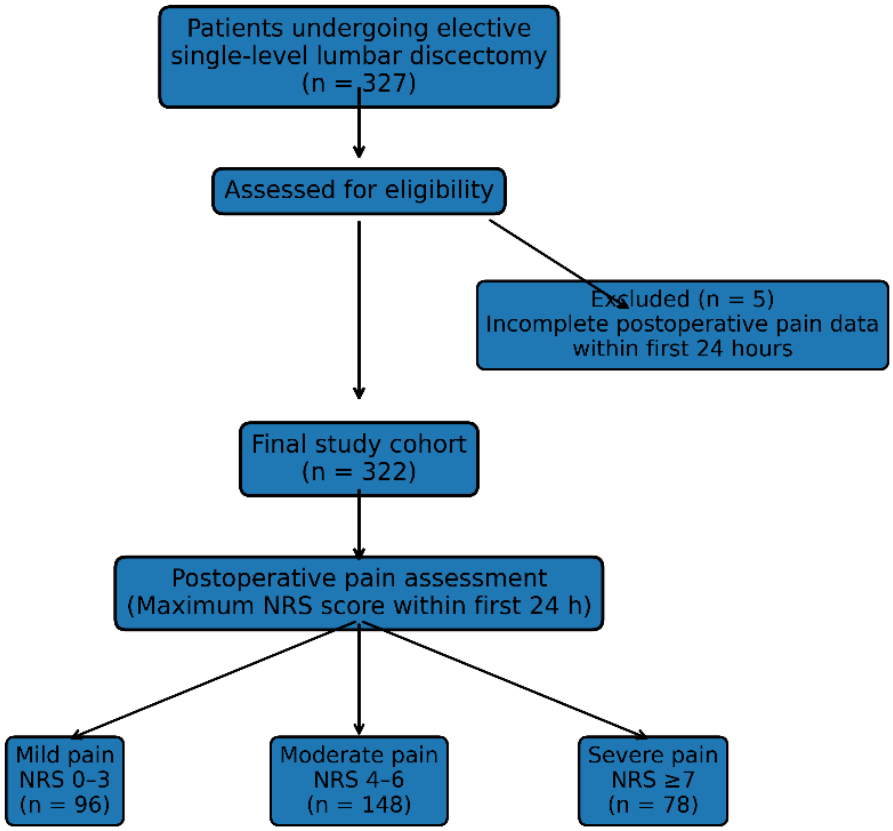

Fig. 1. Flowchart of patient selection and postoperative pain classification.

Postoperative pain severity was assessed using the maximum numeric rating scale (NRS) score recorded within the first 24 hours after surgery. Based on this value, pain severity was categorized as mild (NRS 0–3), moderate (NRS 4–6), or severe (NRS ≥7). Mild pain was observed in 96 patients (29.8%), moderate pain in 148 patients (46.0%), and severe pain in 78 patients (24.2%) (Table 1). Postoperative pain severity was classified according to the maximum numeric rating scale (NRS) score recorded within the first 24 hours after surgery. Values are presented in percentage.

Table 1. Distribution of postoperative pain severity within the first 24 hours.

Postoperative pain severity (NRS)	n	%
Mild (0–3)	96	29.8
Moderate (4–6)	148	46.0
Severe (≥7)	78	24.2

In contrast, several perioperative variables showed significant differences. Patients with severe postoperative pain had longer operative durations and received

higher amounts of intraoperative opioids. The use of multimodal analgesia was less frequent in the severe pain group. In addition, rescue opioid administration in the post-anesthesia care unit and postoperative patient-controlled analgesia use were both more common among patients with severe postoperative pain (Table 2). Values are presented as mean ± standard deviation, median [interquartile range], or percentage, as appropriate.

Table 2. Baseline and perioperative characteristics according to postoperative pain severity.

Variable	Non-severe pain (NRS 0–6) (n = 244)	Severe pain (NRS ≥7) (n = 78)	p value
Age, years	47.6 ± 11.8	49.1 ± 12.3	0.31
Male sex, n (%)	146 (59.8)	49 (62.8)	0.64
Body mass index, kg/m^2	27.1 ± 3.9	27.8 ± 4.2	0.18
ASA physical status I–II / III, n	198 / 46	58 / 20	0.07
Operated disc level (L4–5 / L5–S1), n	140 / 104	46 / 32	0.88
Operative duration, min	52 [45–62]	67 [58–78]	<0.001
Intraoperative opioid dose (fentanyl equivalents), µg	180 [140–220]	250 [210–310]	<0.001
Multimodal analgesia, n (%)	188 (77.0)	42 (53.8)	<0.001
PACU rescue opioid administration, n (%)	64 (26.2)	52 (66.7)	<0.001

ASA: American Society of Anesthesiologists; PACU: post-anesthesia care unit; PCA: patient-controlled analgesia.

In univariable logistic regression analysis, longer operative duration, higher intraoperative opioid exposure, absence of multimodal analgesia, and requirement for rescue opioid administration in the post-anesthesia care unit were significantly associated with severe early postoperative pain (Table 3). Age, sex, and body mass index were not significantly associated with pain severity.

Odds ratios (ORs) with 95% confidence intervals (CIs) are shown in Table 3. Continuous variables were scaled as indicated: operative duration per 10-minute increase and intraoperative opioid dose per 50-µg fentanyl equivalent increase. PACU denotes post-anesthesia care unit.

In the multivariable logistic regression model, longer operative duration (adjusted OR 1.38 per 10-minute increase), higher intraoperative opioid exposure (adjusted OR 1.29 per 50 µg fentanyl equivalents), absence of multimodal analgesia (adjusted OR 0.46), and requirement for rescue opioid administration in the post-anesthesia care unit (adjusted OR 3.12) remained independently associated with severe early postoperative pain. Age and body mass index were not independently associated with the outcome.

Table 3. Univariable and multivariable logistic regression analyses for severe early postoperative pain (NRS ⩾7).

Variable	Univariable OR (95% CI)	p value	Multivariable OR (95% CI)	p value
Operative duration (per 10 min)	1.42 (1.25–1.61)	<0.001	1.38 (1.18–1.62)	<0.001
Intraoperative opioid dose (per 50 µg fentanyl eq.)	1.35 (1.20–1.52)	<0.001	1.29 (1.14–1.47)	<0.001
Multimodal analgesia (yes vs no)	0.39 (0.23–0.65)	<0.001	0.46 (0.26–0.79)	0.005
PACU rescue opioid (yes vs no)	5.46 (3.18–9.37)	<0.001	3.12 (1.78–5.46)	<0.001
Age (per year)	1.02 (0.99–1.04)	0.18	1.01 (0.99–1.03)	0.34
Body mass index (per kg/m^2)	1.06 (1.00–1.12)	0.07	1.04 (0.98–1.10)	0.19
Sex (male vs female)	1.13 (0.68–1.87)	0.64	—	—

4. Discussion

In this retrospective cohort of patients undergoing elective single-level lumbar discectomy, severe postoperative pain within the first 24 hours was observed in approximately one-quarter of cases. Severe pain was associated with longer operative duration, higher intraoperative opioid exposure, lower use of multimodal analgesia, and an increased requirement for rescue opioid administration in the post-anesthesia care unit, while demographic variables were not significantly different between pain groups.

Operative duration showed a clear association with early postoperative pain severity. In spine surgery cohorts, operative time has been discussed as a proxy for tissue trauma and procedural complexity, and longer operations have been linked to increased postoperative pain and analgesic consumption [11,12]. Our findings indicate that this relationship persists even in relatively homogeneous populations undergoing single-level, non-instrumented lumbar discectomy.

Higher intraoperative opioid exposure was independently associated with severe early postoperative

pain. This observation aligns with recent perioperative literature indicating that increasing intraoperative opioid dosing does not always improve postoperative analgesia. Contemporary reviews describe opioid-induced hyperalgesia and acute opioid tolerance as clinically relevant phenomena that may contribute to increased pain during early recovery, particularly with higher opioid exposure [13–15]. Although mechanistic conclusions cannot be drawn from the present study, the observed association supports a cautious approach to escalating intraoperative opioid administration.

In contrast, multimodal analgesia was less frequently used among patients who experienced severe postoperative pain. Recent spine-specific reviews and enhanced recovery protocols emphasize the role of multimodal analgesic strategies in improving early pain control and reducing opioid consumption [16–19]. The present findings reinforce the importance of multimodal analgesia even in procedures that are often perceived as minimally invasive, such as single-level lumbar discectomy.

The requirement for rescue opioid administration in the post-anesthesia care unit was strongly associated with severe early postoperative pain. Early postoperative opioid rescue has been proposed as a marker of insufficient baseline analgesia rather than a direct cause of worse outcomes [20]. Identification of such patients in the immediate postoperative period may allow earlier optimization of analgesic strategies. However, this finding should not be interpreted as a causal relationship. The requirement for opioid rescue analgesia in the post-anesthesia care unit more likely represents a consequence and clinical marker of severe early postoperative pain, reflecting insufficient baseline analgesia rather than a contributing factor, thereby addressing the issue of potential reverse causality.

Several limitations should be acknowledged. First, preoperative pain intensity measured by numeric rating scale (NRS) and a detailed history of chronic opioid use were not consistently available in the retrospective records and therefore could not be included in the analysis. Both factors are well-established predictors of postoperative pain and their omission may have resulted in residual confounding. Consequently, the adjusted odds ratios reported in this study may partially reflect unmeasured baseline pain severity or opioid tolerance, potentially influencing the observed associations. These findings should therefore be interpreted with caution.

5. Conclusions

Severe postoperative pain within the first 24 hours remains common after elective single-level lumbar discectomy and appears to be driven mainly by perioperative factors rather than baseline patient characteristics. Longer operative duration, higher intraoperative opioid exposure, limited use of multimodal analgesia, and early requirement for rescue opioids were associated with an increased risk of severe pain. These findings highlight the importance of optimizing perioperative analgesic strategies, with an emphasis on multimodal and opioid-sparing approaches, to improve early postoperative pain control after lumbar discectomy.

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Conflict of Interest

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this manuscript.

Data Availability

The datasets generated and/or analyzed during the current study are not publicly available but are available from the corresponding author upon reasonable request.

AI Assistance

No AI-based tools were used in the preparation of this manuscript.

Ethics Approval and Consent to Participate

This study was approved by the İstinye University Human Research Ethics Committee (Approval Number: 2026/11; Date: 09.01.2026). Due to the retrospective design, individual informed consent was not obtained; however, all patient data were anonymized prior to analysis. All methods were performed in accordance with relevant guidelines and regulations.

Author Contributions

Erkan Bayram: *conceptualization, data curation, formal analysis, investigation, methodology, supervision, validation, visualization, writing – original draft, writing – review & editing.*
Şükrü Çiftçi: *data curation, visualization, writing – original draft.*

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