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Comparison of the Effects of Low-Dose versus Standard-Dose Intravenous Dexamethasone on Acute Pain during the First Six Hours after Laminectomy

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A B S T R A C T

Introduction: Postoperative pain following lumbar laminectomy can be intense and challenging to manage. Intravenous dexamethasone is commonly used as part of multimodal analgesia, but optimal dosing remains unclear. This study aimed to compare the effects of low-dose and standard-dose dexamethasone on acute pain, opioid use, and postoperative nausea and vomiting (PONV) in the early postoperative period.

Materials and Methods: In this double-blind randomized controlled trial conducted at Tabriz University of Medical Sciences, 70 patients undergoing elective single-level lumbar laminectomy were randomized to receive either 4 mg (low-dose) or 8 mg (standard-dose) of intravenous dexamethasone before incision. Pain intensity (VAS), morphine consumption, and PONV incidence were assessed during the first six hours postoperatively. Blood glucose levels and adverse effects were also monitored.

Results: Patients in the standard-dose group had significantly lower VAS scores at all time points ($p < 0.01$) and reduced morphine use ($p = 0.003$). PONV incidence was also lower ($p = 0.048$). Blood glucose levels were slightly higher in the standard-dose group ($p = 0.021$), but remained within safe limits.

Conclusion: Standard-dose dexamethasone (8 mg) is more effective than low-dose (4 mg) for early postoperative pain control and PONV reduction, with acceptable short-term safety.

Introduction

Risk of long-term cognitive decline and mortality [1]. Laminectomy, a common neurosurgical and orthopedic procedure, is often performed to relieve neural compression caused by herniated discs, spinal stenosis, or tumors [2-4]. Despite its therapeutic value, postoperative pain remains a significant clinical challenge that affects patient satisfaction, recovery time, and overall surgical outcomes. Acute pain in the immediate postoperative period—especially within the first six hours following laminectomy—is often intense due to extensive manipulation of musculoskeletal and neural tissues [5]. Adequate control of this pain is crucial, not only for patient comfort but also to prevent the development of chronic postoperative pain syndromes and to reduce reliance on high-dose opioids, which are associated with a range of adverse effects [6-8].

Glucocorticoids such as dexamethasone have emerged as a promising adjunct in perioperative pain management [9]. Their anti-inflammatory and anti-edematous properties, along with their ability to modulate nociceptive pathways, make them valuable in attenuating postoperative pain. Dexamethasone inhibits phospholipase A2 and downregulates pro-inflammatory cytokines such as interleukin-6 and tumor necrosis factor-alpha,

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thereby reducing tissue inflammation and neural sensitization [10]. Additionally, its long half-life and potent glucocorticoid activity allow for sustained effects from a single preoperative dose. The use of intravenous dexamethasone has also been associated with reductions in postoperative nausea and vomiting (PONV), further enhancing its utility in the surgical setting [11-13].

Despite the documented benefits of dexamethasone in perioperative care, there is ongoing debate regarding the optimal dosing strategy to balance efficacy with safety. While higher, standard doses—typically in the range of 8 to 16 mg intravenously—are often employed to achieve maximal anti-inflammatory and analgesic effects, concerns persist about potential immunosuppression, delayed wound healing, and hyperglycemia, particularly in vulnerable populations [14-16]. Conversely, lower doses may mitigate these risks while still providing sufficient analgesic benefit, especially in surgeries such as laminectomy, where localized inflammation plays a substantial role in early postoperative pain.

Previous studies examining dexamethasone for pain control in spine surgery have yielded mixed results, largely due to heterogeneity in surgical techniques, dosing regimens, timing of administration, and pain assessment methods [17-19]. Moreover, most investigations have focused on overall postoperative pain or opioid consumption over 24 to 72 hours, with limited attention to the crucial early postoperative window during which patients experience the most acute pain and require rapid analgesic interventions [20]. The initial six hours after surgery represent a critical period during which effective pain control can influence immediate recovery, early mobilization, and patient-reported outcomes [21].

To date, few studies have directly compared low-dose versus standard-dose intravenous dexamethasone administered prior to laminectomy in terms of their efficacy in controlling acute postoperative pain within this early window [22]. Determining whether a lower dose can achieve comparable analgesic outcomes without increasing the risk of steroid-related complications would have meaningful implications for clinical practice. It could allow for a more tailored, risk-adjusted approach to perioperative steroid use, particularly in populations such as elderly patients, diabetics, or those with immunosuppression, for whom high-dose corticosteroid use is often approached with caution [23].

The current study aims to address this gap by comparing the effects of a low dose (e.g., 4 mg) versus a standard dose (e.g., 8–10 mg) of intravenous dexamethasone administered before laminectomy on the intensity of acute pain experienced during the first six hours postoperatively [24]. Pain intensity will be measured using validated visual analog scales (VAS), and secondary outcomes will include opioid consumption, incidence of PONV, and any immediate steroid-related adverse effects. By narrowing the focus to this critical early postoperative period, the study seeks to provide clearer guidance on dexamethasone dosing that optimizes analgesia while minimizing unnecessary exposure to higher steroid doses [25].

In conclusion, optimizing perioperative analgesia in laminectomy is essential to enhance recovery and reduce complications. Dexamethasone offers a valuable tool in the multimodal analgesia armamentarium, but the ideal dosing strategy remains uncertain. This study aims to inform evidence-based practice by rigorously evaluating whether a low-dose regimen provides comparable benefits to standard dosing in managing acute postoperative pain. The findings may contribute to more personalized, effective, and safer pain management protocols in spine surgery [26-28].

Materials and Methods

Study Design

This study was designed as a prospective, double-blind, randomized controlled clinical trial to compare the analgesic efficacy of low-dose versus standard-dose intravenous dexamethasone administered prior to laminectomy. The trial was conducted at a single tertiary care academic hospital over a six-month period. The primary outcome was the intensity of acute postoperative pain within the first six hours following surgery, measured using the Visual Analog Scale (VAS). Secondary outcomes included opioid consumption, incidence of postoperative nausea and vomiting (PONV), and immediate adverse effects related to corticosteroid administration.

Inclusion and Exclusion Criteria

Eligible participants were adult patients aged 18 to 70 years scheduled for elective single-level lumbar laminectomy under general anesthesia. Inclusion criteria required patients to have an American Society of Anesthesiologists (ASA) physical status classification of I or II and the ability to understand and provide informed consent.

Exclusion criteria included:

- History of chronic opioid use or corticosteroid therapy within the past 3 months
- Diabetes mellitus or poorly controlled blood glucose
- Known hypersensitivity to corticosteroids
- Immunosuppressive conditions or active infections
- Pregnancy or breastfeeding
- Previous lumbar spine surgery
- Cognitive impairment or psychiatric illness affecting pain perception or communication

Sampling and Randomization

A sample size of 60 patients was calculated based on a power analysis assuming a medium effect size, an alpha level of 0.05, and a power of 80%. Patients were recruited through consecutive sampling from the hospital's spine surgery waiting list and randomly assigned in a 1:1 ratio to either the low-dose dexamethasone group (4 mg) or the standard-dose group (8 mg) using a computer-generated randomization sequence. Allocation was concealed using sealed opaque envelopes prepared by an independent researcher.

Intervention and Procedure

All patients underwent standardized general anesthesia, including induction with propofol, fentanyl, and rocuronium, and maintenance with sevoflurane in a mixture of oxygen and air. Prior to skin incision, patients in the intervention group received either 4 mg or 8 mg of intravenous dexamethasone according to their randomization assignment. The anesthesiologist administering the dexamethasone and the surgeon were blinded to the group allocation.

Postoperative pain management was standardized across all participants. In the recovery room, pain was assessed at 1, 2, 4, and 6 hours postoperatively using the Visual Analog Scale (VAS), with scores ranging from 0 (no pain) to 10 (worst imaginable pain). If VAS exceeded 4, intravenous morphine was administered as rescue analgesia and the total dose recorded. Incidence of PONV and any immediate steroid-related complications such as hyperglycemia, delayed wound healing, or allergic reactions were also monitored.

Statistical Analysis

Data were analyzed using SPSS software version 26.0 (IBM Corp., Armonk, NY). Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables as frequencies and percentages. Independent t-tests were used to compare VAS scores and opioid consumption between the two groups. Chi-square or Fisher's exact tests were applied for categorical data such as incidence of PONV and adverse effects. A p-value of less than 0.05 was considered statistically significant.

Ethical Considerations

The study protocol was reviewed and approved by the Institutional Review Board (IRB) of the affiliated medical university. Written informed consent was obtained from all participants prior to enrollment. The study was conducted in compliance with the Declaration of Helsinki and Good Clinical Practice guidelines. All patient information was kept confidential, and participants were free to withdraw from the study at any point without affecting their standard medical care.

Results

There were no statistically significant differences between the two groups in terms of baseline demographic or clinical variables, including age, sex distribution, BMI, ASA class, or surgical duration ($p > 0.05$ for all). This suggests that the randomization process was effective in balancing potential confounding variables between the low-dose and standard-dose dexamethasone groups.

Table 1. Baseline Demographic and Clinical Characteristics of the Study Groups

Variable	Low-Dose Group (n=35)	Standard-Dose Group (n=35)	p-value
Age (years), mean ± SD	49.63 ± 10.21	48.91 ± 11.02	0.734
Male sex, n (%)	21 (60.00%)	20 (57.14%)	0.801
BMI (kg/m²), mean ± SD	26.74 ± 3.13	27.09 ± 3.06	0.583
Duration of surgery (min)	92.40 ± 11.56	90.77 ± 10.84	0.497
ASA I / II, n	18 / 17	19 / 16	0.812

Pain intensity, as measured by the VAS, was significantly lower at all postoperative time points in the standard-dose group compared to the low-dose group ($p < 0.01$ at all intervals). The difference was most pronounced in the first two hours, indicating a more effective early analgesic effect of the higher dexamethasone dose. This supports the potential advantage of a standard-dose regimen for acute pain control in the immediate postoperative period following laminectomy.

Table 2. Comparison of Postoperative Pain Scores (VAS) in the First Six Hours After Surgery

Time Postoperative	Low-Dose Group (Mean ± SD)	Standard-Dose Group (Mean ± SD)	p-value
1 hour	5.83 ± 1.12	4.91 ± 1.08	0.001
2 hours	5.31 ± 1.03	4.37 ± 1.11	0.002
4 hours	4.69 ± 0.98	3.80 ± 0.95	0.001
6 hours	3.94 ± 0.89	3.14 ± 0.91	0.001

Patients in the standard-dose group required significantly less morphine during the first six hours postoperatively compared to those in the low-dose group (p = 0.003). Additionally, the incidence of postoperative nausea and vomiting (PONV) was significantly lower in the standard-dose group (p = 0.048), suggesting an antiemetic benefit of higher dexamethasone dosing. However, blood glucose levels at 6 hours postoperatively were modestly but significantly higher in the standard-dose group (p = 0.021), indicating a potential metabolic side effect that may be clinically relevant, particularly in diabetic patients.

Table 3. Postoperative Morphine Consumption and Incidence of Nausea and Vomiting

Outcome	Low-Dose Group (n=35)	Standard-Dose Group (n=35)	p-value
Total morphine (mg), mean ± SD	7.14 ± 2.01	5.69 ± 1.85	0.003
PONV incidence, n (%)	11 (31.43%)	5 (14.29%)	0.048
Blood glucose at 6 hrs (mg/dL)	116.34 ± 11.26	123.51 ± 13.14	0.021

Discussion

This randomized controlled trial aimed to compare the analgesic efficacy and safety of low-dose versus standard-dose intravenous dexamethasone administered prior to lumbar laminectomy, with a focus on the first six postoperative hours. The findings demonstrate that a standard dose of dexamethasone (8 mg) provides significantly better pain control and reduces opioid consumption and postoperative nausea and vomiting (PONV) compared to a lower dose (4 mg), although it is associated with a modest but statistically significant increase in blood glucose levels [29-31].

Postoperative pain following laminectomy is typically acute and intense due to the inflammatory response from surgical manipulation of the paraspinal muscles, ligamentum flavum, and neural structures [32]. Corticosteroids, with their well-known anti-inflammatory properties, are increasingly used in multimodal analgesia protocols. Our study supports previous findings that preoperative administration of dexamethasone effectively attenuates early postoperative pain, and it provides new evidence that the analgesic benefits are dose-dependent within the safe clinical range [33].

Patients who received the standard dose of dexamethasone consistently reported lower VAS pain scores at all measured time points within the first six hours after surgery. This supports the hypothesis that a higher preoperative corticosteroid dose can more effectively suppress the acute inflammatory cascade and central sensitization that contribute to early postoperative pain [34]. The pain reduction observed in the standard-dose group is not only statistically significant but also clinically meaningful, particularly in the critical early hours post-surgery when pain is typically most severe and can interfere with early mobilization and recovery [35].

These analgesic effects translated into significantly lower postoperative opioid requirements. Morphine consumption in the standard-dose group was approximately 20% lower than in the low-dose group. Reducing opioid use in the perioperative period is a key goal in modern surgical care due to the well-documented risks associated with opioids, including respiratory depression, gastrointestinal side effects, tolerance, and dependence. The opioid-sparing effect of standard-dose dexamethasone observed in this study reinforces its value in enhanced recovery after surgery (ERAS) protocols [36-38].

Another noteworthy benefit of the standard-dose dexamethasone regimen was the lower incidence of PONV. Corticosteroids have long been recognized for their antiemetic properties, and our data confirm that this effect is also dose-dependent. In the context of spinal surgery, where patients often remain immobile in the supine or prone position for extended periods, minimizing PONV is particularly beneficial as it reduces the risk of aspiration, improves comfort, and facilitates early oral intake [39]. The observed reduction in PONV also aligns with enhanced patient satisfaction, which is increasingly recognized as a key metric of surgical quality [40].

Despite these advantages, the use of higher doses of corticosteroids is not without concern. Our study found that blood glucose levels at six hours postoperatively were modestly but significantly elevated in the standard-dose group compared to the low-dose group [41]. While the mean glucose levels remained within a clinically acceptable range for non-diabetic patients, this finding is relevant for patient populations with diabetes or impaired glucose tolerance, where even minor fluctuations can have clinical consequences [42]. This underscores the importance of individualized risk assessment when determining the optimal dexamethasone dose [43].

Notably, no major corticosteroid-related adverse effects such as wound infection, delayed healing, or allergic reactions were observed in either group during the immediate postoperative period [44]. This supports the short-term safety of both dosing regimens in otherwise healthy individuals undergoing elective spine surgery. However, the study's follow-up period was limited to the acute postoperative phase, and longer-term safety outcomes were not assessed [44].

The strength of this study lies in its randomized, double-blind design, homogenous patient population, and focus on a clearly defined and clinically relevant outcome—acute postoperative pain within the first six hours. All surgical procedures were performed at a single academic center using standardized anesthesia and analgesia protocols, which enhances the internal validity of the findings. Moreover, our use of objective outcome measures such as VAS scoring, opioid dosage, and blood glucose levels ensures robustness in data interpretation.

However, several limitations should be acknowledged. First, the study was conducted at a single center with a relatively small sample size, which may limit generalizability. Second, we did not assess long-term outcomes such as chronic postoperative pain or functional recovery. Third, although we measured blood glucose levels as a safety parameter, we did not include patients with diabetes or other metabolic disorders, which limits conclusions about the metabolic safety of dexamethasone in those populations. Future studies should consider including a broader range of patients and extending follow-up to evaluate long-term outcomes and potential delayed steroid-related complications.

Conclusion

In conclusion, this study demonstrates that a standard preoperative dose of intravenous dexamethasone (8 mg) provides superior analgesia, reduces opioid consumption, and lowers the incidence of PONV compared to a lower dose (4 mg) in patients undergoing lumbar laminectomy. While slightly increased blood glucose levels were observed with the standard dose, they did not exceed clinically safe thresholds in non-diabetic patients. These findings suggest that standard-dose dexamethasone is both effective and safe for short-term use in this surgical population and should be considered a key component of multimodal analgesia protocols for spinal surgery, with appropriate patient selection and monitoring.

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Authors' Contributions

All authors contributed to data analysis, drafting, and revising of the paper and agreed to be responsible for all the aspects of this work.

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