Section: Miscellaneous

Original Research Article

EFFICACY AND SAFETY OF INTERMITTENT POSTOPERATIVE EPIDURAL FENTANYL FOLLOWING LUMBAR DECOMPRESSIVE SURGERY: A RANDOMIZED CONTROLLED STUDY

Rasika Patil[1], Lulu Fatema Vali[2], Shilpa Jaiswal[3]

[1]Senior Resident, at GMCH Nagpur, India.
[2]HOD at Super speciality Hospital, GMCH Nagpur, India.
[3]Assistant Professor, Super speciality Hospital, GMCH Nagpur, India.

Received *: 01/09/2026*
Received in revised form *: 26/09/2026*
Accepted *: 09/10/2026*

Corresponding Author:
Dr. Rasika Patil,
Senior Resident, at GMCH Nagpur, India.
Email: prasika006@gmail.com

DOI: 10.70034/ijmedph.2026.4.366

Source of Support: Nil,
Conflict of Interest: None declared

Int J Med Pub Health
2026; 16 (4); 2427-2433

ABSTRACT

Background: Postoperative pain is a significant concern following lumbar decompressive surgery and may interfere with mobilization and recovery. Epidural administration of opioids provides an option for targeted postoperative analgesia. This study evaluated the efficacy and safety of intermittent postoperative epidural fentanyl in patients undergoing lumbar decompressive surgery.

Materials and Methods: This randomized controlled study included 100 patients undergoing lumbar decompressive surgery who were allocated into two equal groups of 50 patients each. No epidural analgesic was administered intraoperatively. Postoperatively, patients in the Test Group received 15 µg fentanyl as an epidural bolus at 12, 24, and 36 hours through an indwelling epidural catheter. Patients in the Control Group received an equivalent volume of normal saline through the epidural catheter at the same time points. The catheter was removed after the 36-hour dose. Postoperative pain was assessed using the visual analogue scale (VAS) at 4, 8, 12, 24, 36, and 48 hours. Heart rate, systolic and diastolic blood pressure, respiratory rate, and oxygen saturation were also recorded. Epidural catheter blockage and duration of hospital stay were assessed as secondary outcomes.

Results: Preoperative VAS scores were comparable between the Test and Control Groups (8.02 ± 0.68 vs. 7.98 ± 0.74; p=0.7800). No significant difference was observed at 4 hours (5.90 ± 0.76 vs. 5.94 ± 0.77; p=0.7942) or 8 hours (5.60 ± 0.88 vs. 5.82 ± 0.77; p=0.1877). From 12 hours onwards, VAS scores were significantly lower in the Test Group: 4.04 ± 0.95 versus 5.08 ± 0.88 at 12 hours, 3.16 ± 0.99 versus 4.60 ± 0.81 at 24 hours, 2.22 ± 0.93 versus 4.04 ± 0.73 at 36 hours, and 2.16 ± 0.93 versus 3.92 ± 0.80 at 48 hours ($p<0.001$ at all time points). Postoperative heart rate, blood pressure, respiratory rate, and oxygen saturation did not differ significantly between groups. Epidural catheter blockage occurred in 2 (4%) patients in the Test Group and 3 (6%) patients in the Control Group. Mean hospital stay was similar between groups (3.30 ± 0.61 vs. 3.30 ± 0.54 days; p=1.000).

Conclusion: Intermittent postoperative epidural fentanyl administered at 12-hour intervals was associated with significantly lower postoperative pain scores from 12 to 48 hours following lumbar decompressive surgery. No significant differences were observed in routine postoperative hemodynamic or respiratory parameters or duration of hospital stay.

Keywords: Lumbar decompression; Epidural analgesia; Fentanyl; Visual analogue scale; Postoperative analgesia; Lumbar spine surgery.

INTRODUCTION

Lumbar decompressive surgery is commonly performed for symptomatic degenerative lumbar spinal stenosis, particularly in patients presenting with neurogenic claudication and/or radicular symptoms. Although decompression relieves neural compression, postoperative pain remains an important concern and may delay mobilization and recovery.[1]

Postoperative analgesia after lumbar spine surgery frequently relies on systemic analgesics, including opioids. Although effective, opioid administration may be associated with adverse effects such as nausea, vomiting, urinary retention, sedation and respiratory depression. In addition, increasing concern regarding prolonged opioid exposure after surgery has emphasized the need for effective opioid-sparing analgesic strategies.[2]

Several techniques have therefore been investigated to provide analgesia directly at or near the surgical site, including local infiltration, epidural and intrathecal administration of analgesic agents. The epidural space is readily accessible following lumbar decompression, providing an opportunity to administer analgesic medication intraoperatively as a bolus before wound closure. Various agents, including local anesthetics and opioids, have been evaluated using different delivery techniques.[3]

Epidural opioid administration has demonstrated potential for reducing postoperative pain and supplemental analgesic requirements. In a randomized controlled trial, Guilfoyle et al. reported that a single 100-µg epidural fentanyl bolus administered at the completion of lumbar canal decompression resulted in significantly lower pain scores during the immediate recovery period compared with standard postoperative care. However, the difference was not sustained at later postoperative assessments, and no significant difference in hospital stay was observed.[4]

More broadly, a systematic review and meta-analysis of intraoperative epidural analgesia during lumbar decompressive surgery found that several studies demonstrated reductions in postoperative pain and additional analgesic consumption, although considerable heterogeneity existed among the interventions and outcome assessments. Evidence regarding an effect on duration of hospital stay was less consistent.[3,5]

Epidural steroids have also been investigated extensively and may provide short-term postoperative analgesia; however, concerns regarding potential complications, including infection, have limited definitive conclusions regarding their routine use. Reviews of the available evidence have highlighted the need for well-designed randomized trials evaluating alternative epidural analgesic agents and standardized postoperative outcomes.[6,7]

Given these considerations, a single-dose epidural opioid administered at the end of lumbar decompression may provide effective analgesia while avoiding some of the practical limitations associated with prolonged epidural infusions. However, the optimal epidural analgesic regimen and its effectiveness across the early postoperative period remain incompletely defined. Therefore, the present randomized controlled study was undertaken to evaluate the efficacy of Inj Fentanyl 100mcgadministered epidurally at the completion of lumbar decompression, with postoperative pain as the primary outcome, hemodynamic and respiratory parameters, catheter-related complications, and duration of hospital stay as additional outcomes.

MATERIALS AND METHODS

This prospective, randomized, patient-blinded, parallel-group controlled study was conducted atteriary care centre after approval from institutional ethics committee.(**IEC no.).** Adult patients (>18 years) diagnosed with lumbar spinal canal stenosis associated with neurogenic claudication and/or lower-limb radiculopathy and scheduled for lumbar decompression were considered for inclusion. Patients requiring spinal instrumentation, those with previous lumbar spine surgery, or those with contraindications to fentanyl were excluded.

Eligible patients underwent one- to three-level lumbar canal decompression under general anesthesia in the prone position. Participants were randomly assigned in a 1:1 ratio to either the test group or control group. At the completion of decompression and before wound closure, the epidural catheter was positioned at the operative level and advanced rostrally. Following completion of surgery, an epidural catheter was maintained for postoperative analgesia. No epidural analgesic drug was administered intraoperatively. In the Test Group, 15 µg of fentanyl was administered as an epidural bolus at 12, 24, and 36 hours postoperatively through the indwelling epidural catheter. Patients in the Control Group received an equivalent volume of normal saline through the epidural catheter at the same time points. The epidural catheter was removed after administration of the 36-hour dose. Both groups otherwise received the standard postoperative analgesic regimen according to the institutional protocol. Patients with an intraoperative dural tear and cerebrospinal fluid leakage were excluded from epidural drug administration.

Following administration, patients were observed in the postoperative recovery area for monitoring of potential adverse effects. Postoperative analgesia was assessed using the Visual Analogue Scale (VAS), ranging from 0 (no pain) to 10 (worst imaginable pain). Pain scores were recorded at predefined postoperative time points. Secondary outcomes included duration of hospital stay and treatment-related adverse effects.

Randomization was generated using a computer-based sequence, with allocation concealed until treatment assignment. Patients were blinded to their treatment allocation. Outcome assessments were performed using predefined criteria throughout the study.

RESULTS

A total of 100 patients undergoing lumbar decompressive surgery were enrolled in the study and randomly allocated into two equal groups of 50 patients each. The test group received the study epidural analgesic intervention, while the control group received the control treatment. Demographic characteristics, perioperative hemodynamic and respiratory parameters, postoperative pain scores, epidural catheter-related complications, and duration of hospital stay were assessed and compared between the two groups.

Table 1: Comparison of Demographic Characteristics Between the Test and Control Groups

Parameter	Test Group (n=50)	Control Group (n=50)	Mean Difference	P value
Age (years), mean ± SD	47.46 ± 7.95	49.88 ± 5.78	2.42	0.0847 (NS)
Weight (kg), mean ± SD	56.78 ± 7.96	57.84 ± 9.76	1.06	0.5531 (NS)
Sex, n (%)				
Male	23 (46%)	23 (46%)	—	—
Female	27 (54%)	27 (54%)	—	—

Values are expressed as mean ± standard deviation (SD) for continuous variables and number (percentage) for categorical variables. NS = not statistically significant. P values represent between-group comparisons. A p value <0.05 was considered statistically significant.

The demographic characteristics of the study participants are presented in Table 1. The mean age was 47.46 ± 7.95 years in the test group and 49.88 ± 5.78 years in the control group, with no statistically significant difference between the groups (p = 0.0847). Similarly, mean body weight was comparable between the test and control groups (56.78 ± 7.96 kg vs. 57.84 ± 9.76 kg, respectively; p = 0.5531). The sex distribution was identical in both groups, with males comprising 46% and females 54% of participants. Thus, the two groups were demographically comparable at baseline.

Table 2: Comparison of Preoperative Clinical Parameters Between the Test and Control Groups

Parameter	Test Group (n=50) Mean ± SD	Control Group (n=50) Mean ± SD	Mean Difference	P value
Pulse rate (beats/min)	93.70 ± 11.12	93.20 ± 10.01	0.50	0.81
Respiratory rate (breaths/min)	14.48 ± 1.37	14.34 ± 1.66	0.14	0.64
Systolic BP (mmHg)	116.28 ± 7.89	113.78 ± 7.66	2.50	0.11
Diastolic BP (mmHg)	74.98 ± 8.65	77.16 ± 9.36	2.18	0.22
SpO_2 (%)	98.24 ± 1.67	98.16 ± 0.82	0.08	0.76
VAS score	8.02 ± 0.68	7.98 ± 0.74	0.04	0.78

Values are expressed as mean ± standard deviation (SD). BP = blood pressure; SpO_2 = peripheral oxygen saturation; VAS = Visual Analogue Scale; NS = not statistically significant. P values represent between-group comparisons. A p value <0.05 was considered statistically significant

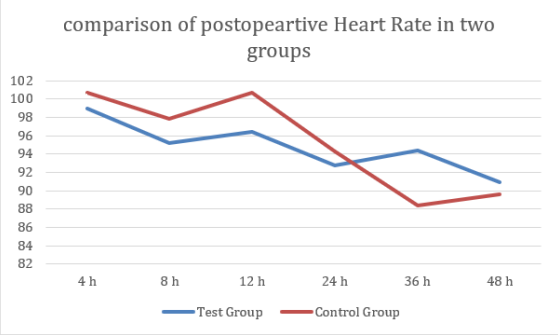
The preoperative clinical parameters of the two groups are presented in Table 2A. There were no statistically significant differences between the test and control groups with respect to preoperative pulse rate, respiratory rate, systolic blood pressure, diastolic blood pressure, SpO_2 , or VAS score (p > 0.05 for all parameters). The mean preoperative VAS scores were also comparable between the test and control groups (8.02 ± 0.68 vs. 7.98 ± 0.74; p = 0.7800). These findings indicate that the two groups were clinically comparable at baseline, minimizing the likelihood that differences in postoperative outcomes were attributable to preoperative physiological or pain-score differences.

Table 3: Comparison of Intraoperative Hemodynamic Parameters Between Test and Control Groups

Parameter	Test Group (n=50) Mean ± SD	Control Group (n=50) Mean ± SD	Mean Difference	P value
Systolic BP (mmHg)	124.28 ± 12.34	122.46 ± 9.80	1.82	0.4161
Diastolic BP (mmHg)	84.48 ± 7.55	82.90 ± 8.62	1.58	0.3321
SpO_2 (%)	100.00 ± 0.00	100.00 ± 0.00	0.00	—

Values are expressed as mean ± standard deviation (SD). BP = blood pressure; SpO_2 = peripheral oxygen saturation; NS = not statistically significant. P values represent between-group comparisons. A p value <0.05 was considered statistically significant. Statistical comparison of SpO_2 was not applicable because both groups had identical values with no variability.

Intraoperative hemodynamic parameters are presented in Table 3. The mean systolic blood pressure was 124.28 ± 12.34 mmHg in the test group and 122.46 ± 9.80 mmHg in the control group, with no statistically significant difference (p = 0.4161). Similarly, mean diastolic blood pressure was comparable between the groups (84.48 ± 7.55 vs. 82.90 ± 8.62 mmHg; p = 0.3321). Intraoperative SpO_2 was 100% in both groups, with no variability observed. Overall, the findings demonstrate comparable intraoperative hemodynamic and oxygenation parameters between the two groups.



Graph 1: comparison of postoperative Heart Rate in two groups.

Postoperative heart rate showed a similar overall pattern between the two groups. Although some differences were observed at individual time points, none of the between-group differences were statistically significant (p>0.05). Thus, the intervention did not produce a significant difference in postoperative heart.

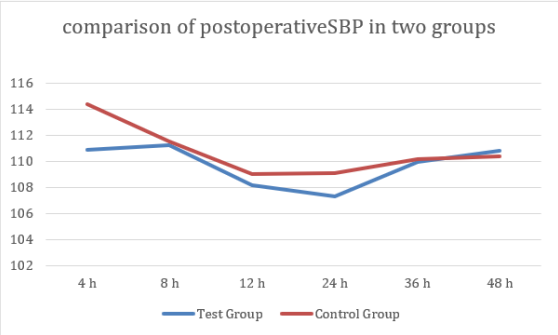


Figure 2: comparison of postoperative SBP in two groups

Postoperative systolic blood pressure showed a similar overall pattern between the two groups. Although some differences were observed at individual time points, none of the between-group differences were statistically significant (p>0.05). Thus, the intervention did not produce a significant difference in postoperative systolic blood pressure.

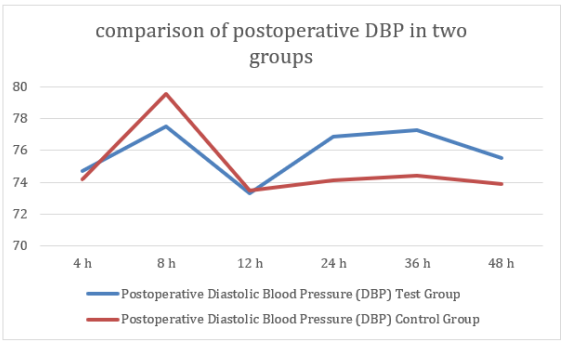


Figure 2: comparison of postoperative DBP in two groups

Postoperative diastolic blood pressure showed a similar overall pattern between the two groups. Although some differences were observed at individual time points, none of the between-group differences were statistically significant (p>0.05). Thus, the intervention did not produce a significant difference in postoperative diastolic blood pressure.

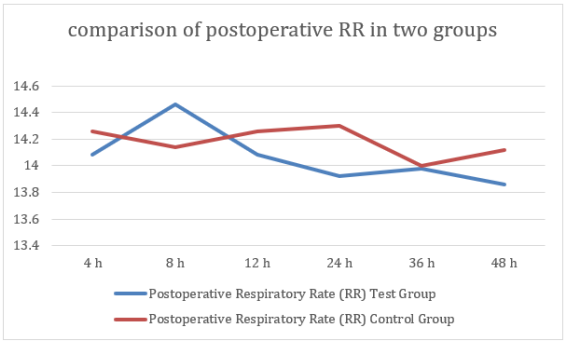


Figure 3: comparison of postoperative RR in two groups

Postoperative respiratory rate showed a similar overall pattern between the two groups. Although some differences were observed at individual time points, none of the between-group differences were statistically significant (p>0.05). Thus, the intervention did not produce a significant difference in postoperative respiratory rate.

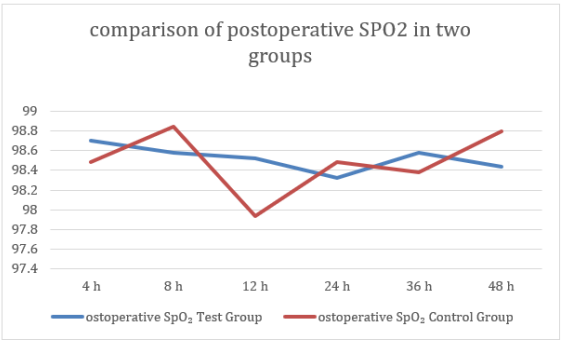


Figure 4: comparison of postoperative SpO2 in two groups

Postoperative saturation showed a similar overall pattern between the two groups. Although some differences were observed at individual time points,

none of the between-group differences were statistically significant (p>0.05). Thus, the intervention did not produce a significant difference in postoperative SpO2

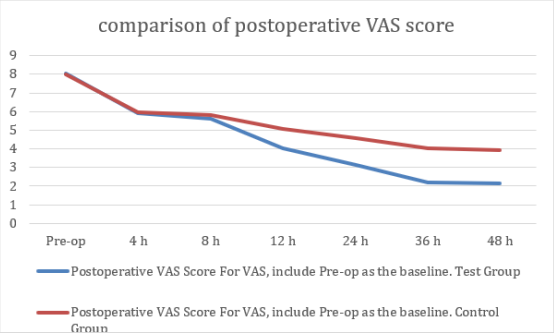


Figure 5: comparison of postoperative VAS score in two groups

Figure 5 demonstrates the change in VAS scores from the preoperative baseline to 48 hours postoperatively. Baseline VAS scores were comparable between the Test and Control Groups. VAS scores decreased progressively in both groups; however, the reduction was greater in the Test Group from 12 hours onwards. The between-group difference was statistically significant at 12, 24, 36, and 48 hours (p<0.001), whereas the differences at 4 and 8 hours were not statistically significant (p>0.05).

Parameter	Test Group (n=50)	Control Group (n=50)	Mean Difference	P value
Duration of hospital stay (days), mean ± SD	3.30 ± 0.61	3.30 ± 0.54	0.00	1.0000

Values are expressed as mean ± standard deviation (SD). Between-group comparison was performed using an appropriate statistical test. p<0.05 was considered statistically significant; NS = not statistically significant.

The mean duration of hospital stay was identical in both groups (3.30 ± 0.61 days in the Test Group versus 3.30 ± 0.54 days in the Control Group). There was no statistically significant difference between the groups (p=1.0000).

Epidural catheter blockage was observed in 2 patients (4%) in the Test Group and 3 patients (6%) in the Control Group during the 48-hour postoperative period. In the Test Group, both episodes occurred at 12 hours, whereas in the Control Group, one episode occurred at 12 hours and two at 24 hours. Overall, catheter blockage was uncommon in both groups, with no apparent clinically important difference in incidence between the groups.

DISCUSSION

Postoperative pain is an important concern following lumbar decompressive surgery and may adversely affect early mobilization, physiotherapy, sleep, and overall recovery. The present randomized controlled study evaluated the effect of intermittent postoperative epidural fentanyl administered through an indwelling epidural catheter at 12, 24, and 36 hours after surgery. In the present randomized controlled study, the preoperative VAS scores were comparable between the Test and Control Groups, indicating similar baseline pain severity. Although no significant difference was observed at 4 and 8 hours postoperatively, a significant reduction in pain was observed in the Test Group from 12 hours onwards. Mean VAS scores were 4.04 ± 0.95 versus 5.08 ± 0.88 at 12 hours, 3.16 ± 0.99 versus 4.60 ± 0.81 at 24 hours, 2.22 ± 0.93 versus 4.04 ± 0.73 at 36 hours, and 2.16 ± 0.93 versus 3.92 ± 0.80 at 48 hours in the Test and Control Groups, respectively (p<0.001). Thus, the principal finding of the study was a sustained reduction in postoperative pain in the Test Group during the later postoperative period.

The analgesic effect of epidural fentanyl can be explained by its action on μ-opioid receptors at both spinal and supraspinal levels. Following epidural administration, fentanyl, because of its high lipid solubility, is rapidly absorbed into the systemic circulation and also reaches the spinal compartment in a smaller proportion. At the spinal level, activation of presynaptic and postsynaptic μ-opioid receptors reduces nociceptive neurotransmission in the dorsal horn. Therefore, the analgesic effect of epidural fentanyl is likely to result from a combination of regional spinal analgesia and systemic/supraspinal effects rather than from a purely spinal mechanism.[8,9]

Fentanyl is highly lipophilic and therefore has a rapid onset of action but a relatively shorter direct duration of analgesia compared with more hydrophilic opioids. In the present study, however, the difference in VAS scores became evident at 12 hours and persisted until 48 hours. The sustained reduction in pain may not represent the direct pharmacological action of fentanyl alone. Improved early analgesia may reduce subsequent nociceptive input and central sensitization, while concomitant postoperative analgesic therapy may also contribute to the observed effect. These mechanisms, however, remain speculative in the absence of pharmacokinetic measurements and standardized rescue analgesic data.[10,11]

An important feature of the present study is that fentanyl was not administered intraoperatively. The intervention consisted of repeated postoperative doses of 15 μg at 12, 24, and 36 hours. Therefore, the sustained reduction in VAS scores through 48 hours can reasonably be considered in the context of

repeated epidural dosing rather than as a prolonged effect of a single fentanyl bolus. The repeated administration provided additional analgesic treatment during the early postoperative period, when pain remained clinically relevant.

Our findings can be compared with the randomized controlled study by Guilfoyle et al., which evaluated epidural fentanyl following lumbar canal decompression. Their study demonstrated improved postoperative analgesia following epidural fentanyl, although the timing and duration of benefit differed from those observed in the present study. Such differences may be explained by variations in fentanyl dose, timing and frequency of administration, background analgesia, surgical characteristics, and postoperative assessment protocols. In particular, the present study used three postoperative epidural doses, whereas studies using a single dose cannot be directly equated with this regimen.[2]

The findings are also broadly consistent with the systematic review and meta-analysis by Hermans et al., which evaluated intraoperative epidural analgesia for pain relief following lumbar decompressive spine surgery. The review demonstrated an overall reduction in postoperative pain with epidural analgesia, although considerable heterogeneity existed with respect to the opioid or other analgesic used, dose, administration technique, and postoperative analgesic regimen. The present study adds to this literature by evaluating a specific regimen of intermittent postoperative epidural fentanyl rather than a single intraoperative administration.[3]

The pharmacological characteristics of the epidural opioid are important when interpreting these findings. Epidural analgesia is not a uniform intervention, and its clinical effect may vary according to the drug, dose, concentration, catheter position, injection site, timing of administration, and concomitant systemic analgesia. Ginosar et al. have also demonstrated that the route and mode of fentanyl administration can influence its relative spinal and systemic effects. Therefore, differences in analgesic outcomes between studies should be interpreted in the context of these methodological and pharmacological differences.[10]

An important secondary finding was that postoperative physiological parameters remained comparable between the groups. Heart rate did not differ significantly at any postoperative time point. Although the difference was relatively greater at 12 hours, with mean heart rates of 96.44 beats/min in the Test Group and 100.64 beats/min in the Control Group, the difference did not reach statistical significance (p=0.0574). Similarly, systolic and diastolic blood pressure remained comparable throughout the 48-hour observation period. Respiratory rate also showed no significant between-group differences, while oxygen saturation remained well maintained, generally between 98% and 99% in both groups.

These findings are relevant because opioid administration may be associated with respiratory depression and other opioid-related adverse effects. The absence of significant differences in respiratory rate and SpO_2 provides some reassurance regarding the observed postoperative safety profile of the intervention. Nevertheless, normal mean respiratory parameters cannot completely exclude transient or episodic respiratory depression. Continuous respiratory monitoring or specific standardized assessment of respiratory depression would provide a more comprehensive evaluation of opioid safety.

The mean duration of hospital stay was identical in both groups at 3.30 days, with no statistically significant difference (p=1.000). This observation is consistent with the findings of Hermans et al., who did not demonstrate a significant reduction in hospital stay following intraoperative epidural analgesia. The absence of a difference in length of stay suggests that improved postoperative analgesia does not necessarily result in earlier discharge. Hospital stay is influenced by several factors, including neurological recovery, mobilization, surgical recovery, institutional discharge protocols, and social circumstances. Therefore, duration of hospitalization should not be considered a direct surrogate for analgesic efficacy.[3]

Overall, the present study demonstrates that intraoperative epidural analgesia was associated with significantly lower postoperative VAS scores from 12 to 48 hours, while postoperative heart rate, blood pressure, respiratory rate, and oxygen saturation remained comparable between the groups. The principal demonstrated benefit was therefore improved postoperative pain control rather than a reduction in hospital stay. These findings support the incorporation of intraoperative epidural analgesia into a multimodal approach to postoperative pain management following lumbar decompression.

The strengths of the study include its randomized parallel-group design, comparable baseline characteristics, serial assessment of pain and physiological parameters, and evaluation of catheter-related complications and hospital stay. Assessment at multiple postoperative time points allowed the temporal pattern of analgesic efficacy to be evaluated. However, the relatively small sample size limits the ability to detect uncommon adverse events. In addition, plasma or cerebrospinal fluid fentanyl concentrations were not measured, and continuous monitoring for transient respiratory depression was not performed. The study also did not establish whether the prolonged reduction in VAS was attributable solely to fentanyl or to its interaction with the overall postoperative analgesic regimen.

CONCLUSION

The present study demonstrates that intermittent postoperative epidural fentanyl at a dose of 15 µg administered at 12, 24, and 36 hours was associated

with significantly lower postoperative VAS scores from 12 through 48 hours following lumbar decompressive surgery. No significant differences were observed in postoperative hemodynamic or routine respiratory parameters, catheter blockage, or duration of hospital stay. These findings suggest that intermittent postoperative epidural fentanyl may be a useful component of multimodal analgesia after lumbar decompression, while larger studies with standardized rescue analgesic assessment and more comprehensive respiratory monitoring are warranted.

REFERENCES

1. Overdevest GM, Vleggeert-Lankamp CLA, Jacobs WCH, Thomé C, Gunzburg R, Peul WC. Effectiveness of posterior decompression techniques compared with conventional laminectomy for lumbar stenosis: a systematic review. Eur Spine J. 2015;24(10):2244-2263. doi:10.1007/s00586-015-4098-4.
2. Guilfoyle MR, Seeley H, Laing RJ. Epidural fentanyl for postoperative analgesia after lumbar canal decompression: a randomized controlled trial. Spine J. 2012;12(10):925-931.
3. Hermans SMM, Lantinga-Zee AAG, Rijkers K, van Santbrink H, van Hemert WLW, Reinders MK, et al. Intraoperative epidural analgesia for pain relief after lumbar decompressive spine surgery: a systematic review and meta-analysis. Brain Spine. 2021;1:100306. doi:10.1016/j.bas.2021.100306
4. Ranguis SC, Li D, Webster AC. Perioperative epidural steroids for lumbar spine surgery in degenerative spinal disease: a review. J Neurosurg Spine. 2010;13(6):745-757.
5. Jamjoom ZA, Jamjoom AB. Efficacy of intraoperative epidural steroids in lumbar discectomy: a systematic review. BMC Musculoskelet Disord. 2014;15:146. doi:10.1186/1471-2474-15-146.
6. Akinduro OO, Miller BA, Haussen D, Pradilla G, Ahmad FU. Complications of intraoperative epidural steroid use in lumbar discectomy: a systematic review and meta-analysis. Neurosurg Focus. 2015;39(4):E12. doi:10.3171/2015.7.FOCUS15269.
7. Wilson-Smith A, Chang N, Lu VM, Mobbs RJ, Fadhil M, Lloyd D, et al. Epidural steroids at closure after microdiscectomy/laminectomy for reduction of postoperative analgesia: systematic review and meta-analysis. World Neurosurg. 2018;110:e212-e221. doi:10.1016/j.wneu.2017.10.133
8. Chan JHH, Heilpern GNA, Packham I, et al. A prospective randomized double-blind trial of the use of intrathecal fentanyl in patients undergoing lumbar spinal surgery. Spine 2006;31:2529–33.
9. Peng PW, Sandler AN. A review of the use of fentanyl analgesia in the management of acute pain in adults. Anesthesiology 1999;90: 576–99.
10. Ginosar Y, Riley ET, Angst MS. The site of action of epidural fentanyl in Humans: the difference between infusion and bolus administration. Anesth Analg 2003;97:1428–38.
11. Ummenhofer WC, Arends RH, Shen DD, et al. Comparative spinal distribution and clearance kinetics of intrathecally administered morphine, fentanyl, alfentanil, and sufentanil. Anesthesiology 2000;92: 739–53.