ISSN: 2474-9206

Research Article

Journal of Anesthesia & Pain Medicine

Can Low-Dose Analgesic Spinal Anesthesia Be a Safe and Effective Anesthetic Strategy for Percutaneous Endoscopic Lumbar Discectomy? A Prospective Single-Center Study

Francesco Saturno[1]*, Giulia Monaco[1], Angela Salerno[2], Antonio Cianciola[3], Nicole Cianciola[3] and Emidio Cianciola[1]

[1]UOC Anestesia, Rianimazione e Terapia del Dolore, P.O. Sapri, ASL Salerno, Italy

[2]UdR - Servizio Trasfusionale, P.O. Sapri, ASL Salerno, Italy

[3]Saint Camillus International University of Health and Medical Sciences (UniCamillus), Rome, Italy.

***Corresponding Author**
Francesco Saturno, UOC Anestesia, Rianimazione e Terapia del Dolore, P.O. Sapri, ASL Salerno, Italy.

Submitted: 2026, Jun 17 **Accepted:** 2026, Jul 13; **Published:** 2026, Aug 24

Citation: Saturno, F., Monaco, G., Salerno, A., Cianciola, A., Cianciola, N., et al. (2026). Can Low-Dose Analgesic Spinal Anesthesia Be a Safe and Effective Anesthetic Strategy for Percutaneous Endoscopic Lumbar Discectomy? A Prospective Single-Center Study. *J Anesth Pain Med, 11*(2), 01-07.

Abstract

Background: *Percutaneous Endoscopic Lumbar Discectomy (PELD) has become an established minimally invasive procedure for lumbar disc herniation. Although general anesthesia is widely used, regional anesthetic techniques may provide advantages by allowing continuous neurological monitoring, minimizing opioid requirements, and facilitating postoperative recovery. However, evidence regarding low-dose analgesic spinal anesthesia during PELD remains limited.*

Objective: *To evaluate the safety, feasibility, and clinical effectiveness of low-dose analgesic spinal anesthesia in patients undergoing single-level PELD.*

Methods: *This prospective single-center observational study included 60 consecutive patients undergoing transforaminal PELD between January 2024 and March 2026.*
Subarachnoid anesthesia consisted of:

- ***Ropivacaine 6 mg***
- ***Fentanyl 15 µg***

Sedation was achieved with ***midazolam 5 mg intravenously.***
Clinical outcomes included:

- *operative time*
- *hospital stay*
- *intraoperative complications*
- *postoperative complications*
- *Visual Analog Scale (VAS)*
- *Oswestry Disability Index (ODI)*

Patients were evaluated preoperatively and at ***3, 6, and 12 months*** *after surgery.*
Results: Sixty patients completed the 12-month follow-up.
The mean age was ***46.8 ± 11.3 years,*** *with* ***34 men*** *and* ***26 women.***
Disc levels included:

- *L3–L4: 16 patients*

- *L4–L5: 24 patients*
- *L5–S1: 20 patients*

*Mean operative time was **50 ± 12 minutes**, while the mean hospital stay was **3 ± 0.8 days.***
*Pain significantly improved from a preoperative VAS score of **7.6 ± 0.8 to 0 at** 12 months.*
*Functional disability improved from an ODI of **28 ± 3.0 to 8.0 ± 4.0.***
No conversion to general anesthesia was required.
No major neurological or anesthetic complications occurred.

***Conclusions:** Low-dose analgesic spinal anesthesia appears to be a safe, feasible, and effective anesthetic strategy for Percutaneous Endoscopic Lumbar Discectomy. Excellent pain control, preservation of neurological monitoring, rapid postoperative recovery, and high patient satisfaction support its use in appropriately selected patients.*

Keywords: Percutaneous Endoscopic Lumbar Discectomy, PELD, Spinal Anesthesia, Ropivacaine, Lumbar Disc Herniation, Minimally Invasive Spine Surgery, Pain Medicine, Endoscopic Spine Surgery

1. Introduction

Lumbar disc herniation remains one of the most common causes of radicular pain and disability worldwide. Although conservative treatment is effective in many patients, surgery is indicated in cases of persistent radiculopathy, progressive neurological deficit, or failure of non-operative management [1,2]. Percutaneous Endoscopic Lumbar Discectomy (PELD) has gained widespread acceptance because it minimizes tissue disruption, reduces blood loss, shortens hospitalization, and promotes faster recovery compared with conventional open surgery[3-5].

The choice of anesthesia plays a fundamental role in determining surgical conditions, patient safety, and postoperative recovery. General anesthesia offers patient immobility and airway control but eliminates real-time neurological feedback during nerve root manipulation. Local anesthesia with conscious sedation preserves neurological monitoring but may provide insufficient analgesia in some patients, particularly during foraminal dilation or discectomy [6-9]. Low-dose analgesic spinal anesthesia represents a potential alternative by combining adequate surgical anesthesia with preserved spontaneous ventilation, stable hemodynamics, and intraoperative neurological assessment. Despite these theoretical advantages, published evidence on its use during PELD remains limited [10-14]. The aim of this prospective single-center study was to evaluate the safety, feasibility, and clinical outcomes of low-dose analgesic spinal anesthesia in patients undergoing transforaminal PELD.

2. Materials and Methods

2.1. Study Design

This prospective, single-center observational study was conducted at the Department of Anesthesia, Intensive Care, Pain Medicine and Perioperative Medicine, P.O. dell'Immacolata, Sapri (ASL Salerno, Italy). Between January 2024 and March 2026, 60 consecutive patients with symptomatic single-level lumbar disc herniation underwent Percutaneous Transforaminal Endoscopic Lumbar Discectomy (PTED/PELD).The study was conducted in accordance with the principles of the Declaration of Helsinki. Institutional review board approval was obtained according to local regulations, and all patients provided written informed consent before enrollment.

2.2. Patient Selection

2.2.1. Inclusion Criteria

- Age between 18 and 80 years
- Single-level lumbar disc herniation confirmed by MRI
- Unilateral lumbar radiculopathy
- Persistent symptoms despite at least 6 weeks of conservative treatment
- Clinical-radiological correlation
- ASA physical status I–III

2.2.2. Exclusion Criteria

- Multilevel lumbar disc disease
- Segmental instability or spondylolisthesis requiring fusion
- Previous surgery at the same lumbar level
- Cauda equina syndrome
- Severe spinal canal stenosis
- Coagulation disorders or anticoagulant therapy not adequately discontinued
- Local infection or systemic sepsis
- Allergy to local anesthetics
- Refusal of spinal anesthesia

2.3. Surgical Technique

All procedures were performed by the same experienced spine surgeon using the ENDOSMART PLUS® endoscopic system through a standard transforaminal approach. Patients were positioned prone on a radiolucent operating table with adequate abdominal decompression.

Under continuous fluoroscopic guidance: [18]

- skin marking was performed,
- a spinal needle was introduced through Kambin's triangle,
- guidewire placement was achieved,
- sequential dilators were inserted,
- a working cannula was positioned,
- endoscopic discectomy was performed using dedicated endoscopic instruments.

Adequate decompression was confirmed by visualization of a freely mobile nerve root.

No surgical drains were routinely placed.

2.4. Anesthetic Technique

Standard monitoring included:

- continuous ECG
- non-invasive blood pressure
- pulse oximetry
- respiratory rate
- supplemental oxygen through nasal cannula

Subarachnoid anesthesia was performed at the **L3–L4 or L4–L5** interspace using a **25-G** Quincke spinal needle under strict aseptic conditions.

The intrathecal solution consisted of:

- **Ropivacaine 6 mg**
- **Fentanyl 15 µg**

Immediately before surgery, all patients received:

- **Midazolam 5 mg intravenously** for light conscious sedation.

The objective was to maintain:

- spontaneous ventilation,
- verbal responsiveness,
- continuous neurological monitoring throughout the procedure.

General anesthesia equipment remained immediately available in the operating room should conversion become necessary.

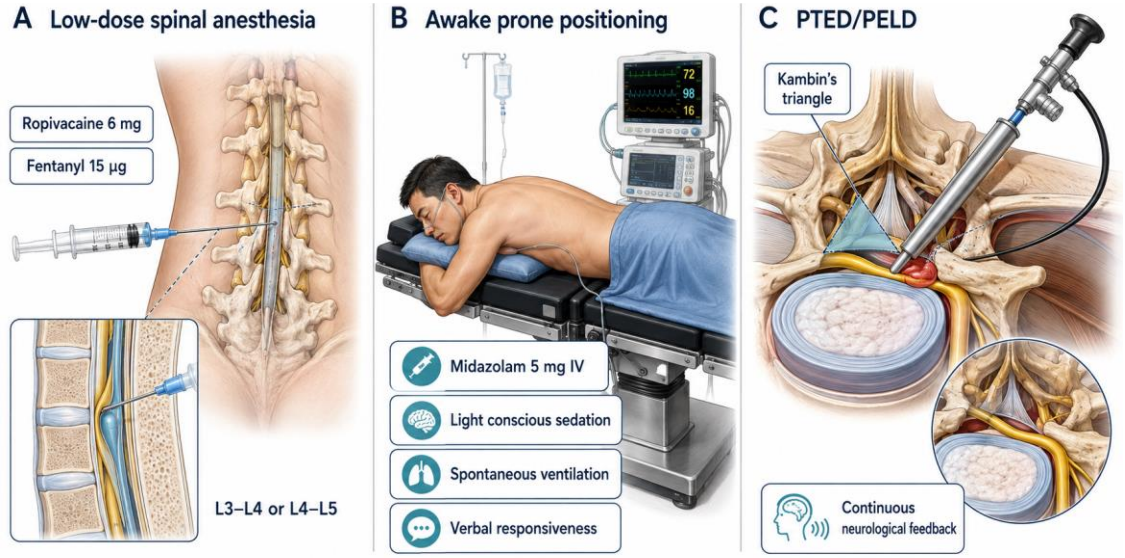

Figure 1: The Anesthetic and Surgical Workflow is Summarized

Figure 1. Low-dose analgesic spinal anesthesia workflow for percutaneous transforaminal endoscopic lumbar discectomy (PTED/PELD). (A) Subarachnoid anesthesia is administered at the L3-L4 or L4-L5 interspace using ropivacaine 6 mg combined with fentanyl 15 µg. (B) The patient is positioned prone and receives midazolam 5 mg intravenously for light conscious sedation, while spontaneous ventilation and verbal responsiveness are maintained. (C) The transforaminal endoscopic approach is performed through Kambin's triangle, allowing continuous patient feedback during working-cannula placement, foraminoplasty, and nerve-root decompression. Illustration created for this study.

2.5. Postoperative Management

Patients were monitored in the post-anesthesia care unit until complete recovery of motor function and stable vital signs.

Early mobilization was encouraged within the first postoperative hours.

Standard postoperative analgesia consisted of non-opioid analgesics administered as required.

Patients were discharged after achieving:

- independent ambulation,
- adequate pain control,
- absence of neurological deterioration,
- stable clinical conditions.

2.6. Outcome Measures

The primary endpoint was the **clinical effectiveness of low-dose spinal anesthesia** during PELD.

Secondary outcomes included:

- operative time,
- length of hospital stay,
- conversion to general anesthesia,
- intraoperative complications,
- postoperative complications,
- neurological deficits,
- Visual Analog Scale (VAS),
- Oswestry Disability Index (ODI).

Clinical evaluations were performed:

- preoperatively,
- at 3 months,
- at 6 months,
- at 12 months.

2.7. Statistical Analysis

Continuous variables are presented as mean ± standard deviation (SD). Categorical variables are expressed as frequencies and percentages. Changes in VAS and ODI over time were analyzed using repeated-measures statistical methods, with a significance level of $p < 0.05$. Statistical analyses were performed using IBM SPSS Statistics (version XX, IBM Corp., Armonk, NY, USA).

2.8. Ethics Statement

The study protocol complied with the ethical standards of the institutional research committee and with the 1964 Declaration of Helsinki and its subsequent amendments. According to institutional policy for prospective observational studies without deviation from standard clinical practice, ethics committee approval was obtained. All participants provided written informed consent for both surgery and inclusion in the study.

3. Results

3.1. Patient Characteristics

Between January 2024 and March 2026, **60 consecutive patients** underwent Percutaneous Transforaminal Endoscopic Lumbar Discectomy (PTED) under low-dose analgesic spinal anesthesia. All patients completed the 12-month follow-up, and no patient was lost to follow-up. The study population included 34 men (56.7%) and 26 women (43.3%), with a mean age of 46.8 ± 11.3 years (range: 22–74 years).

The operated levels were distributed as follows:

- L3–L4: 16 patients (26.7%)
- L4–L5: 24 patients (40.0%)
- L5–S1: 20 patients (33.3%)

The mean duration of symptoms before surgery was 8.4 ± 3.2 months.

No statistically significant differences in baseline characteristics were observed among patients according to the operated level.

3.2. Intraoperative Outcomes

All procedures were successfully completed using the planned transforaminal endoscopic approach. The **mean operative time was 50 ± 12 minutes**. No patient required conversion to general anesthesia, and no procedure was interrupted because of inadequate analgesia or patient discomfort. Intraoperative communication with patients was maintained throughout surgery, allowing continuous neurological monitoring during manipulation of the affected nerve root.

Hemodynamic parameters remained stable in all patients, with no clinically significant hypotension, bradycardia, respiratory depression, or oxygen desaturation requiring advanced airway management.Estimated blood loss was minimal (<30 mL in all cases).

3.3. Postoperative Recovery

Motor recovery was rapid, and all patients regained full lower-limb function within the expected duration of spinal anesthesia. The **mean hospital stay was 3.0 ± 0.8 days**. Early mobilization was achieved in all patients on the day of surgery or the following morning. No patient required postoperative intensive care admission.

3.4. Clinical Outcomes

A progressive and statistically significant improvement was observed in both pain intensity and functional disability throughout the follow-up period. **Pain Assessment (VAS)**

The mean preoperative **Visual Analog Scale (VAS)** score was: **7.6 ± 0.8**

This progressively decreased to:

- **3 months:** 2.1 ± 0.9
- **6 months:** 0.8 ± 0.5
- **12 months: 0.0**

The reduction in pain was statistically significant at every follow-up compared with baseline **($p < 0.001$).**

3.5. Functional Outcome (ODI)

The mean **Oswestry Disability Index (ODI)** score improved from:

28 ± 3.0 preoperatively

to

- **3 months:** 16 ± 3.2
- **6 months:** 11 ± 3.5
- **12 months:** 8.0 ± 4.0

The improvement in disability scores was statistically significant throughout the study period (**$p < 0.001$**).

3.6. Complications

No major anesthetic complications were observed.

Specifically, there were no cases of:

- conversion to general anesthesia,
- respiratory depression,
- high spinal block,
- post-dural puncture headache requiring an epidural blood patch,
- persistent neurological deficit,
- epidural hematoma,
- surgical site infection,
- cerebrospinal fluid leak,
- allergic reactions,
- urinary retention requiring prolonged catheterization.

Minor transient paresthesia during cannula placement occurred in **2 patients (3.3%)** and resolved immediately after repositioning of the working cannula.

No patient required reoperation during the 12-month follow-up

Variable	Value
Patients	60
Age (years)	46.8 ± 11.3
Male	34 (56.7%)
Female	26 (43.3%)
Symptom duration (months)	8.4 ± 3.2
L3–L4	16 (26.7%)
L4–L5	24 (40.0%)
L5–S1	20 (33.3%)

Table 1: Baseline Characteristics

Variable	Value
Operative time (min)	50 ± 12
Blood loss (mL)	<30
Hospital stay (days)	3.0 ± 0.8
Conversion to GA	0
Major complications	0

Table 2: Surgical Outcomes

Follow-up	VAS	ODI
Preoperative	7.6 ± 0.8	28 ± 3.0
3 months	2.1 ± 0.9	16 ± 3.2
6 months	0.8 ± 0.5	11 ± 3.5
12 months	0.0	8.0 ± 4.0

Table 3: Clinical Outcomes

Event	n (%)
Conversion to general anesthesia	0
Respiratory complications	0
High spinal block	0
Post-dural puncture headache	0
Neurological deficit	0
Infection	0
Reoperation	0

Table 4: Complications

4. Discussion

The present prospective single-center study demonstrates **that low-dose analgesic spinal anesthesia** is a safe, feasible, and effective anesthetic technique for patients undergoing **Percutaneous Transforaminal Endoscopic Lumbar Discectomy (PTED).** Our results showed excellent pain control, significant functional improvement, stable intraoperative conditions, and the absence of major anesthetic or surgical complications throughout the 12-month follow-up. To our knowledge, relatively few studies have specifically evaluated a standardized **low-dose intrathecal regimen consisting of 6 mg ropivacaine combined with 15 µg fentanyl** for PTED. Most published series describe procedures performed under local anesthesia with conscious sedation or under general anesthesia. Consequently, evidence regarding optimized spinal anesthesia protocols for endoscopic lumbar surgery remains limited [6-12].

One of the principal advantages observed in our series was the preservation of **continuous neurological monitoring** during surgery. Unlike general anesthesia, spinal anesthesia allowed patients to remain cooperative while maintaining spontaneous ventilation, enabling immediate recognition of nerve-root irritation during critical surgical steps such as foraminoplasty and disc fragment removal. This real-time feedback may contribute

to reducing the risk of neurological injury, particularly during transforaminal access[7-9]. Another important finding was the excellent intraoperative hemodynamic stability. The low dose of intrathecal ropivacaine provided an adequate sensory block while minimizing sympathetic blockade. No clinically significant hypotension, bradycardia, or respiratory depression occurred, and no patient required conversion to general anesthesia. These findings support the hypothesis that reducing the dose of local anesthetic may preserve cardiovascular stability without compromising surgical conditions.

The addition of **15 µg intrathecal fentanyl likely** enhanced analgesia through synergistic action with ropivacaine, allowing the use of a lower dose of local anesthetic while maintaining patient comfort. The administration of **midazolam** for light sedation further improved tolerance of the procedure without interfering with verbal communication or neurological assessment [10-12]. Clinical outcomes were highly favorable. Pain intensity decreased from a mean preoperative **VAS score of 7.6 ± 0.8 to 0** at the 12-month follow-up, while functional disability measured by the **Oswestry Disability Index** improved from **28 ± 3.0 to 8.0 ± 4.0.** These improvements are consistent with previous reports demonstrating the effectiveness of PTED in relieving radicular pain and improving functional recovery. The present study suggests that these excellent outcomes can be achieved without general anesthesia when an appropriately selected spinal anesthetic protocol is adopted [1-5,16,17]. Early postoperative recovery represents another relevant advantage. The combination of minimally invasive surgery and low-dose spinal anesthesia facilitated rapid motor recovery, early mobilization, and a relatively short hospital stay.

Although enhanced recovery protocols were not formally evaluated, our findings are consistent with the principles of **Enhanced Recovery After Surgery (ERAS),** which emphasize multimodal analgesia, opioid-sparing strategies, and early rehabilitation [13-15]. No major complications were observed. Importantly, there were no cases of high spinal block, respiratory compromise, persistent neurological deficit, postoperative infection, or reoperation during follow-up. The only adverse events were two transient episodes of paresthesia during cannula positioning, both of which resolved immediately after repositioning. These observations further support the safety profile of the anesthetic technique when performed by experienced anesthesiologists and surgeons. The present study also has practical implications. PTED is increasingly performed in elderly patients and in individuals with significant comorbidities, in whom avoiding general anesthesia may reduce perioperative risk. A standardized low-dose spinal anesthesia protocol may therefore represent an attractive alternative in carefully selected patients, combining the benefits of regional anesthesia with the technical requirements of endoscopic spine surgery [13-15].

Nevertheless, several limitations should be acknowledged. This was a **single-center observational study** without randomization or a comparison group undergoing general anesthesia or local anesthesia with sedation. The relatively modest sample size limits the generalizability of the findings. In addition, patient satisfaction, quality-of-recovery scores, opioid consumption, and cost-effectiveness were not formally assessed. These outcomes should be incorporated into future investigations. Future research should include **multicenter randomized controlled trials** directly comparing low-dose spinal anesthesia with general anesthesia and local anesthesia plus conscious sedation. Such studies should evaluate not only clinical outcomes and complications but also recovery quality, patient satisfaction, healthcare costs, and long-term functional outcomes. Defining the optimal intrathecal drug combination and dosing strategy for PTED will also be an important objective. Overall, our findings indicate that **low-dose analgesic spinal anesthesia is a reliable anesthetic option for PTED,** providing effective surgical conditions, excellent clinical outcomes, and a favorable safety profile. These results support its consideration as part of routine clinical practice in centers with expertise in endoscopic spine surgery.

5. Conclusions

Low-dose analgesic spinal anesthesia **using 6 mg intrathecal ropivacaine combined with 15 µg fentanyl** proved to be a **safe, feasible, and effective anesthetic strategy** for Percutaneous Transforaminal Endoscopic Lumbar Discectomy in this prospective single-center study. The technique provided adequate intraoperative analgesia while preserving spontaneous ventilation and allowing continuous neurological monitoring throughout the procedure. No conversion to general anesthesia or major anesthetic complications occurred, and all procedures were completed successfully. Patients experienced significant improvements in pain intensity and functional disability, as demonstrated by the marked reductions in VAS and ODI scores during the 12-month follow-up. Rapid postoperative recovery, early mobilization, and a short hospital stay further support the potential advantages of this anesthetic approach within enhanced recovery pathways. Although the present study is limited by its single-center design and the absence of a comparative control group, the findings suggest that **low-dose analgesic spinal anesthesia may represent a valuable alternative to general anesthesia for selected patients undergoing PTED,** combining the benefits of regional anesthesia with the technical requirements of endoscopic spine surgery. Further **multicenter randomized controlled trials** comparing low-dose spinal anesthesia with general anesthesia and local anesthesia plus conscious sedation are warranted to confirm these results, establish the optimal anesthetic protocol, and evaluate long-term clinical outcomes, patient satisfaction, quality of recovery, and cost-effectiveness.

References

1. Gadjradj, P. S., van Tulder, M. W., Dirven, C. M. F., Peul, W. C., & Harhangi, B. S. (2016). Clinical outcomes after percutaneous transforaminal endoscopic discectomy for lumbar disc herniation: A prospective case series. *Neurosurgical Focus, 40*(2), E3.
2. Sairyo, K., Chikawa, T., & Nagamachi, A. (2018). State-of-the-art transforaminal percutaneous endoscopic lumbar

surgery under local anesthesia: Discectomy, foraminoplasty, and ventral facetectomy. *Journal of Orthopaedic Science, 23*(2), 229–236.
3. Ruan, W., Feng, F., Liu, Z., Xie, J., Cai, L., & Ping, A. (2016). Comparison of percutaneous endoscopic lumbar discectomy versus open lumbar microdiscectomy for lumbar disc herniation: A meta-analysis. *International Journal of Surgery, 31*, 86–92.
4. Chen, X., Chamoli, U., Vargas Castillo, J., Ramakrishna, V. A. S., & Diwan, A. D. (2020). Complication rates of different discectomy techniques for symptomatic lumbar disc herniation: A systematic review and meta-analysis. *European Spine Journal, 29(7*), 1752–1770.
5. Mooney, J., Laskay, N., Erickson, N., Salehani, A., Mahavadi, A., Ilyas, A., et al. (2023). General vs local anesthesia for percutaneous endoscopic lumbar discectomy (PELD): A systematic review and meta-analysis. *Global Spine Journal.*
6. Wang, S., Zheng, L., Ma, J. X., Wang, H., Wang, K. Q., Chen, Y., et al. (2025). Comparison of 2 anesthetic methods for transforaminal endoscopic lumbar discectomy: A prospective randomized controlled study. *Global Spine Journal, 15*(2), 1026–1030.
7. Zhen, Z., Zhao, J., Chen, C., Sun, X., Zhang, B., & Yang, Q. (2022). Comparing the effectiveness and safety between local anesthesia versus epidural anesthesia for percutaneous transforaminal endoscopic discectomy: A systematic review and meta-analysis. *World Neurosurgery, 166,* e528–e535.
8. Zhang, L., Chang, T., Xu, Y., Jing, Q., Zhao, X., & Li, C. (2020). Epidural anesthesia with low concentration ropivacaine and sufentanil for percutaneous transforaminal endoscopic discectomy: A randomized controlled trial. *Frontiers in Medicine, 7,* 362.
9. Zhu, Y., Zhao, Y., Fan, G., Sun, S., Zhou, Z., Wang, D., et al. (2018). Comparison of 3 anesthetic methods for percutaneous transforaminal endoscopic discectomy: *A prospective study. Pain Physician, 21*(4), E347–E353.
10. Boztuğ, N., Bigat, Z., Ertok, E., & Erman, M. (2005). Intrathecal ropivacaine versus ropivacaine plus fentanyl for out-patient arthroscopic knee surgery. *Journal of International Medical Research, 33*(4), 365–371.
11. Buckenmaier, C. C., III, Nielsen, K. C., Pietrobon, R., Klein, S. M., Martin, A. H., Greengrass, R. A., et al. (2002). Small-dose intrathecal lidocaine versus ropivacaine for anorectal surgery in an ambulatory setting. *Anesthesia & Analgesia, 95*(5), 1253–1257.
12. Ravipati, P., Isaac, G. A., Reddy, P. N., Krishna, L., & Supritha, T. (2017). A comparative study between intrathecal isobaric ropivacaine 0.75% plus dexmedetomidine and isobaric ropivacaine 0.75% plus fentanyl for lower limb surgeries. Anesthesia: *Essays and Researches, 11*(3), 621–626.
13. Rajjoub, R., Ghaith, A. K., El-Hajj, V. G., Rios-Zermano, J., De Biase, G., Atallah, E., et al. (2024). Comparative outcomes of awake spine surgery under spinal versus general anesthesia: A comprehensive systematic review and meta-analysis. *European Spine Journal, 33*(3), 985–1000.
14. Wilson, J. P., Bonin, B., Quinones, C., Kumbhare, D., Guthikonda, B., & Hoang, S. (2024). Spinal anesthesia for awake spine surgery: A paradigm shift for enhanced recovery after surgery. *Journal of Clinical Medicine, 13*(17), 5326.
15. Assis, M. L. M., Bojaxhi, E., Abode-Iyamah, K. O., et al. (2025). The benefits of awake spinal surgery on minimizing positioning-related complications: A narrative review. *Spine, 50*(8), 555–561.
16. Taha, A. M., Hegab, A., Yousef, M., Abdelhakam, M., & Dahshan, S. A. (2025). A meta-analysis of percutaneous endoscopic discectomy and microdiscectomy for lumbar disc herniation: Assessing surgical efficacy and clinical outcomes. *Neurological Research, 47*(10), 997–1012.
17. Nazwar, T. A., Prihadi, A. I., Zairinal, R. A., et al. (2025). A comparative study of transforaminal and interlaminar approaches in percutaneous endoscopic lumbar discectomy for L5-S1 disc herniation: Systematic review. *Journal of Clinical Neuroscience, 133*, 111022.
18. Zheng, B., Yu, P., Liang, Y., Zhu, Z., & Liu, H. (2025). Efficacy and safety of ultrasound-guided compared to X-ray-guided percutaneous endoscopic lumbar discectomy in China: A systematic review and pooled analysis. *Frontiers in Surgery, 12,* 1572977.

Take-Home Message

Low-dose analgesic spinal anesthesia appears to provide an optimal balance between patient safety, surgical conditions, intraoperative neurological monitoring, and postoperative recovery during Percutaneous Transforaminal Endoscopic Lumbar Discectomy, making it a promising anesthetic option for modern minimally invasive spine surgery.