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Comparison of pulmonary and hemodynamic parameters in patients undergoing lumbar disc herniation surgery in prone and sitting-prone positions

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ABSTRACT

Aims: Patient positioning during lumbar spine surgery plays a crucial role in determining both surgical exposure and perioperative physiological stability. This study aimed to compare the effects of prone and sitting-prone (knee-chest) positions on pulmonary and hemodynamic parameters in patients undergoing lumbar disc herniation surgery under general anesthesia.

Methods: This retrospective observational study included 50 patients classified as ASA I–III who underwent lumbar disc herniation surgery between March 2024 and March 2025. Patients were divided into two groups based on intraoperative positioning: prone (n=25) and sitting-prone (n=25). Hemodynamic variables, arterial blood gas parameters, and respiratory mechanics were recorded at three time points: in the supine position, immediately after positioning, and 30 minutes after surgical incision. Statistical analysis was performed using SPSS software, and a p-value <0.05 was considered statistically significant.

Results: Baseline demographic and physiological parameters were comparable between the groups. Following positioning, lower diastolic blood pressure values were observed in the sitting-prone group. At 30 minutes intraoperatively, oxygenation parameters were higher and peak airway pressure values were lower in the sitting-prone group compared to the prone group. These findings indicate improved pulmonary mechanics in the sitting-prone position.

Conclusion: The sitting-prone position appears to provide superior oxygenation and lower airway pressures compared to the prone position, while maintaining acceptable hemodynamic stability. These findings suggest that sitting-prone positioning may be considered a safer and more physiologically advantageous alternative during lumbar spine surgery.

Keywords: Prone position, sitting-prone position, lumbar herniation surgery, pulmonary mechanics, general anesthesia

INTRODUCTION

Low back pain represents one of the leading causes of disability worldwide and affects approximately 80% of individuals at some point in their lives.[1] Among its etiologies, lumbar disc herniation (LDH) is a predominant condition characterized by the displacement of intervertebral disc material, resulting in nerve root compression and radicular symptoms.[2] While conservative management remains the first-line treatment, surgical intervention is indicated in cases of progressive neurological deficits, severe pain, or failure of non-operative therapy.[2]

Lumbar spine surgeries are commonly performed under general anesthesia, where patient positioning becomes a critical factor influencing both surgical access and physiological responses. The prone position is the most frequently utilized approach, allowing optimal visualization of posterior spinal structures. However, it is associated with significant physiological alterations, including increased intra-abdominal pressure, decreased venous return, reduced cardiac output, and impaired pulmonary function.[3,4]

The increase in intra-abdominal pressure in the prone position leads to cephalad displacement of the diaphragm, resulting in decreased functional residual capacity and lung compliance.[5] Consequently, airway pressures increase, and ventilation-perfusion mismatch may occur, potentially leading to hypoxemia and postoperative pulmonary complications.[6]

The sitting-prone (knee-chest) position, in which the hips and knees are flexed while the chest is supported and the abdomen remains free from compression, has been proposed as an alternative technique designed to reduce abdominal compression and improve surgical exposure (Figure).

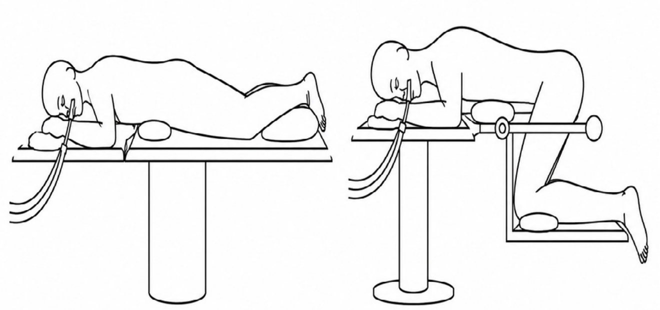

Figure. Prone and sitting prone position

METHODS

This study was conducted with the approval of the Non-interventional Researches Ethics Committee at Kırıkkale University (Date: 28.05.2025, Decision No: 2025.05.03). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

Ethical approval was obtained retrospectively for the review of archived anesthesia and patient records. The medical records of patients who underwent lumbar disc herniation surgery between March 2024 and March 2025 were retrospectively reviewed.

A total of 50 patients aged 18 years and older, classified as ASA I-III, were included in the study. Patients were divided into two groups according to surgical positioning: the prone group (n=25) and the sitting-prone group (n=25). Exclusion criteria included ASA IV-V classification, incomplete clinical data, and the use of regional anesthesia.

All patients underwent a standardized anesthesia protocol. Following routine monitoring, anesthesia was induced with propofol, fentanyl, and rocuronium. Endotracheal intubation was performed, and mechanical ventilation was initiated in volume-controlled mode. Ventilator settings included a tidal volume of 6-8 ml/kg, a respiratory rate of 12-15 breaths per minute, and a PEEP of 5-8 cmH_2O. End-tidal CO_2 was maintained within the range of 30-40 mmHg. Anesthesia maintenance was achieved using sevoflurane and remifentanil infusion.

Hemodynamic parameters, including heart rate, systolic and diastolic blood pressure, and oxygen saturation, were recorded at three time points: in the supine position, immediately after positioning, and 30 minutes after the initiation of surgery. Arterial blood gas analysis was performed concurrently, measuring pH, PaO_2, $PaCO_2$, and SaO_2. Respiratory mechanics were evaluated by measuring peak airway pressure (Ppeak).

Statistical Analysis

The data was performed using SPSS version 25.0. Continuous variables were expressed as mean±standard deviation. Intergroup comparisons were conducted using appropriate parametric or non-parametric tests based on data distribution. A p-value of less than 0.05 was considered statistically significant.

RESULTS

The study population consisted of 50 patients, with 25 patients in each group. There were no statistically significant differences between the groups in terms of demographic characteristics, including age, sex, body weight, height, and ASA classification ($p>0.05$) (Table 1).

Table 1. Demographic and baseline characteristics of the patients

Parameter	Prone group (n=25)	Sitting-prone group (n=25)	p-value
Age (years)	45.2±12.1	46.8±11.5	>0.05
Gender (M/F)	14/11	13/12	>0.05
Weight (kg)	78.4±10.2	76.9±9.8	>0.05
Height (cm)	168.3±7.1	169.1±6.5	>0.05
ASA (I/II/III)	10/11/4	9/12/4	>0.05

M: Male, F: Female, ASA I: Healthy patient, ASA II: Patient with mild systemic disease, ASA III: Patient with severe systemic disease

In the supine position, no significant differences were observed between the groups in terms of hemodynamic parameters or arterial blood gas values, confirming comparable baseline physiological conditions. Hemodynamic parameters measured at different time points are presented in Table 2. Following positioning, diastolic blood pressure was significantly lower in the sitting-prone group ($p<0.05$). At 30 minutes intraoperatively, heart rate was significantly lower in the prone group compared to the sitting-prone group ($p<0.05$).

Table 2. Hemodynamic parameters at different time points

Parameter	Time	Prone group	Sitting-prone group	p-value
HR (bpm)	Supine	78±10	80±9	>0.05
	Position	82±11	85±10	>0.05
	30 min	76±9	84±10	<0.05
SBP (mmHg)	Supine	125±15	128±14	>0.05
	Position	120±13	118±12	>0.05
	30 min	118±12	115±11	>0.05
DBP (mmHg)	Supine	78±9	80±8	>0.05
	Position	76±8	70± 7	<0.05
	30 min	75±7	72±6	>0.05

HR: Heart rate, bpm: Beats per minute, Min: Minute, SBP: Systolic blood pressure, mmHg: Millimeters of mercury, DBP: Diastolic blood pressure

Following positioning, diastolic blood pressure was found to be significantly lower in the sitting-prone group compared to the prone group ($p<0.05$). However, no significant differences were observed in systolic blood pressure, heart rate, or oxygen saturation at this stage.

At 30 minutes after the initiation of surgery, significant differences emerged between the groups. The sitting-prone group demonstrated significantly higher PaO_2 and SaO_2 values compared to the prone group ($p<0.05$), indicating improved oxygenation. Conversely, peak airway pressure was significantly higher in the prone group ($p<0.05$) (Table 3).

Table 3. Respiratory and arterial blood gas parameters

Parameter	Time	Prone group	Sitting-prone group	p-value
PaO_2 (mmHg)	Supine	92±8	93±7	>0.05
	Position	95±9	100±8	>0.05
	30 min	90±7	102±9	<0.05
SaO_2 (%)	Supine	97±1	97±1	>0.05
	Position	97±1	98±1	>0.05
	30 min	96±1	99±1	<0.05
$PaCO_2$ (mmHg)	Supine	38±3	37±3	>0.05
	Position	39±3	38±3	>0.05
	30 min	40±4	38±3	>0.05
Ppeak (cmH_2O)	Supine	18±3	17±2	>0.05
	Position	22±4	19±3	<0.05
	30 min	24±4	20±3	<0.05

PaO_2: Partial pressure of arterial oxygen, Min: Minute, SaO_2: Arterial oxygen saturation, Ppeak: Peak airway pressure, cmH_2O: Centimeters of water

DISCUSSION

The present study demonstrates that patient positioning during lumbar spine surgery significantly influences both pulmonary and hemodynamic parameters. Our findings suggest that the sitting-prone position provides superior oxygenation and lower airway pressures compared to the conventional prone position, while maintaining overall hemodynamic stability.

The prone position has long been considered the standard approach in lumbar spine surgery due to its ability to provide optimal surgical exposure. However, it is well established that this position is associated with increased intra-abdominal pressure, which leads to cephalad displacement of the diaphragm and a subsequent reduction in functional residual capacity and lung compliance.[3,9] These physiological alterations result in increased airway pressures and may impair gas exchange. The significantly higher peak airway pressures observed in the prone group in our study are consistent with these previously reported findings.

In contrast, the sitting-prone position appears to mitigate many of these adverse respiratory effects. By allowing the abdomen to remain free and reducing intra-abdominal pressure, this position facilitates diaphragmatic excursion and improves lung compliance. This likely explains the significantly higher PaO_2 and SaO_2 values observed in the sitting-prone group at 30 minutes intraoperatively. Improved oxygenation in this position may be attributed to better ventilation-perfusion matching, as has been suggested in previous studies evaluating positional effects on pulmonary physiology.[10]

Another important finding of this study is the difference in airway pressures between the two groups. Elevated peak airway pressure is clinically relevant, as it is associated with an increased risk of barotrauma and ventilator-induced lung injury. The lower Ppeak values observed in the sitting-prone group suggest that this position may offer a protective advantage for the lungs, particularly in patients with pre-existing pulmonary compromise.

The hemodynamic effects of patient positioning must also be carefully considered. In our study, diastolic blood pressure was significantly lower in the sitting-prone group immediately after positioning. This finding may be explained by reduced venous return due to gravitational effects and decreased preload, which are known consequences of elevated positioning.[8,11] Although this reduction in blood pressure did not appear to result in clinically significant instability in our cohort, it underscores the importance of vigilant hemodynamic monitoring and appropriate fluid management when using the sitting-prone position.

Interestingly, heart rate was found to be lower in the prone group at 30 minutes intraoperatively. While the clinical significance of this finding is uncertain, it may reflect compensatory autonomic responses to differences in preload and vascular resistance between the two positions. Further studies incorporating advanced hemodynamic monitoring techniques could provide more insight into these mechanisms.

When interpreting our findings, it is important to consider the broader clinical implications. Improved oxygenation and reduced airway pressures are particularly advantageous in patients with limited pulmonary reserve, obesity, or chronic respiratory disease. In such populations, even modest improvements in respiratory mechanics may translate into reduced perioperative morbidity. Therefore, the sitting-prone position may be especially beneficial in selected high-risk patient groups.

Our findings are generally consistent with the existing literature, which suggests that minimizing abdominal compression during prone positioning improves respiratory outcomes. However, direct comparisons between prone and sitting-prone positions remain limited, and our study contributes to this relatively underexplored area. By providing comparative data, this study helps to clarify the physiological advantages of the sitting-prone position.

Limitations

Despite these strengths, several limitations should be acknowledged. First, the retrospective design of the study introduces the possibility of selection bias and limits the ability to establish causal relationships. Second, the relatively small sample size may reduce the statistical power to detect subtle differences between groups. Third, we did not evaluate postoperative outcomes such as pulmonary complications, length of hospital stay, or patient recovery, which would provide a more comprehensive assessment of the clinical impact of positioning.

CONCLUSION

The sitting-prone position appears to offer meaningful advantages in terms of pulmonary function by improving oxygenation and reducing airway pressures. While careful attention must be paid to potential hemodynamic changes, these effects are generally manageable in clinical practice. Taken together, our findings support the consideration of sitting-prone positioning as a viable and potentially superior alternative to the traditional prone position in lumbar spine surgery. Future prospective, randomized controlled studies with larger sample sizes are needed to validate these findings and further explore the long-term outcomes associated with different surgical positions. Additionally, incorporating advanced monitoring techniques, such as dynamic lung compliance measurements and cardiac output monitoring, may provide deeper insights into the physiological mechanisms underlying the observed differences.

ETHICAL DECLARATIONS

Ethics Committee Approval

This study was conducted with the approval of the Non-interventional Researches Ethics Committee at Kırıkkale University (Date: 28.05.2025, Decision No: 2025.05.03).

Informed Consent

As this was a retrospective study, formal written informed consent was not required and was therefore not obtained. This retrospective study used pre-existing anonymized patient data. No additional intervention was performed, and there was no direct patient contact. The study was approved by the Ethics Committee, and the requirement for written informed consent was waived by the ethics committee.

Peer Review Process

This manuscript was subject to external peer review.

Conflict of Interest

The authors declare no conflicts of interest related to this study.

Financial Disclosure

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Author Contributions

Conceptualization: IG; Methodology: IG, SD; Data Collection: SD; Statistical Analysis: SD; Writing-Original Draft: SD, IG; Writing-Review & Editing: IG, MÖ.

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