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# A Novel Combined Anesthetic Technique to Improve the Surgical Working Conditions of Lumbar and Thoracolumbar Spine Surgery from a Spine Surgeon's Perspective: A Prospective Randomized Controlled Study

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**Study Design:** Prospective randomized controlled study.

**Purpose:** This study aimed to assess the effects of a different combination of anesthetic techniques in lumbar and thoracolumbar spinal surgeries in terms of muscle relaxation and surgical field in addition to hemodynamic parameters.

**Overview of Literature:** Adequate relaxation of the erector spinae muscle and good surgical fields are preferred in lumbar spine surgeries. The effects of anesthetic techniques on these parameters have not been evaluated from a surgeon's perspective to date. We propose a novel combined anesthetic technique that improves the working conditions from a surgeon's perspective as we hypothesize that combining general anesthesia (GA) with regional anesthesia (RA) might provide benefits for both techniques.

**Methods:** A prospective randomized study of 76 patients who underwent lumbar and thoracolumbar surgeries was conducted by randomly allocating patients into three anesthetic groups: GA alone, GA with spinal anesthesia (SA), and GA with erector spinae plane block (ESPB) by the allocation concealment method to avoid selection bias. The working conditions were assessed by the same operating surgeon who was blinded by the type of anesthesia to eliminate the assessment bias. Muscle relaxation and surgical field were compared among the three groups along with other hemodynamic parameters to identify any significant differences.

**Results:** Significantly better muscle relaxation, surgeon satisfaction, postoperative analgesia, and blood pressure (BP) were observed in the GA+RA when compared to GA alone ($p<0.01$), whereas no difference was observed between the GA+SA and GA+ESPB groups ($p>0.05$). Complications were only observed in the GA+SA group (19%).

**Conclusions:** The study results suggest that the addition of RA to GA may provide better working conditions and surgeon's satisfaction by improving relaxation of the erector spinae in addition to decreasing the BP and postoperative pain in contrast to the use of GA alone. The combined GA and ESPB techniques may be a viable anesthetic alternative to provide better working conditions for surgeons.

**Keywords:** Lumbar vertebrae; Muscle relaxation; Nerve block; Paraspinal muscles; Spine

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## Introduction

Muscle relaxation and a bloodless field are the preferred surgical working conditions from a spine surgeon's perspective as it eases the operative technique. Adequate relaxation of the erector spinae muscle is important for posterior spine surgeries, especially during instrumentation, and the type of anesthesia determines the extent of its relaxation. General anesthesia (GA) and regional anesthesia (RA) are the techniques used in lumbar surgery. GA is commonly used as it safely secures the airway [1,2], whereas the risk of airway compromises when RA alone is used in the prone position, which might require emergent changes in position in the middle of a surgical procedure for intubation. The merits of RA such as decreased blood loss, better muscle relaxation, and postoperative analgesia are well established in orthopedic limb surgeries, whereas its role in spinal surgery remains controversial [3,4]. Spinal anesthesia (SA) and erector spinae plane block (ESPB) are RA techniques currently used in lumbar spine surgeries including discectomy [5]. Although the use of these anesthetic techniques in spinal surgery has been published from an anesthetist's perspective, its effects from spinal surgeons' perspectives have not been reported to date.

We hypothesized that combining GA and RA for lumbar and thoracolumbar spinal surgeries might provide better working conditions for the surgeon by utilizing the benefits of both techniques. Hence, this study aimed to assess the effects of a different combination of anesthetic techniques in lumbar and thoracolumbar spinal surgeries in terms of muscle relaxation and surgical field in addition to hemodynamic parameters.

## Materials and Methods

A prospective randomized study was conducted to assess the working conditions in different types of anesthesia in patients undergoing lumbar and thoracolumbar surgeries after obtaining approval from the institutional ethics committee. A minimum sample size of 19 patients in each group was decided before starting the study with a 90% confidence interval, 80% power, and 35% estimated differences in muscle relaxation as the primary outcome.

The anesthetic technique was categorized into groups 1 (GA alone) and 2 (GA+RA). Based on the type of RA, group 2 was subdivided into groups 2a (GA+SA) and 2b (GA+ESPB). Patients were assessed by an anesthetist for both groups of anesthesia, and informed consent was obtained from all patients regarding their willingness to participate in the study (VMCIEC/76/2021). All patients who were scheduled for lumbar and thoracolumbar surgeries and who were also considered fit and indicated for combined anesthesia by the anesthetists were included in the study. Patients unwilling to undergo combined anesthetic techniques and those with diseases contraindicated or who cannot undergo SA were excluded. Sequentially the numbered opaque sealed envelope technique of allocation concealment was used for randomization to avoid selection bias. Sealed envelopes mentioning a single anesthesia group were prepared in advance; then, the anesthetist randomly picked one after the patient enters the operating room. The anesthetic technique is revealed only to the anesthetist, whereas the surgeon was blinded by the type of anesthesia. Intraoperative neuromonitoring was not used in any of these patients.

A standard protocol of anesthesia was made by anesthetists for the three groups to avoid technique differences.

Group 1: After the premedication with intravenous lycopyrrolate (0.2 mg) and midazolam (1 mg), GA was induced with fentanyl (2 μg/kg) and propofol (2 mg/kg). Intravenous suxamethonium (2 mg/kg) was used for intubation, and GA was maintained with cisatracurium, oxygen, nitrous oxide, and sevoflurane, and the muscle relaxant dose was repeated based on the train of four fade monitoring. Intraoperative analgesia was maintained with fentanyl (2 μg/kg) and paracetamol injections (15 mg/kg).

Group 2a: After adequate preloading with crystalloids, SA was administered in a sitting position one level above the pathological segment using a 25G/23G Quincke spinal needle with 3 mL of 0.5% bupivacaine heavy and fentanyl (25 μg). GA was then induced as in group 1, 10 minutes after SA to prevent hypotension.

Group 2b: After inducing GA, patients were placed in the prone position. Ultrasound-guided ESPB was administered using a high-frequency linear probe, and a Quincke spinal needle (20G) was inserted beneath the erector spinae muscle to hydrodissect it from the underlying transverse process (Fig. 1), followed by bilaterally injecting 20 mL of 0.25% bupivacaine. ESPB was administered bilaterally at the transverse process level of the vertebra in the middle of the planned surgical incision, which aided the equal spread of drugs both in the proximal and distal aspects of the incision length along the plane of the erector spinae muscle.

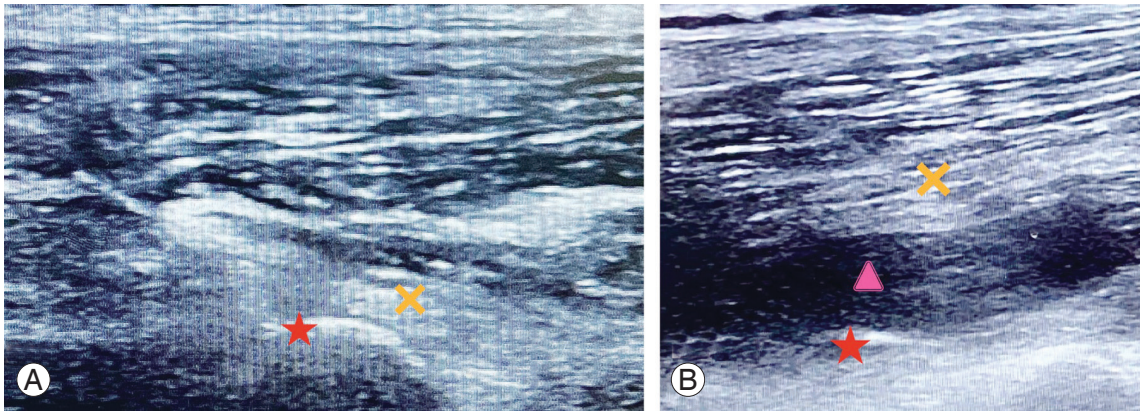


**Fig. 1. (A)** Ultrasound-guided sonoanatomy in a prone position during erector spinae plane block (ESPB) showing transverse process (red star) and erector spinae muscle (yellow cross) above it. The erector spinae muscle is found to be in close contact with the transverse process before injection and the tip of the spinal needle used for ESPB should be directed and placed over the bony surface of transverse process. **(B)** The pink triangle shows the injected anesthetic drug beneath the erector spinae muscle (yellow cross) elevating it from the underlying transverse process (red star).

**Table 1.** Leiden's surgical rating scale [6]

| Score | Conditions | Description |
|---|---|---|
| 1 | Extremely poor conditions | The surgeon is unable to work because of coughing or because of the inability to obtain a visible laparoscopic field because of inadequate muscle relaxation. Additional blocking agents must be given. |
| 2 | Poor conditions | There is a visible laparoscopic field, but the surgeon is severely hampered by inadequate muscle relaxation with continuous muscle relaxations, movements, or both with the hazard of tissue damage. Additional neuromuscular blocking agents must be given. |
| 3 | Acceptable conditions | There is a wide visible laparoscopic field but muscle contractions, movements, or both occur regularly causing some interference with the surgeon's work. There is the need for additional neuromuscular blocking agents to prevent deterioration. |
| 4 | Good conditions | There is a wide laparoscopic working field with sporadic muscle contractions, movements, or both. There is no immediate need for additional neuromuscular blocking agents unless there is the fear for deterioration. |
| 5 | Optimal conditions | There is a wide visible laparoscopic working field without any movement or contractions. There is no need for additional neuromuscular blocking agents. |

Intravenous tranexamic acid (15 mg/kg) was administered 20 minutes before skin incision in all three groups to prevent intraoperative bleeding. Hemodynamic parameters such as intraoperative blood loss including mean blood pressure (BP) and heart rate (HR) were recorded in addition to demographic details. The surgical working conditions were quantified by a spinal surgeon after completing every procedure, and postoperative complications if any were also documented. All surgeries were performed by the same experienced spinal surgeon who was blinded to the type of anesthesia used till the end of the study. Hence, the surgeon's quantification of every patient was without the knowledge of anesthesia used to avoid observer's assessment bias.

The Leiden surgical rating scale (Table 1) [6], a 5-point ordinal scale, was used by the surgeon to quantify muscle relaxation ranging from 1 (extremely poor) to 5 (optimal working condition). Scores 1 and 2 were combined into the "inadequate relaxation" group as an excessive force was needed for muscle retraction to achieve the required visibility for instrumentation. The remaining scores 3, 4, and 5 were combined into "adequate relaxation" as the force required in this group was lesser (Fig. 2). The Modena bleeding score (Table 2) [7], another 5-point ordinal scale, was used to quantify the surgical field, ranging from 1 to 5. Scores 1 and 2 were combined into a "good surgical field" as they did not hinder the surgery. Scores 3, 4, and 5 were combined into "inadequate surgical field" as the bleeding delayed the procedure. Postoperative analgesia was provided with paracetamol infusion in all patients with additional tramadol infusion in those with severe pain with a Visual Analog Scale (VAS) score of 7–10. The same postoperative analgesic regimen was followed up in all three groups, irrespective of the type of anesthesia and pain severity, and was assessed using the VAS score postoperatively for 24 hours. The overall surgical satisfaction

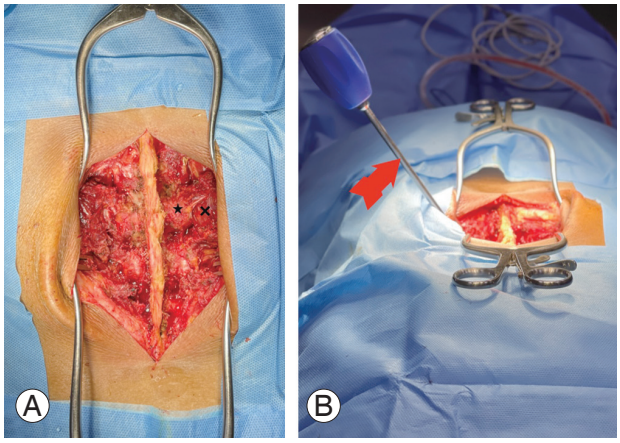


**Fig. 2. (A)** Intraoperative clinical image of an exposed posterior lumbar spine in general anesthesia+erector spinae plane block group with the orientation of head-end in the superior part of the picture and foot end in the inferior part. The spinous process is seen in the midline with excellent retraction of the erector spinae muscle giving adequate visualization of not only the facet joints (black star) but also the transverse process (black cross) which facilitates spine instrumentation. **(B)** Intraoperative image in the same patient showing the extent of angling of pedicle awl (red arrow) that can be achieved for spine instrumentation with the minimal force needed for muscle retraction when the muscle is adequately relaxed.

was recorded as "satisfied" or "not satisfied" after completing the surgery.

R-programming (The R Foundation for Statistical Computing, Vienna, Austria) was used for statistical analysis. Fisher's exact test and chi-square test were used to compare proportions between two categorical variables. Normality verification of the data was performed using the Shapiro-Wilk test. Continuous data between the two groups were compared using an independent sample *t*-test, and a 5% significance level ($p<0.05$) was considered statistically significant.

**Table 2.** Modena bleeding score

| Score | Description |
|---|---|
| 1 | No bleeding |
| 2 | Bleeding easily controlled by suctioning, washing, or packing without any significant modification or slowing of surgical procedure |
| 3 | Bleeding slowing surgical procedure |
| 4 | Most of the maneuvers dedicated to bleeding control |
| 5 | Bleeding that prevents every surgical procedure except those dedicated to bleeding control |

**Table 3.** Comparison of various parameters between the different anesthesia groups

| Variable | Anesthesia | | *p*-value | Anesthesia | | *p*-value |
|---|---|---|---|---|---|---|
| | GA alone | (GA+SA) & (GA+ESPB) | | GA+SA | GA+ESPB | |
| Leiden scale | | | 0.001** | | | 1.000 |
| LS 1 & 2 | 16 (44.4) | 2 (5.0) | | 1 (4.8) | 1 (5.3) | |
| LS 3, 4, & 5 | 20 (55.6) | 38 (95.0) | | 20 (95.2) | 18 (94.7) | |
| Total | 36 (100.0) | 40 (100.0) | | 21 (100.0) | 19 (100.0) | |
| Modena score | | | 0.291 | | | 0.051 |
| MS 1 & 2 | 22 (61.1) | 29 (72.5) | | 18 (85.7) | 11 (57.9) | |
| MS 3, 4, & 5 | 14 (38.9) | 11 (27.5) | | 3 (14.3) | 8 (42) | |
| Total | 36 (100.0) | 40 (100.0) | | 21 (100.0) | 19 (100.0) | |
| Hemodynamic parameters | | | | | | |
| Blood loss (mL) | 238.06±151.75 | 207.25±102.88 | 0.299 | 200.48±115.00 | 214.74±90.13 | 0.667 |
| Systolic BP (mm Hg) | 116.56±13.95 | 105.35±11.69 | 0.001** | 100.67±7.28 | 110.53±13.53 | 0.006** |
| Diastolic BP (mm Hg) | 74.72±11.08 | 67.25±8.77 | 0.002** | 66.19±8.05 | 68.42±9.58 | 0.429 |
| Heart rate (beats/min) | 86.22±9.90 | 83.75±12.61 | 0.349 | 84.52±13.19 | 82.89±12.23 | 0.689 |
| VAS score | 2.22±0.68 | 0.90±0.71 | 0.001** | 0.48±0.11 | 1.37±0.60 | 0.001** |
| Surgeon satisfaction | | | 0.012* | | | 1.000 |
| Satisfied | 18 (50.0) | 31 (77.5) | | 16 (76.2) | 15 (78.9) | |
| Not satisfied | 18 (50.0) | 9 (22.5) | | 5 (23.8) | 4 (21.1) | |
| Total | 36 (100.0) | 40 (100.0) | | 21 (100.0) | 19 (100.0) | |

Values are presented as number (%) or mean±standard deviation.
GA, general anesthesia; SA, spinal anesthesia; ESPB, erector spinae plane block; BP, blood pressure; VAS, Visual Analog Scale.
*$p<0.05$. **$p<0.01$.

## Results

A total of 76 patients (35 males and 41 females) with a mean age of 48 years (range, 16–75 years) were included. Surgical indications were spondylolisthesis in 28 patients, spondylodiscitis in 14, unstable fracture in 18, degenerative disk disease in six, decompression and discectomy in six, and failed back surgery syndrome in four. A total of 17 patients underwent surgeries at the thoracolumbar junction while the remaining 59 patients underwent lumbar surgeries. Then, 36 procedures were performed under GA alone. GA+RA was used in 40 surgeries, of which SA was used in 21 and ESPB in the remaining 19 patients. The addition of ESPB or SA to GA took an additional 10–15 minutes in the total surgical time (Table 3).

### 1. Muscle relaxation

Group 1: Relaxation was inadequate in 16 patients administered with GA alone with a Leiden score of 1 in two and 2 in 14 patients. Adequate relaxation was observed in 20 patients with scores of 3 in four patients, 4 in 10, and 5 in six. Group 2: Adequate relaxation was observed in 38 patients in the GA+RA in which a score of 5 was observed in 10 patients, 4 in 21, and 3 in seven. Inadequate relaxation was observed only in two patients with a score of 2, whereas none of them had a score of 1.

Adequate relaxation was found in the majority of patients in the GA+RA group (95%) when compared to GA alone (55.6%), and this difference was statistically significant ($p$=0.001). However, no statistically significant difference ($p$=1.000) was observed between the subgroups in group 2 as adequate relaxation was achieved in 20 patients (95.2%) in SA and 18 patients (94.7%) in ESPB, which was comparable.

### 2. Surgical field

Group 1: The surgical field was inadequate in 14 patients (38.9%), in which GA alone was administered, of which 13 patients had a score of 4 and one had a score of 3. A good surgical field was observed in the remaining 22 patients (61.1%), of which a score of 2 was observed in 22 cases and none had a score of 1. Group 2: A good surgical field was observed in 29 patients (72.5%) in the GA+RA group with a bleeding score of 2 in 29 patients and none had a score of 1 while an inadequate field was observed in 11 patients (27.5%) with a score of 5 in no patient, 4 in nine, and 3 in two. Among the RA group, an adequate surgical field was observed in 18 patients (85.7%) in the SA group and 11 patients (57.9%) in whom ESPB was administered. The surgical field difference between the two groups was not statistically significant ($p$=0.291), and similarly, no significant difference was observed between the GA+SA and GA+ESPB groups ($p$=0.051).

### 3. Postoperative Visual Analog Scale score for pain

The mean VAS score during the postoperative period was significantly higher in the group with GA alone ($p$=0.001) when compared to the GA+RA group. In group 2a, GA+SA had a significantly lesser pain score than ESPB ($p$=0.001).

### 4. Hemodynamic parameters

The mean BP was 117/75 mm Hg in the GA-alone group (90/60–140/100 mm Hg), which was higher than that of the GA+RA group with a BP of 105/67 mm Hg, and this difference was statistically significant ($p$<0.05). Among the patients in group 2, the mean BP of 101/66 mm Hg was observed in the GA+SA group (90/60–110/90 mm Hg), whereas 111/68 mm Hg was observed in the GA+ESPB group (130/80–80/50 mm Hg), and the systolic BP was significantly lower when SA was used ($p$=0.006). The mean HR was 86 beats/min in group 1 (range, 60–110 beats/min), 84 beats/min in group 2a (range, 55–120 beats/min), and 83 beats/min in group 2b (range, 40–102 beats/min). The mean blood loss in group 1 was 238 mL (range, 10–700 mL), while it was 200 mL in group 2a (range, 50–300 mL) and 214 mL in group 2b (range, 50–400 mL). Apart from BP with significantly low in the GA+SA group, no statistically significant difference was observed in other hemodynamic parameters.

### 5. Overall surgeon satisfaction

The satisfaction was good in 31 patients in group 2 (77.5%), whereas the same satisfaction level was observed only in 18 patients in group 1 (50%), and this difference was statistically significant ($p$=0.012). The satisfaction rate was similar between the SA and ESPB groups.

**6. Complications**

Following complications occurred only in the GA+SA group (four patients [19%]). Severe hypotension occurred in two patients due to exacerbation of SA-induced vasodilatation and post-spinal headache in two patients. Cerebrospinal fluid (CSF) leakage from the wound occurred in one patient who underwent revision surgery. The wound was re-explored, and the leak was found to be originating from the superior to the decompressed level. Hence, decompression was extended cranially, and the leak was found to be from the spinal needle puncture site in the midline, which was then repaired with dural suturing following the leak stopped, and the wound healed well. No complications were reported in the GA-alone and GA+ESPB groups.

## Discussion

Lumbar spine surgeries are commonly performed under GA [8,9], whereas uninstrumented surgeries like decompression and discectomies are performed under SA [10,11]. McLain et al. [12] reported that SA was safe and effective for lumbar laminectomy, and Attari et al. [1] reported better hemodynamic stability and surgeon satisfaction in SA when compared to GA. ESPB is another technique of RA that has been used since 2016 with the advantages of bladder function preservation and better postoperative analgesia [13]. The parameters including good muscle relaxation and surgical field reduce morbidity by easing the surgical technique and minimizing tissue trauma as the force needed for muscle retraction is significantly lesser when the muscle is relaxed.

Randomization was performed by allocating concealment to prevent selection bias. The same surgeon quantified muscle relaxation, surgical field, and overall satisfaction in all surgeries. The surgeon was also blinded to the type of anesthesia until the study was completed to eliminate the observer's assessment bias, and the results were analyzed by a statistician who was also blinded to how the patients were grouped.

Significantly better relaxation in the GA+RA group, when compared to the GA-alone group, suggests the addition of RA to GA to provide better muscle relaxation without any difference between the types of RA used, i.e., SA and ESPB. This might be helpful, especially in spinal instrumentation to access the desired angle of pedicle screw insertion in the lumbar spine as the erector spinae muscle group is adequately relaxed requiring minimal force for its retraction (Fig. 2). The rationale for our combined multimodal approach was to prevent complications and delayed recovery, which may be associated with frequent use of nondepolarizing agents for neuromuscular blockade. It thus helped decrease the frequency of using muscle relaxants, which was monitored by a train of four fade monitoring to achieve a speedy and smooth recovery from GA.

Regarding the surgical field, although the mean bleeding score was lower in the GA+RA group than in the GA-alone group, the difference was not statistically significant and a similar result was also observed when comparing GA+RA and GA+SA groups without any significant difference. However, the mean BP was significantly lower in the GA+RA group than that in the GA-alone group and those in group 2, and the mean systolic BP was significantly lower in the GA+SA group than that in the GA+ESPB group. No significant difference was observed in other hemodynamic parameters, such as the HR and blood loss. This significantly lower BP in the GA+RA group might additionally help provide a better surgical field in that group. The overall surgeon satisfaction was more significant in the GA+RA group than that in the GA-alone group and among those in group 2, and no significant difference was observed between the SA and ESPB, suggesting equal satisfaction rates in both types of RA.

Postoperative pain management is challenging in spinal surgery even after opioids due to their invasiveness [14]. Inadequate pain management increases cardiorespiratory complications, lengthens hospital stay duration, and delays mobilization. Although SA eliminates postoperative pain, immediate neurological examination, an important procedure in spinal surgery, is impossible. A novel interfascial plane block including ESPB allows neurological examination by generating regional analgesia without affecting the spinal cord function in addition to providing muscle relaxation and managing postoperative pain [13]. Similarly, the postoperative VAS score in our study was significantly lower in the GA+RA group than that in the GA-alone group, suggesting that the addition of RA to GA will also improve postoperative analgesia. Although postoperative analgesia was more significant in the SA than ESPB in group 2, the inability to perform immediate neurological examination following the surgery is a disadvantage when using SA.

Complications including hypotension [15], post-spinal

headache, and CSF leakage requiring repair were only observed in the GA+SA group, whereas none of them were reported in the GA+ESPB group, further confirming its safety. The additional requirement of muscle relaxants also decreased in patients with RA was combined with GA and anesthesia in this group was maintained with oxygen, nitrous oxide, and sevoflurane [16].

ESPB was first described for postoperative analgesia. The reported mechanism of action is by blocking the dorsal and ventral rami of spinal nerves, which innervate the erector spinae group of muscles and might be attributed to the excellent muscle relaxation observed in patients where ESPB was added to GA. Furthermore, ESPB has a very low risk of complications as ultrasound-guided sonoanatomy can be easily recognized and no structures nearby are at risk of needle injury (Fig. 1). Although SA provides the same extent of relaxation, immediate postoperative neurological examination, an important procedure following spinal surgery, is not possible in SA. However, this novel ESPB technique generates RA without interfering with spinal cord function and aids immediate postoperative neurological evaluation in addition to providing good muscle relaxation. Based on the study results, we advocate a combination of GA and ESPB for lumbar spine surgeries in providing favorable surgical working conditions for surgeons with a low risk of complications. ESPB provides necessary relaxation and postoperative analgesia while GA maintains hemodynamic parameters in addition to a safe prone positioning without the risk of airway compromise. However, the small sample size is a limitation of this study, and further studies with larger sample sizes will be needed to confirm these results.

## Conclusions

The study results suggest that the addition of RA to GA may provide better working conditions and surgeon's satisfaction by improving relaxation of the erector spinae in addition to decreasing the BP and postoperative pain in contrast to the use of GA alone. The combined GA and ESPB technique may be a viable anesthetic alternative to provide better working conditions for surgeons.

## Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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