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Comparison of Ultrasound-Guided Erector Spinae Plane Block and Thoracic Epidural Analgesia for Postoperative Pain Management Following Thoracotomy: A Prospective Randomized Comparative Study

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ABSTRACT

Background: Thoracotomy is associated with severe postoperative pain that can impair respiratory function and delay recovery. Thoracic epidural analgesia (TEA) is considered the gold standard for post-thoracotomy pain management; however, ultrasound-guided erector spinae plane (ESP) block has emerged as a promising alternative with a favorable safety profile. This study compared the analgesic efficacy and safety of TEA and ESP block for postoperative pain management following thoracotomy.

Methods: This prospective, randomized comparative study included 50 adult patients (ASA physical status I–III) undergoing elective thoracotomy under general anesthesia. Patients were randomly allocated into two equal groups: Group T received thoracic epidural analgesia (n = 25) and Group E received ultrasound-guided erector spinae plane block (n = 25). Postoperative pain was assessed using the Visual Analog Scale (VAS) at predefined intervals up to 48 hours. The primary outcome was postoperative pain intensity. Secondary outcomes included time to first rescue analgesia, total tramadol consumption over 48 hours, hemodynamic stability, postoperative complications, patient satisfaction, and duration of hospital stay.

Results: Baseline demographic characteristics, ASA physical status, body mass index, duration of surgery, and duration of anesthesia were comparable between the groups ($p > 0.05$). The thoracic epidural group demonstrated significantly lower VAS pain scores during the first 8 postoperative hours ($p < 0.05$), whereas pain scores at 12, 24, and 48 hours were similar. Time to first rescue analgesia was significantly longer in the thoracic epidural group (11.8 ± 2.9 vs. 9.2 ± 2.6 hours; $p = 0.002$), and total tramadol consumption during the first 48 hours was significantly lower (118 ± 34 mg vs. 152 ± 39 mg; $p = 0.003$). The ESP block group exhibited significantly fewer hypotensive episodes than the thoracic epidural group (8% vs. 32%; $p = 0.03$). The incidences of postoperative nausea and vomiting, respiratory complications, block failure, patient satisfaction, and duration of hospital stay were comparable between the groups, although urinary retention occurred more frequently in the thoracic epidural group.

Conclusion: Thoracic epidural analgesia provided superior early postoperative analgesia and reduced opioid consumption after thoracotomy. However, ultrasound-guided erector spinae plane block offered comparable analgesia beyond the early postoperative period with significantly better hemodynamic stability and fewer epidural-related adverse effects. ESP block represents a safe and effective alternative to thoracic epidural analgesia, particularly in patients where maintenance of hemodynamic stability is desirable.

Keywords: *Thoracic epidural analgesia, erector spinae plane block, thoracotomy, postoperative analgesia, ultrasound-guided regional anesthesia, pain management.*

INTRODUCTION

Thoracotomy is one of the most painful surgical procedures because of extensive tissue dissection, rib retraction, intercostal nerve injury, and pleural irritation. Inadequate postoperative pain control following thoracotomy can impair respiratory function by limiting deep breathing and effective coughing, leading to atelectasis, retained secretions, pneumonia, hypoxemia, prolonged hospital stay, delayed recovery, and the development of chronic post-thoracotomy pain syndrome. Therefore, effective postoperative analgesia is an integral component of enhanced recovery protocols and plays a crucial role in improving patient outcomes.[1]

Thoracic epidural analgesia (TEA) has long been regarded as the gold standard for post-thoracotomy pain management. By providing excellent segmental sensory blockade, TEA offers superior analgesia, improves pulmonary mechanics, facilitates early ambulation, and reduces postoperative pulmonary complications. However, epidural analgesia is associated with several limitations, including technical difficulty, hypotension due to sympathetic blockade, urinary retention, motor weakness, nausea, epidural hematoma, infection, accidental dural puncture, and contraindications in patients receiving anticoagulant therapy or those with coagulopathy. These limitations have prompted the search for safer and equally effective regional analgesic techniques.[2]

The ultrasound-guided erector spinae plane (ESP) block, first described by Forero et al. in 2016, has emerged as a promising interfascial plane block for thoracic and abdominal surgeries. The technique involves injection of local anesthetic deep to the erector spinae muscle and superficial to the transverse process, allowing cranio-caudal spread along the fascial plane with diffusion into the paravertebral and epidural spaces. This results in blockade of the dorsal and ventral rami of the thoracic spinal nerves, providing effective unilateral somatic and visceral analgesia over multiple thoracic dermatomes.[3]

The ESP block has gained popularity because it is technically easier to perform under ultrasound guidance, is performed away from the neuraxis and pleura, and carries a lower risk of serious complications compared with thoracic epidural analgesia. It is particularly advantageous in patients with contraindications to neuraxial techniques or those at increased risk of hypotension. Several clinical studies have demonstrated that the ESP block provides satisfactory postoperative analgesia, reduces opioid consumption, lowers the incidence of opioid-related adverse effects such as nausea and vomiting, and facilitates early mobilization after thoracic surgery. Nevertheless, whether its analgesic efficacy is comparable to thoracic epidural analgesia remains an area of ongoing investigation.[4]

Recent randomized controlled trials and systematic reviews have reported encouraging results with the ESP block in thoracic surgery, suggesting that it may provide analgesia comparable to thoracic epidural analgesia while maintaining better hemodynamic stability and a more favorable safety profile. However, the available evidence remains heterogeneous because of differences in study design, local anesthetic regimens, catheter techniques, outcome measures, and patient populations. Consequently, further well-designed comparative studies are required to establish the relative efficacy and safety of these two techniques.[5]

The present study was therefore undertaken to compare ultrasound-guided erector spinae plane block with thoracic epidural analgesia for postoperative pain control in patients undergoing thoracotomy. The study aims to evaluate postoperative pain scores, opioid consumption, hemodynamic stability, pulmonary function, rescue analgesic requirements, adverse effects, patient satisfaction, and overall quality of recovery. The findings of this study may help determine whether the ultrasound-guided erector spinae plane block can serve as an effective and safer alternative to thoracic epidural analgesia for post-thoracotomy pain management.

MATERIALS AND METHODS

This prospective, randomized, comparative study was conducted in the Department of Anaesthesiology at a tertiary care teaching hospital after obtaining approval from the Institutional Ethics Committee and written informed consent from all participants. The study included 50 adult patients scheduled to undergo elective posterolateral thoracotomy under general anesthesia. The study was carried out over a period of 18 months.

Sample Size

A total of 50 patients were enrolled in the study, with 25 patients allocated to each group. The sample size was determined based on previous published studies comparing ultrasound-guided erector spinae plane block and thoracic epidural analgesia for post-thoracotomy pain control. Considering the expected difference in postoperative pain scores,

an alpha error of 0.05, a study power of 80%, feasibility of patient recruitment during the study period, and allowing for possible dropouts, a sample size of 25 patients per group was considered adequate for this comparative study.

Study Population
Adult patients aged 18–70 years of either sex, belonging to the American Society of Anesthesiologists (ASA) physical status I–III, scheduled for elective open thoracotomy under general anesthesia were included in the study.

Inclusion Criteria
- Patients aged 18–70 years.
- ASA physical status I–III.
- Elective unilateral thoracotomy under general anesthesia.
- Ability to understand the Visual Analogue Scale (VAS).
- Provision of written informed consent.

Exclusion Criteria
- Patient refusal.
- Allergy to local anesthetics.
- Coagulopathy or ongoing anticoagulant therapy.
- Local infection at the block site.
- Severe spinal deformity or previous thoracic spine surgery.
- Chronic opioid use or chronic pain syndrome.
- Neurological disorders affecting pain assessment.
- Body mass index greater than 35 kg/m².
- Severe hepatic or renal dysfunction.
- Emergency thoracic surgery.

Randomization
Patients were randomly allocated into two equal groups (n = 25 each) using a computer-generated randomization sequence. Group allocation was concealed using sequentially numbered, opaque, sealed envelopes, which were opened immediately before administration of the regional analgesic technique.

Study Groups
Group E (Erector Spinae Plane Block Group)
Patients received an ultrasound-guided erector spinae plane block at the T5 vertebral level before induction of anesthesia. Under strict aseptic precautions, a high-frequency linear ultrasound probe was used to identify the transverse process and erector spinae muscle. A 22-G echogenic block needle was advanced in-plane until the tip reached the fascial plane deep to the erector spinae muscle. After negative aspiration, 20 mL of 0.375% ropivacaine was injected with visualization of adequate hydrodissection.

Group T (Thoracic Epidural Analgesia Group)
Patients received thoracic epidural catheter placement at the T5–T6 or T6–T7 intervertebral space under aseptic precautions using the loss-of-resistance technique. Following a negative aspiration test and a test dose, 8–10 mL of 0.2% ropivacaine was administered before surgical incision, followed by continuous epidural infusion of 0.2% ropivacaine at 8–10mL/hour for postoperative analgesia.

Anaesthetic Technique
Standard fasting guidelines were followed. Routine monitoring included electrocardiography, non-invasive blood pressure, pulse oximetry, capnography, and temperature monitoring. General anesthesia was induced with intravenous fentanyl 2 µg/kg, propofol 2 mg/kg, and vecuronium 0.1 mg/kg to facilitate endotracheal intubation with an appropriately sized double-lumen endotracheal tube. Anesthesia was maintained with oxygen-air mixture, sevoflurane, and intermittent doses of vecuronium. Intraoperative analgesia was supplemented with fentanyl as required according to hemodynamic responses.

Postoperative Analgesia
All patients received intravenous paracetamol 1 g every 8 hours as part of multimodal analgesia. Rescue analgesia consisted of intravenous tramadol 1 mg/kg whenever the Visual Analogue Scale (VAS) score was ≥4. The total rescue analgesic consumption over 48 hours was recorded.

Outcome Measures

Primary Outcome

The primary outcome was postoperative pain intensity assessed using the Visual Analogue Scale (VAS; 0–10) at rest at 1, 2, 4, 8, 12, 24, and 48 hours following surgery.

Secondary Outcomes

Secondary outcome measures included VAS during coughing, time to first rescue analgesic requirement, total rescue analgesic consumption during the first 48 hours, intraoperative opioid requirement, hemodynamic parameters (heart rate and mean arterial pressure), incidence of postoperative nausea and vomiting, hypotension, urinary retention, respiratory complications, block-related complications, patient satisfaction score at 48 hours, and duration of hospital stay.

Data Collection

Demographic variables including age, sex, body mass index, ASA physical status, duration of surgery, and duration of anesthesia were recorded. Hemodynamic parameters were documented intraoperatively and during the postoperative period. Pain scores, rescue analgesic requirements, adverse events, and patient satisfaction were assessed by an investigator blinded to group allocation.

Statistical Analysis

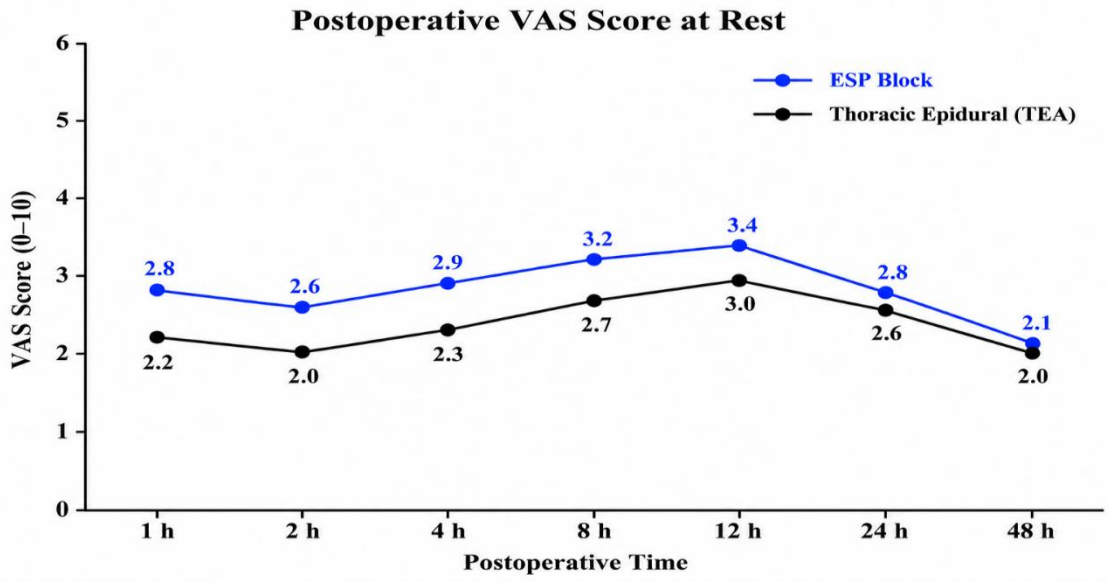
Data were entered into Microsoft Excel and analyzed using Statistical Package for the Social Sciences (SPSS) software version 26.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were expressed as frequencies and percentages. The independent Student's t-test was used for comparison of normally distributed continuous variables, whereas the Mann–Whitney U test was applied for non-normally distributed data. Categorical variables were compared using the Chi-square test or Fisher's exact test as appropriate. Repeated measures analysis of variance (ANOVA) was used to compare changes in pain scores and hemodynamic parameters over time. A p-value of less than 0.05 was considered statistically significant.

RESULTS

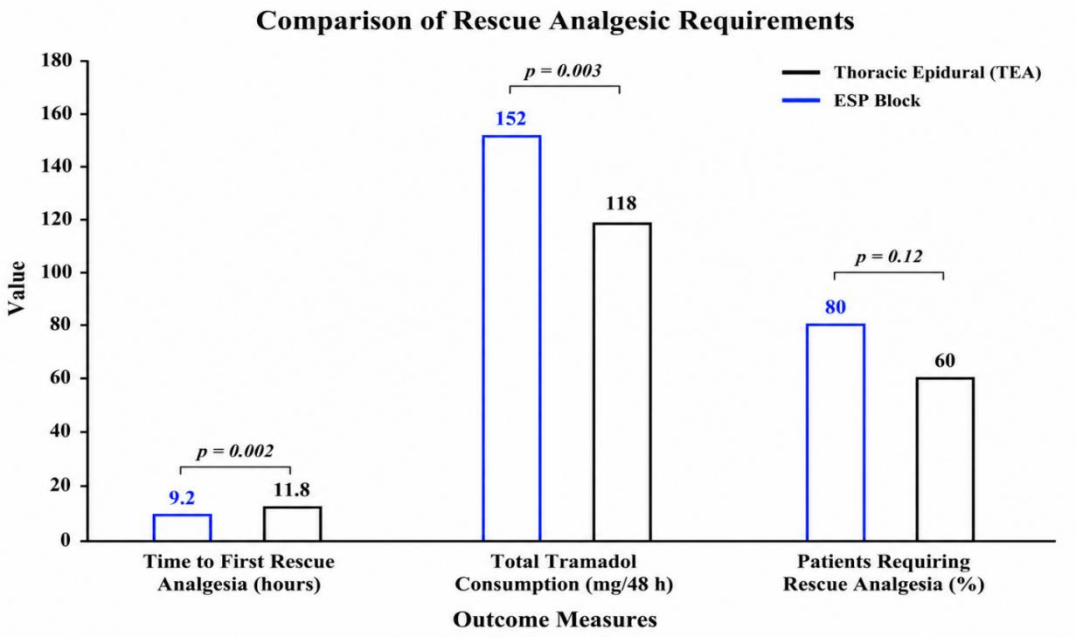
Fifty patients completed the study, with 25 patients in each group. Baseline demographic characteristics, ASA status, body mass index, duration of surgery, and duration of anesthesia were comparable between the groups ($p > 0.05$). Patients in the thoracic epidural group had significantly lower postoperative VAS pain scores at rest during the first 8 postoperative hours ($p < 0.05$). However, pain scores at 12, 24, and 48 hours were comparable between the two groups.

The time to first rescue analgesic requirement was significantly longer in the thoracic epidural group (11.8 ± 2.9 hours vs. 9.2 ± 2.6 hours; $p = 0.002$), and total tramadol consumption during the first 48 hours was significantly lower (118 ± 34 mg vs. 152 ± 39 mg; $p = 0.003$).

Hemodynamic stability was superior in the ESP block group, with significantly fewer hypotensive episodes compared with the thoracic epidural group (8% vs. 32%; $p = 0.03$). The incidences of postoperative nausea and vomiting, urinary retention, respiratory complications, and block failure were similar between the groups, although urinary retention occurred more frequently in the thoracic epidural group. Patient satisfaction scores and duration of hospital stay were comparable between the two groups.



Graph 1: Post operative VAS score at rest



Graph 2: Comparison of rescue analgesia requirement

DISCUSSION

Effective postoperative pain control following thoracotomy remains challenging because of the severe nociceptive and neuropathic pain associated with thoracic incision and rib retraction. Thoracic epidural analgesia (TEA) has long been regarded as the gold standard; however, ultrasound-guided erector spinae plane (ESP) block has emerged as an attractive alternative because of its technical simplicity and favorable safety profile. The present study demonstrated that TEA provided superior early postoperative analgesia and reduced opioid consumption, whereas ESP block offered comparable analgesia after the early postoperative period with significantly better hemodynamic stability.

In the present study, patients receiving thoracic epidural analgesia experienced significantly lower VAS pain scores during the first 8 postoperative hours compared with those receiving ESP block. However, pain scores became comparable after 12 hours and remained similar until 48 hours. These findings suggest that TEA provides a more profound early sensory blockade, while the analgesic efficacy of ESP block becomes comparable during the later postoperative period. Similar findings were reported by Gurkan et al.[2], who demonstrated that ultrasound-guided ESP block provided effective analgesia after thoracic surgery, although early pain scores tended to be slightly higher than those observed with epidural analgesia. Likewise, Elsabeeny et al.[3] found that thoracic epidural analgesia produced marginally lower pain scores immediately after surgery, whereas both techniques offered satisfactory pain control during subsequent follow-up.

The present study also showed that the time to first rescue analgesia was significantly longer in the thoracic epidural group, accompanied by significantly lower tramadol consumption during the first 48 postoperative hours. These observations indicate that continuous epidural analgesia provides more sustained analgesic efficacy and decreases opioid requirements. Similar results were reported by Yeung et al.[4], who observed lower postoperative opioid consumption in patients receiving thoracic epidural analgesia compared with newer regional fascial plane blocks. In contrast, several recent studies evaluating ESP block have demonstrated clinically acceptable opioid-sparing effects despite slightly higher rescue analgesic requirements than epidural techniques. Forero et al.[1], who first described the ESP block, reported excellent postoperative analgesia with substantial reductions in opioid use, highlighting its potential as an effective multimodal analgesic technique.

A major finding of the present study was the significantly superior hemodynamic stability observed in patients receiving ESP block. Hypotensive episodes occurred significantly less frequently in the ESP group compared with the thoracic epidural group. This finding is consistent with the known mechanism of epidural analgesia, where sympathetic blockade frequently results in vasodilation and hypotension. ESP block predominantly acts through fascial plane spread without producing extensive sympathetic blockade, thereby preserving cardiovascular stability. Similar observations have been reported by Tulgar et al.[5], who demonstrated minimal hemodynamic alterations following ESP block in thoracic procedures. Meta-analyses by Pacheco et al.[6] and other investigators have also concluded that ESP block is associated with a significantly lower incidence of hypotension than thoracic epidural analgesia.

The incidence of postoperative nausea and vomiting, respiratory complications, block failure, and duration of hospital stay was comparable between the two groups in the present study. Although urinary retention occurred more frequently in the thoracic epidural group, the difference was not associated with prolonged hospitalization. Similar findings have been reported by Kendall et al.[7] and Yeung et al.[4], who observed comparable postoperative complications between ESP block and thoracic epidural analgesia, while noting a higher frequency of epidural-related adverse effects such as hypotension and urinary retention in patients receiving epidural analgesia.

Patient satisfaction scores were comparable between the two groups despite differences in early postoperative pain scores. This finding suggests that both analgesic techniques provided satisfactory overall pain management when incorporated into a multimodal analgesic regimen. Similar patient satisfaction outcomes have been reported in randomized controlled trials comparing ESP block with thoracic epidural analgesia, where the improved safety profile and ease of administration of ESP block offset its slightly lower early analgesic efficacy.[8]

The findings of the present study support the evolving role of ultrasound-guided ESP block as a safe and effective alternative to thoracic epidural analgesia. Although thoracic epidural analgesia continues to provide superior early postoperative analgesia and greater opioid-sparing effects, the improved hemodynamic stability and lower incidence of epidural-related adverse effects associated with ESP block make it particularly suitable for patients with cardiovascular instability, anticoagulation concerns, or contraindications to epidural catheter placement. These findings are consistent with recent systematic reviews and meta-analyses that conclude ESP block offers analgesic efficacy approaching that of thoracic epidural analgesia while providing a superior safety profile.

CONCLUSION

Thoracic epidural analgesia provided superior early postoperative pain relief, prolonged the time to first rescue analgesia, and reduced opioid consumption following thoracotomy. However, ultrasound-guided erector spinae plane block offered comparable analgesia after the early postoperative period with significantly better hemodynamic stability and fewer epidural-related adverse effects. These findings suggest that ESP block is a safe and effective alternative to thoracic epidural analgesia, particularly in patients in whom hemodynamic stability or avoidance of epidural-related complications is a priority.

Conflict of interest: Nil

Acknowledgement: Nil

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