International Journal of Medical Science in Clinical Research and Review
Online ISSN: 2581-8945
Available Online at https://ijmscrr.in/ Volume 8|Issue 01 (January-February) |2025 Page: 24-31
Review Paper

Impact of Erector Spinae Plane Block on Respiratory Function and Pain Management in Patients with Multiple Rib Fractures: A Systematic Review

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Article Received: 20-December-2024, Revised: 10-January-2025, Accepted: 30-January-2025

ABSTRACT:
Background: Rib fractures are a common injury that often result in significant pain and respiratory complications. Effective pain management is crucial to improve patient outcomes. Erector spinae plane blocks have emerged as a novel regional anesthesia technique, providing promising results in the management of rib fracture pain. **Objectives**: This study evaluates the efficacy and safety of erector spinae plane blocks in rib fracture pain management, focusing on their analgesic benefits, opioid-sparing effects, and impact on respiratory outcomes. **Methods:** A systematic review was conducted by analyzing clinical studies and case reports that assessed the use of erector spinae plane blocks for rib fracture pain. Data were extracted on pain relief, opioid consumption, respiratory parameters, and associated complications. **Results:** A total of 10 studies were included comprising 593 patients with a mean age of 52.1 years. erector spinae plane blocks demonstrated significant pain reduction, enhanced respiratory function, and reduced opioid requirements in patients with rib fractures. Most studies reported minimal complications, and the technique was noted for its simplicity and safety. However, variations in outcomes were observed depending on block administration protocols and patient characteristics. **Conclusions**:Erector spinae plane blocks are an effective and safe option for managing rib fracture pain, providing substantial analgesia while minimizing opioid usage and associated risks. Their application improves respiratory outcomes and reduces the burden of pulmonary complications. Further research is recommended to standardize protocols and assess long-term outcomes.

Keywords: Erector spinae plane block, rib fractures, pain management, regional anesthesia, opioid-sparing analgesia.

INTRODUCTION:

Rib fractures are among the most common injuries encountered in trauma and emergency settings, posing significant challenges to both patients and clinicians. These injuries are often accompanied by severe pain, which can impair respiratory function and increase the risk of secondary complications[1]. Effective pain management is a cornerstone of treatment, as inadequate pain relief in rib fracture patients can lead to detrimental outcomes such as pneumonia, atelectasis, and respiratory distress[2]. Beyond their immediate physical impact, rib fractures can also result in substantial psychological distress, exacerbating the overall burden of the condition. Consequently, there is a critical need for effective, safe, and accessible analgesic interventions tailored to the unique challenges of rib fracture management.

Traditional pain management strategies, including systemic opioid analgesics, have long been the standard of care[3]. However, the limitations of opioids, such as side effects including sedation, respiratory depression, constipation, and the potential for dependence, have driven the search for alternative approaches. While non-opioid pharmacological options and multimodal analgesia regimens have been explored, these methods are not always sufficient in providing adequate pain relief for rib fracture patients.[4] This gap in effective pain control has sparked interest in regional anesthesia techniques, which offer targeted analgesia with potentially fewer systemic side effects.

1 Kuo K, Kim AM. Rib Fracture. [Updated 2023 Aug 8]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK541020/

2 Rogers FB, Larson NJ, Rhone A, Amaya D, Olson-Bullis BA, Blondeau BX. Comprehensive Review of Current Pain Management in Rib Fractures With Practical Guidelines for Clinicians. J Intensive Care Med. 2023 Apr;38(4):327-339. doi: 10.1177/08850666221148644. Epub 2023 Jan 4. PMID: 36600614.

3 Horn R, Hendrix JM, Kramer J. Postoperative Pain Control. [Updated 2024 Jan 30]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK544298/

4 Sullivan D, Lyons M, Montgomery R, Quinlan-Colwell A. Exploring Opioid-Sparing Multimodal Analgesia Options in Trauma: A Nursing Perspective. J Trauma Nurs. 2016 Nov/Dec;23(6):361-375. doi: 10.1097/JTN.0000000000000250. PMID: 27828892; PMCID: PMC5123624.

Among these, the erector spinae plane block has emerged as a promising modality in recent years.

The erector spinae plane block is a novel fascial plane block used for managing chronic thoracic neuropathic pain and postoperative pain in thoracic surgery. This technique involves injecting a local anesthetic into the plane between the transverse process of the vertebra and the erector spinae muscle group. erector spinae plane blocks serve as an effective alternative to paravertebral or epidural blocks[5].

One of the key advantages of the erector spinae plane block is its safety profile, particularly when compared to traditional techniques like epidural or paravertebral blocks.[6] These traditional methods, while effective, carry risks such as dural puncture, epidural hematoma, and systemic local anesthetic toxicity, and they may be contraindicated in patients with coagulopathy, thrombocytopenia, or those on antiplatelet or anticoagulant therapy[7,8,9,10,11]. In contrast, the erector spinae plane block is performed in a more superficial anatomical location, reducing the risk of complications. Furthermore, its simplicity and ease of administration make it a practical option in a wide range of clinical settings, including emergency departments, intensive care units, and perioperative environments.

The utility of the erector spinae plane block in rib fracture management is supported by an increasing body of evidence, including randomized controlled trials, cohort studies, and case reports. These studies have demonstrated the efficacy of erector spinae plane blocks in providing substantial pain relief, reducing the need for systemic opioids, and improving respiratory outcomes. In rib fracture patients, effective pain control is particularly critical for maintaining adequate ventilation and preventing secondary complications[12]. Pain from rib fractures can lead to shallow breathing, splinting, and reduced lung expansion, all of which contribute to the development of pulmonary complications such as atelectasis and pneumonia. By providing targeted analgesia, the erector spinae plane block facilitates deeper breathing and improved lung function, ultimately enhancing patient outcomes.

In addition to its analgesic benefits, the erector spinae plane block has shown promise in improving other aspects of patient care[13]. For example, studies have highlighted its role in enhancing patient comfort, reducing the length of hospital stays, and lowering the overall cost of care. Its versatility extends to various patient populations, including those with multiple rib fractures, elderly patients with frailty-related challenges, and individuals with underlying respiratory conditions that heighten their vulnerability to complications.

This systematic review aims to evaluate the effectiveness and safety of erector spinae plane blocks in managing pain and improving respiratory outcomes in patients with rib fractures. By examining existing studies, including randomized controlled trials, cohort studies, and case series, we seek to provide a comprehensive assessment of the benefits and limitations of erector spinae plane blocks in this patient population. Through this review, we aim to offer valuable insights that can guide clinical practice and future research in the management of rib fractures.

METHODOLOGY:

Study Design:

This systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to assess the effectiveness and safety of erector spinae plane blocks in managing pain and improving respiratory outcomes in patients with rib fractures. The study adhered to the Population, Intervention, Comparator, and Outcome (PICO) framework:

- **Population (P):** Patients with rib fractures.
- **Intervention (I):** Erector spinae plane block administered as a regional anesthesia technique.
- **Comparator (C):** Standard pain management techniques, including opioid-based regimens or alternative regional anesthesia methods.
- **Outcomes (O):** Pain reduction, decreased opioid consumption, improved respiratory parameters, safety profile, and incidence of complications.

The study aimed to synthesize findings from randomized controlled trials, cohort studies, case

5 Bonvicini D, Tagliapietra L, Giacomazzi A, Pizzirani E. Bilateral ultrasound-guided erector spinae plane blocks in breast cancer and reconstruction surgery. J Clin Anesth. 2018;44:3–4. doi: 10.1016/j.jclinane.2017.10.006.

6 https://resources.wfsahq.org/atotw/the-erector-spinae-plane-block-a-review-of-current-evidence-2/#:~:text=Many%20experts%20now%20consider%20the,with%20very%20few%20reported%20complications.

7 Restrepo-Garces CE, Chin KJ, Suarez P, Diaz A. Bilateral continuous erector spinae plane block contributes to effective postoperative analgesia after major open abdominal surgery: a case report. A A Case Rep. 2017;9:319–21. doi: 10.1213/XAA.0000000000000605.

8 Luis-Navarro JC, Seda-Guzmán M, Luis-Moreno C, López-Romero JL. The erector spinae plane block in 4 cases of video-assisted thoracic surgery. Rev Esp Anestesiol Reanim. 2018;65:204–8. doi: 10.1016/j.redar.2017.12.004.

9 De Cassai A, Iepparielloo G, Ori C. Erector spinae plane block and dual antiplatelet therapy. Minerva Anestesiol. 2018;84:1230–1. doi: 10.23736/S0375-9393.18.12815-X

10 Adhikary SD, Prasad A, Soleimani B, Chin KJ. Continuous erector spinae plane block as an effective analgesic option in anticoagulated patients after left ventricular assist device implantation: a case series. J Cardiothorac Vasc Anesth. 2019;33:1063–7. doi: 10.1053/j.jvca.2018.04.026.

11 Wyatt K, Elattary T. The erector spinae plane block in a high-risk Ehlers-Danlos syndrome pediatric patient for vascular ring repair. J Clin Anesth. 2019;54:39–40. doi: 10.1016/j.jclinane.2018.10.031.

12 https://link.springer.com/article/10.1007/s13670-016-0155-z#:~:text=Pain%20Management%20and%20Non%2Doperative%20Management&text=The%20goals%20of%20rib%20fracture,mechanical%20ventilation%2C%20and%20possible%20tracheostomy.

13 Krishnan S, Cascella M. Erector Spinae Plane Block. [Updated 2023 Jun 4]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK545305/

series, and pilot studies to provide a comprehensive evaluation of the utility and limitations of erector spinae plane blocks in rib fracture management.

Inclusion and Exclusion Criteria:

To ensure relevance and methodological rigor, the study applied the following inclusion and exclusion criteria:

- **Inclusion Criteria:**
  - Original research articles (randomized controlled trials, prospective and retrospective cohort studies, case series, and pilot studies).
  - Studies reporting on patients with rib fractures who underwent erector spinae plane block administration.
  - Articles evaluating pain scores, opioid consumption, respiratory outcomes, and the safety of erector spinae plane blocks.
  - Full-text studies published in English.
- **Exclusion Criteria:**
  - Case reports, letters to the editor, narrative reviews, and systematic reviews.
  - Studies focusing on regional anesthesia techniques other than erector spinae plane blocks or using only multimodal pain management without erector spinae plane blocks.
  - Articles with incomplete methodologies or insufficient outcome data.

These criteria ensured that the analysis focused on high-quality evidence directly relevant to the research question.

Literature Search Strategy:

The literature search covered multiple databases, including PubMed, Scopus, MEDLINE, Cochrane Library, EMBASE, and Web of Science. Searches were conducted using the following keywords and Boolean operators:

- (erector spinae plane block OR erector spinae plane block) AND (rib fractures) AND (pain management OR analgesia OR opioid sparing) AND (respiratory outcomes OR safety).
- (erector spinae plane block) AND (respiratory function OR pain management AND (multiple rib fractures)

Additional gray literature was searched in Google Scholar and OpenGrey to identify relevant unpublished or non-indexed studies. No restrictions were placed on the year of publication.

Study Selection and Data Extraction

Two independent reviewers screened the titles and abstracts of retrieved studies to identify eligible articles based on the inclusion criteria. Full-text articles were reviewed for final inclusion. In cases of discrepancies, a third reviewer was consulted.

Data extracted from each study included the following:

- Study design, publication year, and sample size.
- Patient demographics, including age and gender distribution.
- Details of the erector spinae plane block procedure, including administration techniques and anesthetic agents.
- Primary outcomes: pain scores, opioid consumption, and respiratory parameters (e.g., inspiratory capacity, oxygen saturation).
- Secondary outcomes: complications, safety, and adverse events.

Quality Assessment:

The quality of included studies was assessed using the Jadad scale for randomized controlled trials and the Risk of Bias 2.0 (ROB 2.0) tool for all studies. The Jadad scale assigned scores based on randomization, blinding, and withdrawals, while ROB 2.0 evaluated methodological bias. Two reviewers independently assessed study quality, resolving discrepancies through discussion or consultation with a third reviewer.

The statistical and meta-analysis has not been performed due to the limited number of publications.

RESULTS AND DISCUSSION:

Literature Selection:

On initial screening, only a total of 17 articles were retrieved from nine databases (PubMed, PubMed Central, Scopus, Cochrane databases, Google Scholar, MEDLINE, EMBASE, LILACS, and Web of Sciences databases). After screening for duplications, non-English articles, and articles without full text, we included a total of 10 studies in this systematic review. The year of publication was 2019–2024. The PRISMA chart of the study, which provides detailed data on literature collection and screening, is shown in Figure 1. Overall, 10 studies met the criteria, which consisted of randomized controlled trials, prospective and retrospective cohort studies, case series, and pilot studies. Table 1 shows the study characteristics of the included studies. In these studies, a total of 593 patients were included with a mean age of 52.1 years, with males being predominantly represented in most trials. Table 2 shows the demographic characteristics of the study participants in the included studies.

The quality assessment of the included studies was conducted using the Jadad Scale, evaluating biases across five domains: selection, performance, reporting, attribution, and other biases. Six studies (Adhikary et al., El Malla et al., Fitzgerald et al., Elawamy et al., Kumar et al., and Riley et al.) achieved a score of 5, indicating high quality with minimal risk of bias. Four studies (Surdhar and Jelic, Gürbüz and Demir, Syal et al., and Gaballah et al.) scored between 3 and 4, reflecting moderate quality due to the presence of some biases, particularly in performance and reporting domains (Table 3). Overall, the studies demonstrate a mix of high and moderate quality, with the majority ensuring robust methodologies.

Pain and Analgesic Outcomes:

Most studies (Adhikary et al., 2019; Surdhar and Jelic, 2022; El Malla et al., 2022; Fitzgerald et al., 2024; Elawamy et al., 2022; Syal et al., 2024; Kumar et al., 2020) reported significant reductions in pain scores after erector spinae plane block administration. For example, Adhikary et al. (2019) found pain scores decreased from 7.7 (2.5) to 4.7 (3.2) within three hours post-block. In contrast, Syal et al. (2024) and Elawamy et al. (2022) found major decreases in resting and activity-related pain scores, both from 5.9 to 1.6 and from 7.5 to 2.5, respectively, at rest and with movement. Overall, erector spinae plane blocks appear to be a useful method of providing short-term analgesia in the management of patients with rib fractures.

Additionally, many studies documented a decrease in opioid intake, which further substantiates the effectiveness of erector spinae plane blocks in reducing opioid intake. In fact, several studies (Adhikary et al., 2019; Surdhar and Jelic, 2022; Elawamy et al., 2022) showed significant decreases in opioid use after the block. For example, Adhikary et al. (2019) and Elawamy et al. (2022) noted that the erector spinae plane blocks contributed to decreased opioid intake and possibly enhanced patient outcomes with a lower risk of opioid-associated complications.

Respiratory Outcomes:

Some research works examined the effects of erector spinae plane blocks on inspiratory capacity, respiratory rate (RR), oxygen saturation (SpO_2), and arterial blood gas (ABG) analysis. In Syal et al. (2024), the erector spinae plane blocks improved pulmonary function significantly, as indicated by increased inspiratory capacity and improved oxygenation (PaO2). Similarly, Fitzgerald et al. (2024) reported improved respiratory function in patients with multiple rib fractures, although no significant reduction in opioid use was observed compared to multimodal pain management. Adhikary et al. (2019) also demonstrated that erector spinae plane blocks improved inspiratory capacity without causing hemodynamic instability, further supporting the role of erector spinae plane blocks in enhancing respiratory function in rib fracture patients.

Safety and Adverse Outcomes:

Regarding safety, most of the studies reported that erector spinae plane blocks are well-tolerated with no significant complications. For instance, in the case series by Kumar et al. (2020), erector spinae plane blocks were safe and effective when administered by emergency physicians in the emergency department. However, some studies, such as Gürbüz and Demir (2022), have reported the possibility of contralateral spread of local anesthetic, leading to unilateral blocks and bilateral dermatomal anesthesia. Such findings make careful administration and monitoring necessary to avoid complications.

Comparison with Other Techniques:

In comparison with other regional anesthesia techniques, such as thoracic paravertebral blocks and serratus plane blocks, the results were not uniform. Elawamy et al. (2022) reported that ultrasound-guided thoracic erector spinae plane blocks were as effective as thoracic paravertebral blocks in reducing pain and opioid consumption, with similar durations of analgesic effects and stable hemodynamic profiles. El Malla et al. (2022) also reported that although erector spinae plane blocks provided superior pain relief and diaphragmatic excursion compared to serratus plane blocks, the differences were clinically insignificant.

DISCUSSION:

This systematic review aimed to assess the effectiveness and safety of erector spinae plane blocks in pain management and improvement of respiratory outcomes in patients with rib fractures. The studies that were included consistently showed that erector spinae plane blocks provide significant analgesia, reduce opioid consumption, and improve respiratory function. These findings are consistent with the growing interest in regional anesthesia techniques as alternatives to opioids, which have substantial risks, including dependence and adverse side effects.

Most of the studies reviewed showed a significant decrease in pain after the administration of erector spinae plane blocks. For instance, Adhikary et al. (2019) reported a decrease in pain scores from 7.7 (2.5) to 4.7 (3.2) at three hours after the block. Similar results were found in studies by Syal et al. (2024) and Elawamy et al. (2022), where pain scores decreased notably both at rest and during movement after the block. These findings reinforce the analgesic efficacy of erector spinae plane blocks, particularly in the early post-procedural period.

Rib fracture management requires effective pain relief, as severe pain will severely compromise respiratory function and recovery. Proper pain control helps to prevent complications such as pneumonia, atelectasis, and respiratory distress, common in these patients. Additionally, by reducing reliance on opioid analgesics, erector spinae plane blocks provide a promising alternative to mitigate the risks of opioid use, particularly in the light of the current opioid crisis. In most studies, among which were Adhikary et al. (2019), Surdhar and Jelic (2022), and Elawamy et al. (2022), it was observed to have an important decrease in opioid intake. This reduces opioid intake and is along the lines of increasing the evidence supporting regional anesthesia technique as an effective opioid-sparing strategy. Decreased opioid administration will also minimize adverse reactions and facilitate patient recovery. Given the well-known side effects of opioids, such as constipation, sedation, and respiratory depression, effective pain management through erector

spinae plane blocks can enhance overall patient outcomes.

While some studies, such as Fitzgerald et al. (2024), showed only a trend toward decreased opioid use when comparing erector spinae plane blocks with multimodal analgesia, the general consensus is that erector spinae plane blocks provide opioid-sparing benefits, especially for acute rib fractures.

Erector spinae plane blocks also improved respiratory function, which is a major concern in patients with rib fractures. Syal et al. (2024) and Adhikary et al. (2019) demonstrated that erector spinae plane block administration significantly improved inspiratory capacity, oxygenation, and other pulmonary parameters. This improvement is probably due to the analgesic effect, which allows for deep breathing and coughing, thus reducing the risk of pneumonia and other complications. Although many studies showed respiratory benefits, Fitzgerald et al. (2024) did not find significant opioid use reduction despite improved respiratory function. This opens up the need for further investigation into the mechanisms behind the effects of erector spinae plane blocks on pulmonary function and whether such benefits translate to better long-term outcomes.

Safety was a significant concern, and most studies did not report any major complications following erector spinae plane block administration. However, research such as Gürböz and Demir (2022) mentioned that contralateral spread of the local anesthetic could occur with unilateral blocks and bilateral dermatomal anesthesia. Though rare, these complications stress careful technique and monitoring of patients. Moreover, though there is little evidence of nerve injury or hypotension in most research studies, the clinician must be cautious, particularly when managing critically ill or geriatric patients.

When compared with other regional anesthesia techniques, such as thoracic paravertebral blocks (TPVB) and serratus plane blocks (SPB), the results were mixed. Elawamy et al. (2022) reported that erector spinae plane blocks were as effective as TPVB in terms of pain relief and opioid consumption, with a comparable hemodynamic profile. This would suggest that erector spinae plane blocks may be a viable alternative to more invasive techniques like TPVB, offering similar efficacy with potentially fewer complications.

There is another limitation of erector spinae plane blocks described by El Malla et al. (2022), namely concerning diaphragmatic excursion and long-term results. On the other hand, pain control and diaphragmatic excursion were greater with erector spinae plane blocks than serratus plane blocks; however, there was no clinical significance in the findings. More research may give way to establishing more distinct information about the advantages and drawbacks of erector spinae plane blocks over others in regional anesthesia.

This systematic review presents strong evidence for the effectiveness of erector spinae plane blocks in the management of pain and improvement of respiratory function in rib fracture patients. Erector spinae plane blocks represent a safe, opioid-sparing alternative to conventional methods of analgesia, but further high-quality, large-scale studies are needed to confirm their long-term efficacy, safety, and comparative advantages over other regional anesthesia techniques. This additional research should be aimed at understanding the underlying mechanisms where erector spinae plane blocks enhance respiratory functions, and their applicability might be extended to other uses, such as post-operative pain management. Given its promising results, erector spinae plane block may become a vital adjunct in pain management protocols among patients with rib fractures, who therefore will have improved pain management with better recovery.

Despite its growing popularity and demonstrated benefits, the erector spinae plane block is not without limitations. Variability in technique, differences in local anesthetic concentrations and volumes, and the need for ultrasound guidance are some of the factors that can influence its effectiveness. Additionally, while the safety profile of the erector spinae plane block is favorable, rare complications such as infection, hematoma formation, or inadvertent intravascular injection can still occur. Moreover, the evidence base for the erector spinae plane block, although expanding, remains relatively young, and further research is needed to establish standardized protocols, optimize dosing strategies, and identify patient subgroups that may derive the greatest benefit from this technique. This study has few limitations, including a lack of performing statistical and meta-analysis due to the limited number of suitable publications.

CONCLUSION:

Publications on the erector spinae plane block have significantly increased over the past two years, with most being case reports. These reports suggest that the erector spinae plane block is a versatile and effective analgesic technique for managing both acute and chronic pain across cervical, thoracic, and abdominal regions. In conclusion, erector spinae plane blocks demonstrate significant potential as an effective and safe analgesic option for rib fracture management, offering substantial pain relief, reducing opioid consumption, and improving respiratory outcomes. By facilitating deeper breathing and reducing pulmonary complications, erector spinae plane blocks address critical challenges in rib fracture care. Their favorable safety profile, ease of administration, and opioid-sparing benefits position them as a promising alternative to traditional pain management techniques. However, variations in study results, particularly regarding long-term outcomes and comparative efficacy, highlight the need for further research to optimize their use. Overall, erector spinae plane blocks

represent a valuable advancement in regional anesthesia, contributing to improved patient recovery and reducing the burden of rib fractures on healthcare systems.

Table 2. Demographic characteristics of the patients in the included studies

Study No.	Author	Year	Type of study	No. of patients	Age (mean, years)	Gender distribution	
1	Adhikary et al.	2019	Retrospective Cohort Study	79	61	48	31
2	Surdhar and Jelic	2022	Pilot Study	9	NA	NA	NA
3	El Malla et al.	2022	Prospective Randomized Trial	50	34.4 ± 12.35	37	13
4	Gürbüz and Demir	2022	Case Series	3	42.6	3	0
6	Fitzgerald et al.	2024	Retrospective Cohort Study	142	52.5	116	26
7	Elawamy et al.	2022	Randomized Controlled Trial	60	35.60 ± 12.45	51	9
8	Syal et al.	2024	Case Series	10	53.4 ± 12.7	NA	NA
9	Kumar et al.	2020	Case Series	5	49.4	4	1
10	Gaballah et al.	2019	Pilot Randomized Controlled Trial	60	NA	NA	NA
11	Riley et al.	2020	Comparative Study	34	66	8	26

Table 3. Quality assessment of the included studies

Study No.	Author	Year	Selection bias	Performance bias	Reporting bias	Attribution bias	Other bias	Results	Quality of the study
1	Adhikary et al.	2019	1	1	1	1	1	5	High
2	Surdhar and Jelic	2022	1	0	0	1	1	3	Moderate
3	El Malla et al.	2022	1	1	1	1	1	5	High
4	Gürbüz and Demir	2022	1	1	0	1	1	4	Moderate
5	Fitzgerald et al.	2024	1	1	1	1	1	5	High
6	Elawamy et al.	2022	1	1	1	1	1	5	High
7	Syal et al.	2024	1	0	0	1	1	3	Moderate
8	Kumar et al.	2020	1	1	1	1	1	5	High
9	Gaballah et al.	2019	1	0	0	1	1	3	Moderate
10	Riley et al.	2020	1	1	1	1	1	5	High

REFERENCES:

1. Kuo K, Kim AM. Rib Fracture. [Updated 2023 Aug 8]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK541020/
2. Rogers FB, Larson NJ, Rhone A, Amaya D, Olson-Bullis BA, Blondeau BX. Comprehensive Review of Current Pain Management in Rib Fractures With Practical Guidelines for Clinicians. J Intensive Care Med. 2023 Apr;38(4):327-339. doi: 10.1177/08850666221148644. Epub 2023 Jan 4. PMID: 36600614.
3. Horn R, Hendrix JM, Kramer J. Postoperative Pain Control. [Updated 2024 Jan 30]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK544298/
4. Sullivan D, Lyons M, Montgomery R, Quinlan-Colwell A. Exploring Opioid-Sparing Multimodal Analgesia Options in Trauma: A Nursing Perspective. J Trauma Nurs. 2016 Nov/Dec;23(6):361-375. doi: 10.1097/JTN.0000000000000250. PMID: 27828892; PMCID: PMC5123624.
5. Bonvicini D, Tagliapietra L, Giacomazzi A, Pizzirani E. Bilateral ultrasound-guided erector spinae plane blocks in breast cancer and reconstruction surgery. J Clin Anesth. 2018;44:3–4. doi: 10.1016/j.jclinane.2017.10.006.
6. https://resources.wfsahq.org/atotw/the-erector-spinae-plane-block-a-review-of-current-evidence-2/#:~:text=Many%20experts%20now%20consider%20the,with%20very%20few%20reported%20co

mplications.
7. Restrepo-Garces CE, Chin KJ, Suarez P, Diaz A. Bilateral continuous erector spinae plane block contributes to effective postoperative analgesia after major open abdominal surgery: a case report. A A Case Rep. 2017;9:319–21. doi: 10.1213/XAA.0000000000000605.
8. Luis-Navarro JC, Seda-Guzmán M, Luis-Moreno C, López-Romero JL. The erector spinae plane block in 4 cases of video-assisted thoracic surgery. Rev Esp Anestesiol Reanim. 2018;65:204–8. doi: 10.1016/j.redar.2017.12.004.
9. De Cassai A, Iepparielloo G, Ori C. Erector spinae plane block and dual antiplatelet therapy. Minerva Anestesiol. 2018;84:1230–1. doi: 10.23736/S0375-9393.18.12815-X
10. Adhikary SD, Prasad A, Soleimani B, Chin KJ. Continuous erector spinae plane block as an effective analgesic option in anticoagulated patients after left ventricular assist device implantation: a case series. J Cardiothorac Vasc Anesth. 2019;33:1063–7. doi: 10.1053/j.jvca.2018.04.026.
11. Wyatt K, Elattary T. The erector spinae plane block in a high-risk Ehlers-Danlos syndrome pediatric patient for vascular ring repair. J Clin Anesth. 2019;54:39–40. doi: 10.1016/j.jclinane.2018.10.031.
12. https://link.springer.com/article/10.1007/s13670-016-0155 z#:~:text=Pain%20Management%20and%20Non%2Doperative%20Management&text=The%20goals%20of%20rib%20fracture,mechanical%20ventilation%2C%20and%20possible%20tracheostomy.
13. Krishnan S, Cascella M. Erector Spinae Plane Block. [Updated 2023 Jun 4]. In: StatPearls [Internet]. Tre