Ultrasound-guided Erector Spinae Plane Block in Combination with Superficial Parasternal Intercostal Plane Block Versus Paravertebral Block for Perioperative Pain after Median Sternotomy Surgeries

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Abstract

Background: Postoperative pain management improves cardiac surgery outcomes. Sternotomy is the primary source of pain, with nerve injury, pleural involvement, and chest drains contributing. Ultrasound-guided interfacial plane blocks, including the paravertebral block (PVB), erector spinae plane block (ESPB), and superficial parasternal intercostal block (S-PIP), reduce analgesic needs and opioid use.

Objectives: This study compares the Perioperative analgesic effects of S-PIP + ESP versus PVB in elective median sternotomy.

Patients and methods: A randomized clinical trial at Qena University Hospitals (March 2023–February 2025) included 57 patients (ASA II–III, 18–70 years). Group A (n=29) received ESP + S-PIP, while Group B (n=28) received PVB. Pain was assessed using the Numerical Rating Scale (NRS) with patient-controlled analgesia (PCA) and rescue tramadol. Opioid use and adverse events were monitored for 48 hours.

Results: No significant differences were found in patient characteristics, operative data, extubation time, 48-hour morphine use, or overall outcomes ($P>0.05$). However, Group A had significantly lower NRS at 4 hours (2.55 ± 0.736 vs. 3.14 ± 0.756, $P = 0.004$) and during coughing at 0, 2, and 6 hours ($P<0.001$).

Conclusion: S-PIP + ESP provides comparable analgesia to PVB in sternotomy patients, with similar morphine consumption, pain scores, and rescue analgesia needs. No significant differences were noted in ICU stay, extubation time, or hospital stay, supporting S-PIP + ESP as an effective alternative to PVB.

Keywords: Erector Spinae Plane Block; Paravertebral Block; Superficial Parasternal Intercostal Block; Perioperative Pain Management; Median Sternotomy.

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Introduction

Clinical results increase with effective cardiac surgery postoperative pain treatment. Sternotomy is the main cause of postoperative pain, on the other hand, sternal retraction, parietal pleura, pericardium involvement, and rib/intercostal nerve damage all play a role. To effectively treat severe pain, multimodal analgesia now includes ultrasonography (US)-guided interfacial plane blocks **(Dost et al., 2022).**

Regional anesthesia reduces the requirement for perioperative analgesics and anesthetics, reduces PONV, lowers the risk of chronic pain, and aids early rehabilitation **(Yang et al., 2018).** PVB is one of the most effective postoperative analgesic procedures. It is difficult to perform because of its proximity to the pleura and central neuraxial structures. PVB blocks several dermatomes, improving perioperative pain, postoperative pulmonary function, and thrombotic risk **(Gomes Martins et al., 2022).**

New regional anesthetic techniques include the ESPB for thoracic and abdominal surgery. Local anesthetic (LA) injections deep into the ESM cause cranial and caudal paravertebral spread. LA injection site, volume, and concentration affect dermatome coverage **(Taketa et al., 2020).**

The S-PIP may also reduce opioid use after median sternotomy. This fascial block targets the anterior cutaneous branches of Th2-6 to relieve parasternal pain **(Samerchua et al., 2024).**

The aim of this study is to evaluate the Perioperative analgesic effect of combining the S-PIP and ESP blocks in patients scheduled for elective median sternotomy, compared to the well-established paravertebral block.

Patients and methods

This prospective, randomized, controlled clinical trial was conducted at the Anesthesia, ICU, and Pain Management Department of Qena University Hospitals, South Valley University, Egypt. Patient enrollment occurred between March 2023 and February 2025. The research adhered to the ethical guidelines established in the Declaration of Helsinki and obtained clearance from the institutional ethics committee.

The study included patients scheduled for elective surgeries involving median sternotomy as CABG, valve replacement and others. Participants were divided into two groups. Group A (n=29) consisted of adults undergoing median sternotomy under general anesthesia with superficial parasternal intercostal block (S-PIP) and erector spinae plane block (ESP). Group B (n=28) included adults undergoing the same procedure under general anesthesia with a paravertebral block (PVB).

Eligible participants were aged 18 to 70 years and classified as ASA physical status II or III, with informed consent provided. Patients were excluded if they refused participation, had known sensitivity to local anesthetics, or had a pre-existing infection at the block site. Other exclusion criteria included severe coagulopathy, cognitive impairment affecting pain assessment, emergency or reoperative procedures, minimally invasive surgeries, and severe dysfunction of major organs such as renal or hepatic failure. Furthermore, individuals with a left ventricular ejection fraction under 50%, psychological problems, pregnancy or breastfeeding, hematologic conditions, substance misuse, or daily opioid consumption were excluded.

All patients underwent a comprehensive preoperative evaluation, including a complete medical history and laboratory investigations. Routine tests such as CBC, coagulation profile, and random blood sugar levels were performed, along with liver and kidney function assessments.

Perioperative management followed the hospital's standard cardiac anesthesia protocols. When patients reached the surgery room, they were monitored using standard ASA guidelines, which include non-invasive blood pressure monitoring, electrocardiography, and pulse oximetry. An arterial line was inserted under local anesthesia for continuous arterial pressure monitoring. Group A received an erector spinae plane block (ESP) preoperatively and a superficial parasternal intercostal block (S-PIP) immediately after induction of anaesthesia, while Group B underwent a paravertebral block (PVB) preoperatively.

General anesthesia was induced using intravenous Fentanyl (2 µg/kg), propofol (2 mg/kg), and atracurium (0.5 mg/kg). Anesthesia was maintained by breathed sevoflurane (MAC 1-2), oxygen/air (FIO2 0.50), and intravenous fentanyl infusion (1-2 µg/kg/hour), adjusted to keep hemodynamic parameters within 20% of baseline. Subsequent to tracheal intubation, a central venous catheter was placed via the right internal jugular vein. Hemodynamic changes were recorded within the first minute of skin incision, sternotomy, and sternal retractor placement. At the end of the procedure, all patients received 0.05 mg/kg IV morphine before being transferred to the ICU

In Group A, patients received both a parasternal intercostal block (S-PIP) and an ESP for regional anesthesia.

For the ESP block, patients remained awake and were positioned sitting upright. A high-frequency linear ultrasonic probe (Sonoite M-Turbo, Bothell, WA, USA) was positioned in a craniocaudal orientation, and the T3 spinous process was identified by counting down from C7. The T4 transverse process, erector spinae muscle, rhomboid major, and trapezius muscle were examined by laterally shifting the probe. Approximately 3–4 cm from the midline, the erector spinae muscle and transverse process were identified. Under aseptic conditions, 2 mL of 2% lidocaine was infiltrated into the skin prior to the insertion of a 10 cm block needle (Stimuplex® Ultra 360® 22 G, B-Braun, Melsungen, Germany) in an in-plane craniocaudal direction until it contacted the transverse process. Following the verification of needle location using hydro-dissection with 2 mL of normal saline, 20 mL of 0.25% bupivacaine was injected **(Fig.1).** The real-time ultrasound guided the craniocaudal spread of the anesthetic, and the same procedure was repeated on the opposite side.

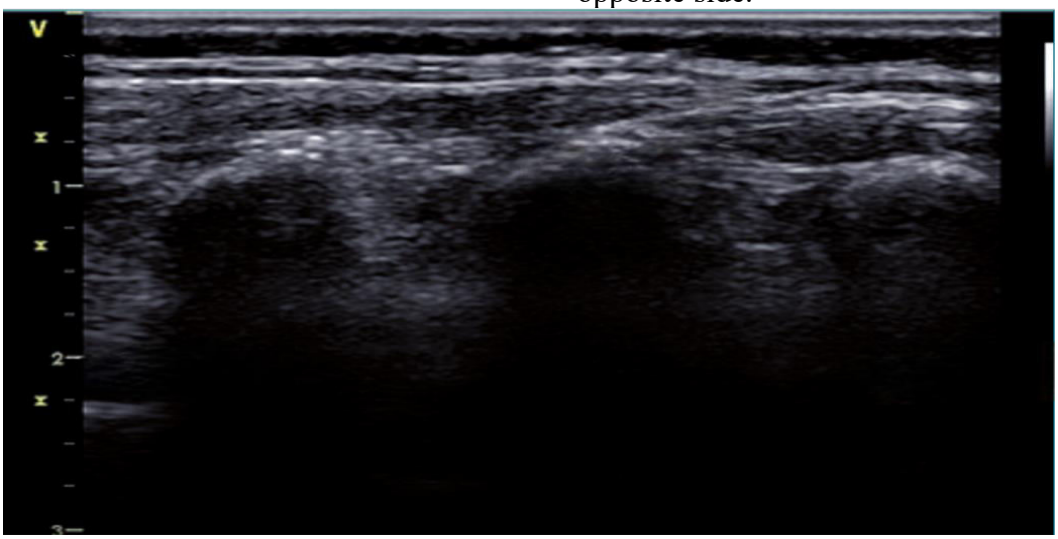

Fig.1. Ultrasound image for an erector spinae nerve block.

Not only was the ESP block applied with ultrasound guidance, but the S-PIP block as well **(Fig.2).** Following intubation and before to the initiation of operation, The area to be injected was prepared with the patient in a supine posture. A linear ultrasonic probe was positioned between the fourth and fifth intercostal spaces, approximately 2–3 cm lateral to the parasagittal midline. The ultrasound image depth was set to 2–3 cm. Hydro-dissection with 1–3 mL of 0.9% saline was used to confirm the correct needle tip position, ensuring the saline spread into the interfacial area. Following negative pressure application, 10 mL of 0.25% bupivacaine was injected, with real-time observation of craniocaudal diffusion. The procedure was repeated on the other side, ensuring the total dose of bupivacaine did not exceed 2.5 mg/kg based on the patient's ideal body weight.

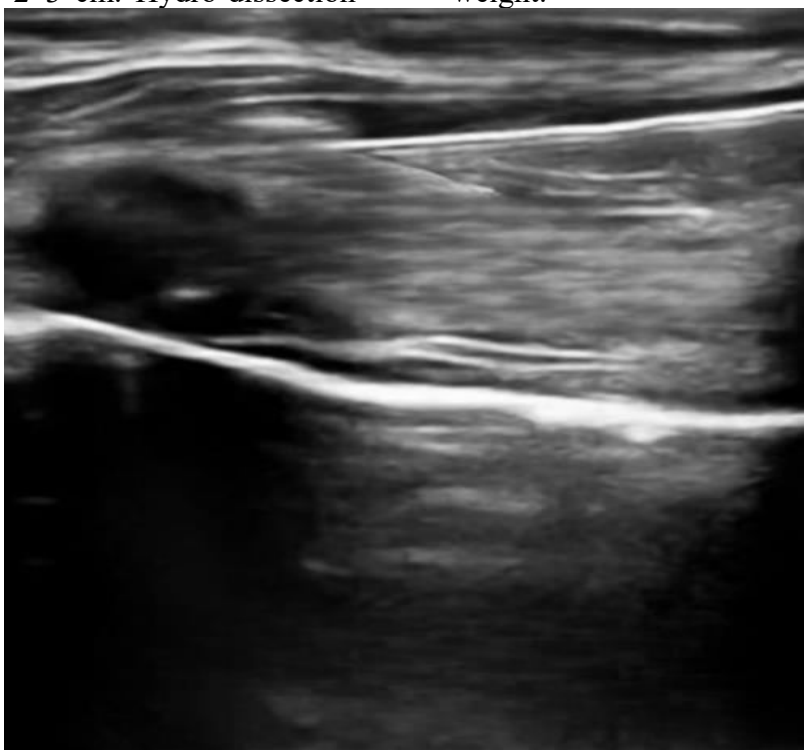

Fig.2. The ultrasound-guided SPIP block targets the fascial plane between the pectoralis major and external intercostal muscles. The needle is precisely guided under ultrasound to this interface for effective local anesthetic deposition.

In Group B, regional anesthesia was administered using a paravertebral block (PVB) technique **(Fig.3).** While the patient remained conscious, they were positioned sitting upright, and the upper border of the fourth thoracic spinous process was identified. A high-frequency ultrasound probe was placed in a parasagittal orientation over the transverse processes of T4 and T5, approximately 2.5 cm lateral to the midline. The thoracic paravertebral space was visualized as a wedge-shaped hypoechoic region between the ligament that runs across the pelvis and the pleura.

Following strict aseptic preparation, local anesthetic was applied to the skin prior to insertion of a 10 cm block needle (Stimuplex® Ultra 360® 22G, B-Braun). The needle was advanced in a cranial-to-caudal trajectory toward the paravertebral space, with ultrasound-guided hydro-dissection facilitating accurate placement.

Upon penetrating the superior costotransverse ligament, correct needle positioning was confirmed by negative aspiration for blood, air, or cerebrospinal fluid. Subsequently, 20 mL of 0.25% bupivacaine was administered under direct ultrasound visualization, ensuring deposition superficial to the pleura. Successful block placement was confirmed by observable displacement of the pleural lining during injection. The procedure was then replicated contralaterally, with total bupivacaine dosage maintained below 2.5 mg/kg, calculated according to the patient's ideal body weight.

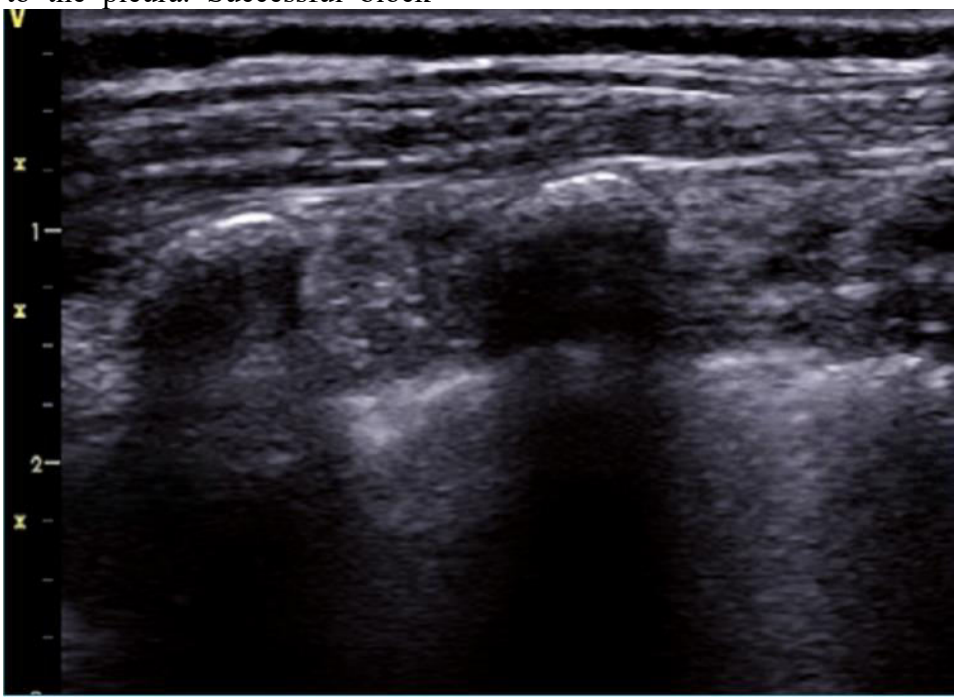

Fig.3. Ultrasound image illustrating the needle tip positioned at the target site for local anesthetic administration during a paravertebral block.

For postoperative analgesia, patients spent the first 24 hours after extubation in the ICU. Incorporating a variety of pain relief methods, all received intravenous acetaminophen (1 g every 8 hours). Intravenous patient-controlled analgesia (PCA) using the Bodyguard 575 (UK) delivered morphine at 20 µg/kg with a 10-minute lockout and a 4-hour limit set at 80% of the maximum allowable dose. If pain persisted with a Numerical Rating Scale (NRS) score ≥4 despite PCA use, IV tramadol (100 mg, up to 300 mg/day) was administered as rescue analgesia within 30 minutes.

Pain was assessed using the NRS (0 = no pain, 10 = worst pain) at rest and during coughing at extubation, and at 2, 4, 6, 12, and 24 hours postoperatively **(Pascual and Gaulton, 2021).** Patients were instructed preoperatively on how to use both the NRS and PCA device, and were instructed to seek opioid medication if their resting NRS score was higher than 4.

Postoperative complications, including nausea and vomiting (PONV), block-related hematomas, and pneumothorax, were closely monitored and documented.

Ethical approval code: SVU-MED-AIP029-2-23-3-607.

Statistical analysis

SPSS version 24.0 was utilized for the purpose of data analysis. Frequencies and percentages were used to display categorical data, whereas mean ± SD was

used for continuous variables. Multivariate research and univariate logistic regression were among the statistical methods used to look into significant correlations. The Student's t-test was used to compare means between two independent groups, and the Mann-Whitney U test was employed for data that did not follow a normal distribution. Fisher's exact test was used to non-parametric categorical data, and the chi-square test was used to look at the correlations between categorical variables. Statistical significance was defined as a p-value of less than 0.05; the lower the p-value, the stronger the evidence of significance.

Results

No statistically significant difference was found between the studied groups in terms of patient characteristics (P > 0.05). (**Table.1).**

Table 1. Distribution of patients characteristics between studied groups.

Variables	Group A N=29	Group B N=28	P value
Age	47.86 ±9.88	42.75 ±10.99	0.07
Weight	65.51 ±10.6	65.39 ±9.5	0.96
Height	165.7 ±8.19	166.9 ±8.83	0.60
BMI	23.78 ±3.5	23.51 ±3.13	0.75
Sex			
• **Male**	10 (34.5%)	11 (39.3%)	0.7
• **Female**	19 (65.5%)	17 (60.7%)	
ASA			
• **II**	23 (79.3%)	19 (67.9%)	0.32
• **III**	6 (20.7%)	9 (32.1%)	
B Blocker	18 (62.1%)	17 (60.7%)	0.91

There was no statistically significant difference between studied groups regarding operative data (P>0.05), (**Table.2).** No statistically significant difference was observed between the studied groups concerning operative data (P > 0.05), **(Table.3).**

Table 2. Distribution of operative data between studied groups.

Variables	Group A N=29	Group B N=28	P value
Duration of surgery	258.96 ±49.6	269.46 ±44.2	0.4
CPB Time	119.31 ±39.99	138.75 ±40.98	0.075
XC Time	73.59 ±28.19	86.75 ±31.13	0.1
Type of surgery			
• **CABG**	7 (24.1%)	5 (17.9%)	0.93
• **MVR**	15 (51.7%)	16 (57.1%)	
• **AVR**	2 (6.9%)	2 (7.1%)	
• **DVR**	3 (10.3%)	4 (14.3%)	
• **Others**	2 (6.9%)	1 (3.8%)	

Table 3. Distribution of intraoperative data between studied groups.

Variables	Group A N=29	Group B N=28	P value
HR Baseline	61.44 ±8.33	61.42 ±8.5	0.9
Skin Incision	68.27 ±8.9	70.78 ±8.5	0.28
Sternotomy	70.17 ±9.4	73.46 ±10.17	0.21
Sternotomy Retraction	71.86 ±10.29	76.9 ±9.71	0.06
MAP Baseline	64.27 ±5.06	65.03 ±4.84	0.56
Skin Incision	67.96 ±6.6	69.46 ±6.4	0.39
Sternotomy	71.72 ±9.33	71.5 ±6.43	0.91
Sternotomy Retraction	72.27 ±8.46	74.14 ±8.7	0.41
Fentanyl Amount (µg)	476.37 ±98.3	482.67 ±83.9	0.79
Complications			
Pneumothorax	1 (3.4%)	3 (10.7%)	0.28
Bleeding	1 (3.4%)	0 (0%)	0.33
CVS Toxicity	0 (0%)	0 (0%)	-

There is no statistically significant difference between the studied groups in extubation time, NRS at 0, 2, 6, 12, and 24 hours, NRS during coughing at 4, 12, and 24 hours, morphine consumption at 48 hours, and the number of rescue analgesia doses within 48 hours. However, a statistically significant difference was observed in NRS at 4 hours and NRS during coughing at 0, 2, and 6 hours, **(Table. 4).** There was no statistically significant difference between studied groups regarding outcome, **(Table.5)**

Table 4. Distribution of postoperative data between studied groups.

Variables	Group A N=29 Mean ± SD	Group B N=28 Mean ± SD	P value
Extubation Time (min)	130 ± 52.44	120.79 ± 51.78	0.507
NRS			
• **0 h**	2.07 ± 0.799	2.29 ±0.810	0.314
• **2 h**	2.34 ± 0.897	2.61± 0.685	0.221
• **4 h**	2.55 ± 0.736	3.14 ±0.756	**0.004***
• **6 h**	2.79 ± 0.774	3.04 ± 0.838	0.261
• **12 h**	3.00 ± 0.756	3.36±0.678	0.066
• **24 h**	3.17 ± 0.805	3.50 ± 0.694	0.106
NRS COUGH			
• **0 h**	2.14 ± 0.74	3.43 ± 0.79	**<0.001***
• **2 h**	2.52 ± 0.83	3.93 ± 0.98	**<0.001***
• **4 h**	3.41 ± 1.05	3.64 ± 0.91	0.384
• **6 h**	3.00 ± 0.80	3.57 ± 1.10	0.029*
• **12 h**	3.55 ± 1.12	3.39 ± 0.69	0.523
• **24 h**	3.48 ± 0.87	3.64 ± 0.73	0.456

Morphine Amount 48 h (mg) Mean ±SD	21.37 ±4.9	22.92 ±5.5	0.27
Rescue Analgesia Times 48 h	N (%)	N (%)	
• **No**	18 (62.1%)	17 (60.7%)	0.17
• **1**	10 (34.5%)	6 (21.4%)	
• **2**	0 (0%)	4 (14.3%)	
• **3**	1 (3.4%)	1 (3.6%)	
Complications			
• **POVN**	3 (10.3%)	8 (28.6%)	0.08
• **Drowsiness**	2 (6.9%)	3 (10.7%)	0.61
• **Itching**	4 (13.8%)	6 (21.4%)	0.44

Table 5. Distribution of outcome between studied groups.

Mean ±SD	**Group A N=29**	**Group B N=28**	**P value**
ICU Discharge (D)	2.41 ±0.56	2.71 ±0.71	0.08
Hospital Stay(D)	5.31 ±1.5	5.6 ±1.25	0.42
Satisfaction score	4.58 ±0.56	4.5 ±0.69	0.6
	N (%)	N (%)	
• **1**	0 (0%)	0 (0%)	0.54
• **2**	0 (0%)	0 (0%)	
• **3**	1 (3.4%)	3 (10.7%)	
• **4**	10 (34.5%)	8 (28.6%)	
• **5**	18 (62.1%)	17 (60.7%)	

Discussion

Cardiac sympatholysis benefits myocardial blood flow **(Bulte et al., 2017)** but reduces the heart's ability to manage hemodynamic challenges, particularly in patients with pulmonary hypertension **(Wink et al., 2019).** A meta-analysis of 6000 patients estimated the risk at 1:3552 (95% CI 1:2552–1:5841) **(Landoni et al., 2015).** Our study findings align with these concerns, reinforcing the necessity of minimizing risks over maximizing analgesic potential.

Single-level PVB exhibits high variability due to unpredictable LA spread **(Cowie et al., 2010).** Multiple-injection techniques were traditionally favored over single-injection patterns **(Kotzé et al., 2009; Naja et al., 2006).** However, US-guided PVB (PVBUS) challenged this assumption **(Renes et al., 2010; Marhofer et al., 2013).** Later, **Uppal et al. (2017)** proven that single- and multilayer PVBUS offer comparable coverage and duration of pain alleviation, with single-level PVBUS offering faster performance and better patient tolerance. Our study findings support this equivalence, highlighting the efficiency of single-level PVBUS.

Hemorrhagic complications remain a crucial consideration, as in thoracic epidural analgesia (TEA). Unlike TEA, the risk quantification of spinal epidural hematoma (SEH) in PVB is uncertain and debated. The ASRA keeps the anticoagulation guidelines for neuraxial blocks and PVB the same **(Horlocker et al., 2019).** However, ASRA does not distinguish between PVBLM and PVBUS or between single-shot PVB and catheter-based PVB. Our study findings align with recent data suggesting that US guidance significantly reduces spinal injury risk, even with high heparin doses in cardiopulmonary bypass **(Okitsu et al.,**

2017). El Shora et al. (2020) compared catheter-based PVBUS to TEA for post-cardiac surgery pain management, showing that PVBUS was non-inferior to TEA in pain relief, with no reported bleeding complications. Our findings similarly support the safety and efficacy of PVBUS.

Post-mortem data question the concept of TPVS as a distinct anatomical space, suggesting that the superior costotransverse ligament (SCTL) allows LA diffusion **(Costache et al., 2017).** This implies that effective paravertebral nerve blockade can occur even if the needle tip is placed just outside the TPVS. US guidance has led to the development of superficial needle placement techniques collectively termed "paraspinal blocks" **(Wild and Chin, 2017),** with ESPB being the most well-characterized.

The ESPB involves the injection of LA between the ESM and the thoracic TP. When performed correctly at a single level, the injection elevates the ESM off the TP, enabling ipsilateral craniocaudal spread of LA across three to seven intercostal levels **(Choi et al., 2019; Vidal et al., 2018).** Similar to the paravertebral block, the analgesic effect of ESPB is attributed to the transforaminal, intercostal, and epidural diffusion of the LA **(Schwartzmann et al., 2018; Vidal et al., 2018).** Our findings align with these mechanisms, demonstrating ESPB's efficacy in providing broad analgesic coverage.

Krishna et al. (2019) discovered that patients undergoing sternotomy-related cardiac surgery who were also given general anesthesia and bilateral single-shot ESPB fared better and had reduced postoperative pain, earlier extubation and ambulation, lower opioid use, and shorter ICU stays compared to those who only received general anesthesia. Additionally, rescue analgesia was needed at 10 hours post-extubation in the ESPB group, compared to 6 hours in the control group ($p = 0.0001$).

Fifty patients undergoing open heart surgery were randomized to receive either bilateral continuous ESPB or TEA, and both groups reported similar levels of discomfort after the procedure **(Nagaraja et al., 2018).** Our study findings support the equal analgesic efficacy of ESPB and PVB, likely due to the ease of ESPB performance and its extensive cutaneous sensory blockade **(Chin et al., 2019; El-Boghdadly and Pawa, 2017).** Similarly, studies on breast surgery reported no significant differences between ESPB and PVB in opioid-sparing effects. **El Ghamry and Amer (2019)** found comparable postoperative morphine consumption and pain levels in women undergoing modified radical mastectomy. **Moustafa et al. (2020)** reported similar results, showing no significant differences in opioid use between ESPB and PVB. The findings align with a 2017 randomized controlled trial and a subsequent comprehensive review and meta-analysis, both indicating no significant difference in postoperative analgesic efficacy between ESPB and PVB in patients following breast surgery **(Gürkan et al., 2020; Schnabel et al., 2010).**

In contrast, our study's findings differ from a randomized, double-blind trial by **Swisher et al. (2020),** which demonstrated that in women having non-mastectomy breast surgery, PVB produced more postoperative analgesia than ESPB. In the first 24 hours after surgery, the PVB group used less morphine and scored lower on the VAS. The authors hypothesized that these differences might be explained by the limited dissemination of local anesthetics to the paravertebral region following ESPB, as opposed to the direct diffusion seen with PVB **(Forero et al., 2016; Ivanusic et al., 2018).**

We found that adding the S-PIP block to the ESP block in sternotomy procedures leads in equivalent 24-hour postoperative morphine intake, pain ratings, and rescue analgesic use compared to PVB. PONV incidence, ICU stay duration, extubation time, and hospital stay were similar across research groups.

A recent meta-analysis by **Li et al. (2022)** confirmed that the parasternal block reduces opioid consumption and associated complications, improving pain management. The integration of ESP and S-PIP blocks seems to enhance recovery and patient satisfaction following open-heart surgery by diminishing pain levels and decreasing the necessity for rescue analgesia within the initial 24 hours postoperatively. Our study supports these findings, showing similar benefits.

The precise mechanisms of ESP block remain uncertain, though it has been suggested that local anesthetic spreads to the thoracic paravertebral space and neural structures **(Chin et al., 2019).** However, variable results and low failure rates have been observed due to anatomical differences that influence the distribution of local anesthetics (LA). The primary dissemination of LA in the paravertebral or epidural areas, its blockage of cutaneous side branches in the interfascial plane, or its encirclement of the nerve or nerve root remains ambiguous. Anatomical adhesions within the interfascial gap may potentially lead to the failure of blocks **(Selvi et al., 2022).** While ESP block is effective in managing post-cardiac surgery pain, **Taketa et al. (2018)** It was observed that the anterior skin branch exhibits a diminished dermatomal distribution in comparison to the lateral skin branch. Our study recognizes these limitations, emphasizing the necessity for further blockage of the front chest wall.

S-PIP and D-PIP blocks are emerging truncal interfacial plane blocks increasingly utilized in cardiac surgery for improved pain management. **(Khera et al., 2021; Kumar et al., 2021).** A study comparing S-PIP and D-PIP for post-sternotomy pain management found similar effects on postoperative 24-hour morphine consumption. Since S-PIP is simpler to administer and has a lower risk of complications, it was deemed a more favorable option for acute post-sternotomy pain management **(Kaya et al., 2022).** Additionally, S-PIP reduces the risk of injuring the left internal mammary artery (LIMA), frequently harvested for coronary grafting in cardiac surgeries. Based on this, we incorporated the S-PIP block into our study to achieve more comprehensive analgesia by blocking the anterior branches of the chest wall, which ESP block alone may not fully target.

Bousquet et al. (2021) demonstrated that combining bilateral parasternal and ESP blocks significantly reduced morphine consumption in ten cardiac surgery patients per group compared to the control group. Similarly, **Dost et al. (2022)** reported that adding the S-PIP block to the ESP block in cardiac surgery resulted in reduced morphine consumption, lower pain scores, and fewer patients needing rescue analgesia within the first 24 hours postoperatively. Our study supports these findings, further confirming the effectiveness of this combined approach.

In our study, S-PIP was performed after anesthesia induction and before surgery as preemptive analgesia. This strategy aims to prevent peripheral and central sensitization triggered by surgical tissue trauma, which can intensify postoperative pain **(Rodriguez-Aldrete et al., 2016).** Additionally, it mitigates intraoperative noxious stimuli, including skin incision, sternotomy, sternal retraction, and wiring, all of which pose risks of hemodynamic instability in patients with preexisting

cardiac ischemia **(Padala et al., 2020).** Our study findings reinforce the benefits of this technique in improving pain control and hemodynamic stability during cardiac surgery.

Conclusion

Our study demonstrated that combining S-PIP with erector ESP provides pain relief comparable to PVB in sternotomy patients. Postoperative morphine consumption, pain scores, and rescue analgesia requirements were similar between groups. No significant differences were observed in postoperative nausea and vomiting, ICU stay, extubation time, or hospital stay. These findings support S-PIP + ESP as an effective alternative to PVB for post-sternotomy pain management.

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