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Original Research Article

Opioid sparing effect of ultrasound-guided continuous bilateral erector spinae plane block in cardiac surgery requiring sternotomy: A cross-sectional observational study

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ABSTRACT

Background: The erector spinae plane (ESP) block is mostly used to relieve pain in people who have had breast surgery. The block is now being used in cardiac surgery. Because sternotomy discomfort is severe, individuals undergoing this require multimodal analgesia. The ESP block has recently become popular in cardiac anaesthesia, necessitating the study.

Aim and Methodology of the Study: To determine the efficacy of ESP block in reducing the opioid requirement for postoperative analgesia in cardiac surgeriesThe study enrolled 66 people who were having heart surgery between January-2020 to December-2021; that required a median sternotomy. The anaesthesiologist separated them into two groups: group-1 received intravenous morphine, while group-2 received ESP block. The subjects were secured with a catheter in the ESP using USG guidance after receiving general anaesthesia according to institutional practice. Following Surgery, group-2 received 0.25% levobupivacaine bolus of 10ml, followed by a 0.125% levobupivacaine infusion at a rate of 5ml/hour. The other group was given 0.1mg/kg body weight of morphine every six hours. Following extubation, the subjects were assessed for pain using the Prince Henry hospital pain scale at intervals of 0, 3, 6, 12, 24, 48 hours

Results and Conclusion: 12 participants in the group-2 had the pain score of 1/5, at 6th hour interval whereas only 5 participants in the group-1 had 1/5. Further at 48-hour interval 30 of the participants in study group had pain score of 0/5, and only 19 participants in the control group had the pain score of zero. ESP block group had more patients with a pain score of zero than morphine group at different time points i.e., 5 vs 0 at 6 h; 30 vs 19 at 48 h ($P<0.05$). ESP block has significantly reduced the intravenous opioid consumption, and it has also proved to have better patient satisfaction

1. Introduction

The International Association for the Study of Pain (IASP) defines pain as an unpleasant, sensory & emotional sensation caused by existing or potentially threatening damage to tissue, accompanied by autonomic & behavioral systemic response.[1]

The postoperative pain in cardiac surgery patients is moderate to severe secondary to sternotomy, sternal retraction, and multiple chest tubes.[2] Inefficient pain management causes hemodynamic disturbances like hypertension, tachycardia, pulmonary atelectasis, pneumonia, and stasis of bronchial secretion due to insufficient chest expansion.[2] So, all patients undergoing cardiac surgery require analgesia in one or another form.

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The dermatomes involved in the sternotomy pain are from T2 to T6 level. The nociceptive information is conducted along the Aδ & C fibres to the ganglia of posterior roots & subsequently to the dorsal horn of the spinal cord. The final perception of pain takes place in the cerebral cortex.[2]

The American Society of Anesthesiologists Task Force has proposed multimodal techniques to alleviate postoperative pain. These include the use of NSAIDs and opioids administered through various routes such as oral, sublingual, rectal, intramuscular, subcutaneous, and intravenous. Additionally, the guidelines recommend epidural analgesia and regional or local analgesia as effective options for pain management.[1]

Most commonly, opioids and non-steroidal anti-inflammatory drugs like paracetamol, diclofenac, and tramadol are conventionally used. Intravenous drugs. However, opioids can cause nausea, vomiting, pruritus, sedation, and respiratory depression in those patients leading to, respiratory depression, sedation, and mechanical ventilator dependence resulting in prolonged ICU stay.[3] NSAIDs have a risk of surgical wound bleeding, and renal failure, especially diclofenac, whereas paracetamol can cause liver toxicity, and tramadol use is associated with nausea and vomiting.[4]

Although very effective, epidural is not without complications like epidural hematoma resulting in hemi/paraplegia, mainly among cardiac patients taking an anticoagulant.[2]

More recently, ultrasound-guided regional analgesic techniques have evolved in the management of postoperative pain, one of them being erector spinae plane block (ESP block).[1] Erector spinae plane block has been known to provide required analgesia with a seemingly more straightforward technique compared to thoracic epidural with a speculatively safer margin. ESP block with a catheter has minimal to no risk of hematoma. The quality of analgesia provided by the block may decrease opioid consumption and may be helpful in the early recovery of the patients, especially in fast-track cardiac surgery. As not many studies have been conducted on ESP block for sternotomy and an emergent need for an alternate option with minimal side effects when compared to opioid analgesics is the need of the hour, there is a need for this study.

2. Materials and Methods

Based on the data from the study by Nagaraj et al.[5] comparing thoracic epidural and erector spinae block, with 1% alpha error, 99% power of the study and a clinically significant measured VAS score of 1.2 units the required sample size in each group was 33.

$$N = 2\frac{(Z_{1-\alpha/2}+Z_{1-\beta})^2\sigma^2}{d^2}$$

$\sigma 1$ = The standard deviation of VAS in Group 1 = 1.32

$\sigma 2$ = The standard deviation of VAS in Group 2 = 0.64

σ = Average standard deviation = 0.98

d = The minimum difference in the values which will make clinically relevant impact = 1.2

Z(1-α/2) = Z score for the alpha error chosen = 2.575829

Z(1-ß) Z score for the power chosen = 2.326348

It was a single tertiary center, cross-sectional observational study. Data was collected from January 2020 to June 2021. After approval from the institutional ethics committee and registration of study with the clinical trial registry, India (CTRI/2020/11/028840), patients posted for elective cardiac surgeries requiring sternotomy under general anaesthesia were enrolled for this study. Patients who refused the study, emergency sternotomies, vertebral anomalies, renal failure, and on chronic analgesic medications were excluded from the study. After taking informed consent, a thorough preoperative evaluation was performed.

Standard fasting guidelines were advised, i.e., nil per oral 8 hours for solids and 2 hours for clear liquids.

On the day of surgery, the patient was shifted to the operating room, where all the standard monitors (noninvasive blood pressure, pulse oximeter, electrocardiogram, invasive blood pressure) were attached. The procedure was performed under the standard cardiac general anaesthesia protocol.

Enrolled participants were divided into two groups, namely 1 and 2, according to the choice of the consultant providing anaesthesia, group '1' was the control group, receiving only IV morphine analgesia, group '2' was the study group, receiving continuous erector spinae plane block.

In study group '2', after providing standard cardiac general anaesthesia, the patients were placed in lateral decubitus, an experienced anaesthesiologist placed the catheter for continuous erector spinae plane block using an ultrasound-guided technique under strict aseptic precautions. A high frequency 8-15 MHz linear ultrasound transducer (General Electric, model: Vivid 3, Schenectady, New York, USA) was placed in longitudinal orientation after locating the T4 spinous process, which corresponds to the T5 transverse process. Three muscles, i.e., trapezius, rhomboids major, and erector spinae, were identified. Using an in-plane approach, an 18 G Tuohy needle was inserted in the caudal to cephalad direction until the tip was deep to the erector spinae plane, which was evidenced by the visible hydro-dissection below the muscular plane with 5ml saline injection in the cephalad direction, a 20 G epidural catheter was threaded for measurement of 5cm and secured in the site**.** The same procedure was performed on the other side. (Figure 1)

Paracetamol 1gm IV was infused into both groups before the sternal closure. The patient was shifted to the

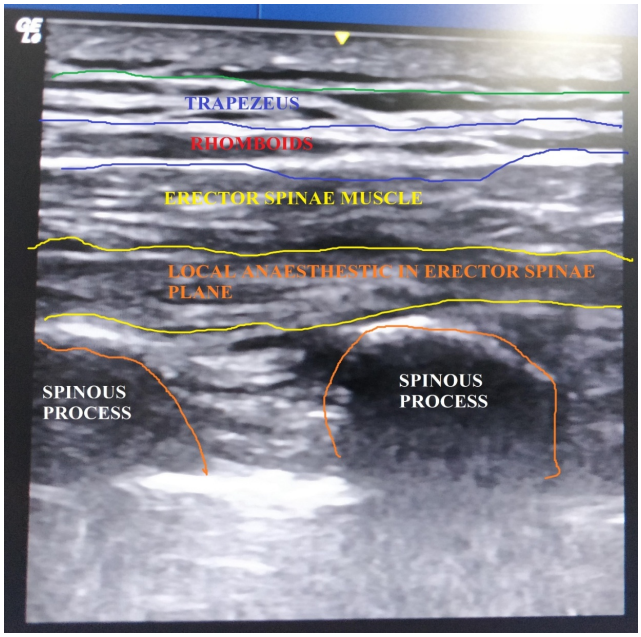


Figure 1: Block sonograph

cardiac ICU after the surgery without extubating. Group' 1' received 0.1mg/kg of IV infusion of Morphine over 6 hours after shifting out, whereas group '2' received a total bolus dose of 0.25% levobupivacaine 2 mg/kg (max 100 mg/dose) divided equally through each catheter, the ESP block infusion was continued with 0.125% levobupivacaine at 5 ml/H in each catheter. Any rescue analgesic drugs required and hemodynamics parameters till extubation were noted.extubation using Prince Henry Hospital scores at 0, 3, 6, 12, 24, and 48 H in both groups.(Figure 2)

Inj. paracetamol 1 gm IV was given as the primary rescue analgesic in both groups if the score was more than or equal to 3. Suppose the pain score was persistently more than 3, Inj. Tramadol 50 mg was given as a secondary rescue analgesic.

Postoperatively, patients were monitored at regular intervals to assess pain levels at 0, 3, 6, 12, 24, and 48 hours after extubation. Pain was also evaluated at the time of intercostal drain (ICD) removal, with analgesics provided upon the patient's request. Additionally, complications such as pleuritis, bronchospasm, and drowsiness were noted. Patient satisfaction with analgesia was measured using the CSAT score at the time of discharge from the ICU. Patient satisfaction score for analgesia was assessed using the CSAT score at the time of discharge from the ICU.[7] (Figure 3)

The sedation score was assessed using Brussels sedation score at 0, 3, 6, 12, 24, and 48 H intervals. However, if the score is less than 2 or any associated respiratory/hemodynamic complication occurs, the same was managed, and time was noted down.[8] (Table 1)

Table 1: Brussels sedation score[8]

Level	Description
1	Unarousable
2	Responds to pain stimulation (pinching of trapezius muscle) but not to auditory stimulation
3	Responds to auditory stimulation
4	Awake and calm
5	Agitated

3. Results

The groups were equal in demography as there was no significant difference in gender distribution (P=0.18). Post extubation (Zero Hour) group 1 participants had a better pain score (P=<0.01). With progressing time, group 2 patients recorded a better pain score at 6 h and 48 h postoperatively (P<005). At 12 h and 24 h postoperatively, the pain relief was similar between the groups (P>0.05). There was no difference in pain scores at the time of ICD removal as well. There was no significant difference in the requirement of rescue analgesia between the groups.

3.1. Statistical analysis

Collected data was computed on Microsoft Excel 2019 (Windows 10, Microsoft Inc. Redmond, Washington, USA), and categorical data were analyzed by the chi-square test and continuous variables by independent t-test. A two-tailed value of p<0.05 is considered statistically significant.

Table 2: Demographic data

Parameters	Group 1	Group 2	P value
Age(yr)			
<45	6(18.2)	6(18.2)	0.67
46 to 55	11(33.3)	7(27.3)	
56 to 65	10(30.3)	11(33.3)	
>65	6(18.2)	9(27.3)	
Sex			
M	25(75.8)	20(68.2)	0.18
F	8(24.2)	13(39.4)	
Height (cm)	162.76±8.53	161.30±	1.45
Weight (kg)	61.45±11.90	60.15±9.71	1.30
BMI kg/m2	23.04±3.72	23.11±3.27	-0.06
Duration of surgery (hr.)	6.26±	6.91±1.15	-0.65

4. Discussion

This study explored the efficacy of the erector spinae plane (ESP) block in managing postoperative pain among cardiac surgery patients undergoing median sternotomy, specifically comparing it to intravenous morphine. Notably, demographic variables like age, gender, surgery type, and duration were comparable across the groups, enabling a valid comparison of outcomes. Our findings indicate that

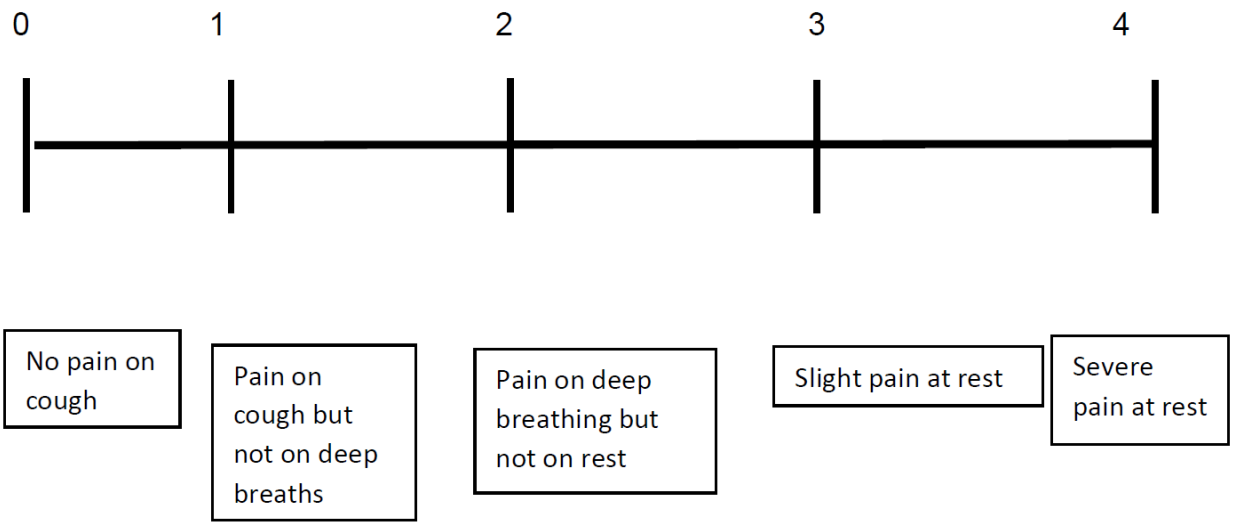


Figure 2: Prince henry hospital pain score[6]

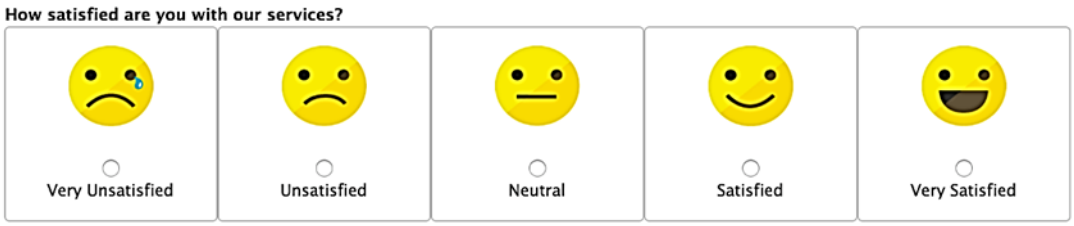


Figure 3: CSAT score

Table 3: Analgesic parameters

Parameters	Group 1	Group 2	P value
No of patients requiring rescue analgesia over 48 hours duration	33	17	0.26
Patient satisfaction score	Satisfied (15) Very satisfied (15)	Very satisfied (30)	<0.001
Secondary complications	Respiratory depression (1)	Soakage at catheter site (1)	0.38
Input/output balance	Positive (27±6)	Positive (8±6)	<0.01

Table 4: Pain scores

Time Interval	Pain Score in Group 1	Pain Score in Group 2	Chi-square value	P-Value
Baseline	0-33	0-22; 1-11	13.2	>0.001*
3 hours	0-19; 1-7; 2-4; 3-3	0-12; 1-13; 2-6; 3-2	3.98	0.26
6 hours	0-18; 1-5; 2-5; 3-5; 4-0	0-18; 1-12; 2-2; 3-0; 4-1	10.16	0.038*
12 hours	0-19; 1-9; 2-4; 3-1; 4-0	0-22; 1-8; 2-1; 3-1; 4-1	3.04	0.55
24 hours	0-19; 1-7; 2-3; 3-3	0-22; 1-7; 2-3; 3-1	1.2	0.75
48 hours	0-19; 1-8; 2-4; 3-2	0-30; 1-2; 4-1	11.01	0.026*
AT ICD Removal	0-21; 1-9; 2-3	0-27; 1-5; 2-0; 4-1	4.38	0.22

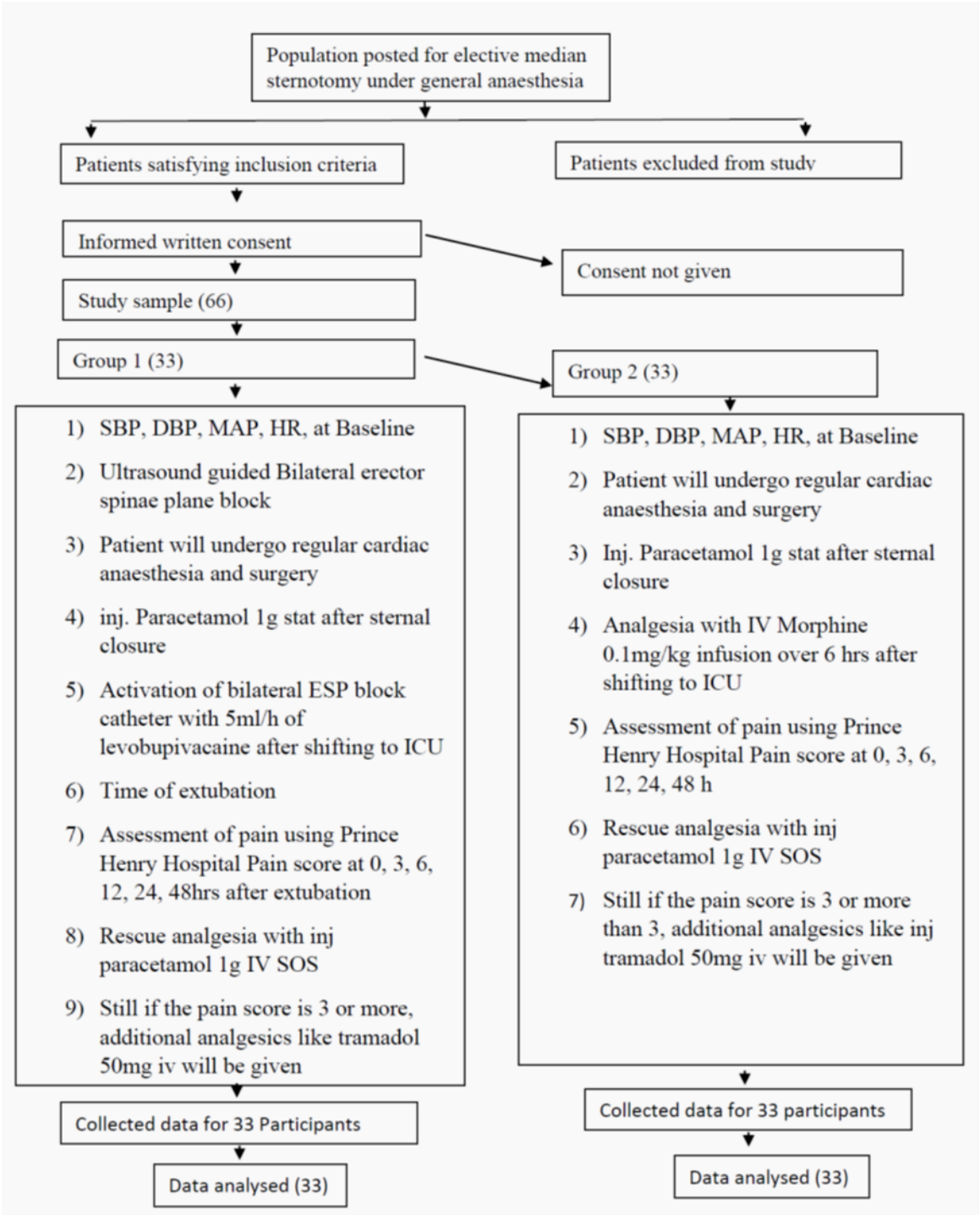
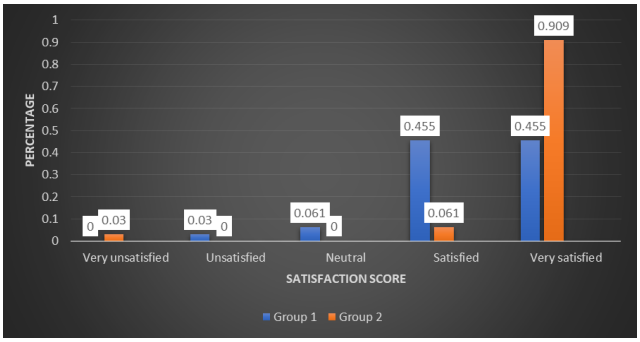


Diagram 1: Consort diagram



Graph 1: Distribution of participants based on satisfaction score

while initial postoperative pain scores were similar between the two groups, the ESP block demonstrated significantly better pain relief from 6 hours post-extubation onwards, aligning with results from previous studies like that of Krishna et al.[9] This delay in efficacy could be attributed to the onset of the block, suggesting that pre-emptive administration or starting the infusion earlier could enhance its effectiveness.

We also compared the participant satisfaction scale at the end of the discharge, unlike in the previous two studies. Because participant satisfaction holds the uttermost value in the clinical practice, as patient satisfaction increases, so does the clinical practice in the present-day scenario.[10] Moreover, patient satisfaction scores were significantly higher in the ESP group, potentially reflecting the superior pain control and lower side-effect profile. This finding supports the use of ESP block as a viable alternative, especially in the context of fast-track cardiac surgery, where rapid recovery and early mobilization are critical. (Table 3)

We have tried to evaluate the severity of the pain; even though it is subjective, the comparative tests performed have superior values in terms of quantification of the pain.[11] At the same time, we validated the pain score by measuring the Brussels sedation score, and we can say that the values given by the patients were accurate and were not under the influence of any sedatives.

A new problem, which was found in this study was the secondary complication of ESP block, i.e. soakage at the catheter site, it was statistically insignificant and managed by giving rescue analgesics. A similar secondary complication was also observed in the other group, i.e. respiratory depression, further, this was handled by giving rescue analgesics. (Table 3)

There is little literature supporting the ESP block in cardiac surgery, except that it has been used in plenty for noncardiac surgery and as an analgesic modality in chest injuries.[12]

Rescue analgesia requirements were comparable between the two groups, signifying that the ESP block offers a perioperative pain management option nearly as effective as intravenous morphine. This was in concordance with the results obtained by Krishna et al.[8]

While the analgesic efficacy of the ESP block in the sternotomy region was comparable to morphine, the need for rescue analgesia in both groups might suggest that ESP primarily targets the pain originating from sternotomy. The inclusion of saphenous vein graft harvesting and intubation in the procedures may have contributed to the additional analgesic requirements. This is consistent with findings from Nagaraj et al., who reported similar analgesia needs in thoracic epidural and ESP block groups.[5] Therefore, future studies should consider multimodal analgesia to address pain from multiple surgical sites, potentially improving overall outcomes. This is per the study conducted by Rafiq S. et al in the year 2014.[13]

The study also identified that intravenous morphine led to unexpected higher heart rates, despite its known association with bradycardia.[14] The mean arterial pressures remained similar across groups, indicating stable hemodynamics irrespective of the analgesic technique used. The ESP block did extend operating room time due to block placement, yet it did not impact the total surgery duration. This suggests that the block's placement can be incorporated into the surgical workflow without significantly delaying the procedure.

In this study we managed to note the fluid balance of the patients, we were able to note that the IV morphine group had a significantly positive fluid balance compared to the ESP block group, this can be explained by the action of morphine on the ADH hormone.[15]

The primary strength of this study lies in its rigorous comparison of the ESP block with intravenous morphine, one of the most potent analgesics.[8] We also utilized a more comprehensive pain assessment approach, employing the Prince Henry Hospital Pain Score to evaluate both static and dynamic pain.[5] Additionally, we used 0.125% levobupivacaine, a comparatively new drug that offers a safer cardiovascular profile than racemic bupivacaine, further enhancing the safety of the ESP block. However, in the study conducted by Nagaraj et al. in 2018, 0.125% bupivacaine was used for the erector spinae plane block.[5]

While prior research has established the efficacy of the ESP block primarily in non-cardiac procedures, this study is among the first to demonstrate its comparable analgesic effectiveness to intravenous morphine in a cardiac surgical setting. However, the study had several limitations. The use of continuous infusion and bolus administration, while effective, may not provide the same level of control as patient-controlled analgesia (PCA).[16] Without PCA, accurately assessing individual analgesic needs could be challenging. Future research could improve pain management by incorporating PCA to better capture these requirements. Additionally, the study did not compare extubation times, which limits our ability to evaluate the

impact of each analgesic modality on recovery time. Future research should aim for larger, multi-center trials that include objective pain measurement tools like heart rate variability or skin conductance to complement subjective pain scores. Comparative studies focusing on patients with specific comorbidities (e.g., low ejection fraction, and chronic analgesic use) would also provide more targeted insights into the ESP block's applicability across diverse cardiac surgery populations.

5. Conclusion

The erector spinae plane (ESP) block proved to be as effective as intravenous morphine for managing postoperative pain after median sternotomy in cardiac surgery patients. It outperformed morphine from 6 hours post-extubation, offering better patient satisfaction and fewer side effects. Due to its favourable safety profile, particularly regarding cardiac complications, the ESP block is a promising alternative for patients with limited or contraindicated opioid use.

These findings advocate for the routine inclusion of the ESP block in postoperative pain management for cardiac surgeries, which may enhance recovery and promote early mobilization. Future research should aim to optimize ESP block administration and explore its efficacy in various patient populations and surgical contexts.

6. Sources of Funding

None.

7. Conflict of Interest

None.

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