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Research Article

Comparison of Ultrasound-Guided Pecto-Intercostal Fascial Plane Block and Transversus Thoracic Muscle Plane Block for Post-Operative Analgesia in Cardiac Surgery: A Prospective Randomised Double-Blind Study

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ABSTRACT

Background: Post-operative pain after cardiac surgery requiring median sternotomy is common and, when inadequately controlled, contributes to hemodynamic instability, respiratory complications and delayed recovery. Ultrasound-guided interfascial plane blocks have emerged as safer alternatives to neuraxial techniques in anticoagulated cardiac patients.
Aim: To compare the analgesic efficacy of ultrasound-guided pecto-intercostal fascial plane block (PIFB) and transversus thoracic muscle plane block (TTMPB) in patients undergoing open cardiac surgery.
Materials and methods: A prospective randomised double-blind study was conducted on 86 patients (ASA III–IV, aged 30–50 years) undergoing elective cardiac surgery via median sternotomy. Patients were randomised into Group P (PIFB, n=43) and Group T (TTMPB, n=43); both received 20 mL of 0.25% bupivacaine bilaterally. Hemodynamic parameters (pulse rate, mean arterial pressure) were recorded peri-sternotomy, and post-operative pain (VAS), time to first rescue analgesia and 24-hour analgesic consumption were compared.
Results: Intraoperative pulse rate and MAP during and after sternotomy were significantly lower in Group P than Group T ($p<0.0001$), indicating better intraoperative hemodynamic control with PIFB. Intraoperative fentanyl use was lower in Group P (351.05±41.25 vs 429.77±36.81 mcg, $p<0.0001$). However, Group T had a markedly longer time to first rescue analgesia (514.42±43.82 vs 110.93±34.00 min, $p<0.0001$), lower immediate post-operative median VAS (2 vs 7, $p<0.0001$) and lower 24-hour analgesic consumption ($p<0.0001$).
Conclusion: PIFB provided superior intraoperative hemodynamic stability and pain control during sternotomy, whereas TTMPB provided superior post-operative analgesia with a longer duration and reduced rescue analgesic requirement.

Keywords: Pecto-intercostal fascial plane block; Transversus thoracic muscle plane block; Cardiac surgery; Median sternotomy; post-operative analgesia; Ultrasound-guided regional anaesthesia.

INTRODUCTION

Cardiac surgery has rapidly evolved since the 1950s and has emerged as one of the most commonly performed major interventions. Valve replacement and coronary artery bypass grafting are lengthy, complex procedures that require advanced intraoperative support, intensive care and effective post-operative pain relief.

Post-operative pain following cardiac surgery is very common, occurring in approximately 75% of patients, and may be moderate to severe. The multiple sources of pain include the skin incision, tissue dissection, sternal retraction, internal mammary artery harvesting, chest-drain placement and sternal wires. Musculoskeletal pain arising from rib fracture or dislocation during sternal retraction contributes further.

Inadequately controlled post-surgical pain hinders recovery in several ways. Respiratory complications are a major concern: poor cough effort and shallow breathing lead to retained secretions, atelectasis and pneumonia, while reduced mobilisation and poor physiotherapy compliance compound the problem. Pain-induced sympathetic activation makes patients vulnerable to arrhythmia and increases myocardial oxygen demand, which is particularly undesirable in a recently operated heart. Prolonged acute pain also predisposes to chronic pain syndromes, with an incidence of 21–25% after cardiac surgery. These adverse outcomes prolong mechanical ventilation and hospital stay, increasing morbidity and mortality.

Until recently, opioids and NSAIDs were the primary analgesics used in cardiac surgery. However, the adverse effects of high-dose opioids and the bleeding risk associated with NSAIDs have driven the search for more suitable analgesic modalities. Regional analgesia offers an attractive option, but the routine use of anticoagulants after cardiac surgery limits neuraxial techniques—paving the way for interfascial plane blocks.

In the era of ultrasound-guided anaesthesia, interfascial plane blocks have become an easier and safer option for post-operative analgesia in cardiac surgery. These techniques involve depositing a generous volume of local anaesthetic into musculofascial planes containing nerve branches, rather than around nerve roots, thereby avoiding injury to the spinal cord and major vessels.

Among the various fascial plane blocks, this study compares the efficacy of the pecto-intercostal fascial plane block and the transversus thoracic muscle plane block for post-operative pain relief in cardiac surgery patients.

AIM AND OBJECTIVES

Aim: To compare the analgesic efficacy of ultrasound-guided pecto-intercostal fascial plane block and transversus thoracic muscle plane block in patients undergoing open cardiac surgery.

Primary objective: To compare hemodynamic changes during pre-sternotomy, sternotomy and post-sternotomy.

Secondary objective: To compare the total dose of analgesic requirement over 24 hours.

MATERIALS AND METHODS

Study design and setting: A prospective randomised double-blind study conducted in the Department of Cardiothoracic Surgery, Government Rajaji Hospital, Madurai Medical College, Madurai, among patients undergoing cardiac surgery requiring median sternotomy.

Study period: One year

Study population: Coronary artery disease and valvular heart disease patients scheduled for cardiac surgery requiring median sternotomy. Eligible consenting patients were recruited according to the inclusion and exclusion criteria.

Inclusion criteria: Patients aged 30–50 years; ASA physical status III and IV; elective cardiac surgery requiring median sternotomy.

Exclusion criteria:

Emergency or redo surgery

- Left ventricular ejection fraction <30%
- Patient refusal to participate
- Pregnancy, breastfeeding or psychiatric illness
- Daily opioid use
- Allergy to local anaesthetics
- High vasopressor requirement
- Requirement for left internal mammary artery harvest

Sample size: The sample size was calculated based on the primary outcome (VAS) using a two-sample t-test with alpha 0.05, power 0.95 and effect size 0.75, yielding 43 patients per group (86 total).

Randomisation: Simple randomisation using computer-generated random numbers allocated patients into Group P (PIFB, n=43) receiving ultrasound-guided pecto-intercostal fascial plane block pre-operatively, and Group T (TTMPB, n=43) receiving ultrasound-guided transversus thoracic muscle plane block pre-operatively.

Blinding: The block was performed by a senior anaesthetist with more than seven years' experience. The surgeon and the observer recording parameters were blinded to the allocated block.

Materials: Ultrasound machine with a 7–13 MHz linear transducer; 45 mm 18-gauge needle; 0.25% bupivacaine (30 mL) for the block; standard monitors (ECG, NIBP, pulse oximeter); resuscitation drugs and equipment; and all drugs for general anaesthesia.

Conduct of anaesthesia: Standard monitors (NIBP, 5-lead ECG, pulse oximeter) were applied. Two 18-G intravenous cannulae were secured. After a modified Allen's test, the radial artery was cannulated under local anaesthesia for invasive pressure monitoring and arterial blood-gas sampling. Patients were premedicated with midazolam 20 mcg/kg, fentanyl 4 mcg/kg and morphine 100 mcg/kg intravenously. Following pre-oxygenation, anaesthesia was induced with thiopentone 5 mg/kg and succinylcholine 2 mg/kg, and patients were intubated and connected to a closed circuit after confirming bilateral air entry. Anaesthesia was maintained with vecuronium, sevoflurane 1–2% and O_2/N_2O (FiO_2 0.4). A central venous catheter was placed under ultrasound guidance using the Seldinger technique. Both blocks were performed with an 18-gauge needle using a high-frequency linear ultrasound probe.

Pecto-intercostal fascial plane block (Group P): After intubation, patients were positioned supine and the site was cleaned with chlorhexidine. A linear probe (7–13 MHz) was placed between the 4th and 5th intercostal spaces in the parasagittal plane, 2–3 cm lateral to the midline. The needle was advanced in-plane in the caudocranial direction, and after negative aspiration 20 mL of 0.25% bupivacaine was injected into the fascial plane between the pectoralis major and the internal intercostal muscles. The procedure was repeated on the contralateral side for bilateral blockade. At the end of the procedure, approximately 10 mL of 0.25% bupivacaine was injected around the chest tubes in all patients.

Transversus thoracic muscle plane block (Group T): With the patient supine and the site prepared, a linear probe was placed between the 4th and 5th intercostal spaces in the parasagittal plane, 2–3 cm lateral to the midline, and the depth adjusted to image the internal intercostal muscle, transversus thoracic muscle and pleura. After confirming with colour Doppler that the internal mammary vessels were not in the path, the needle was advanced in-plane in the caudocranial direction. Following negative aspiration, 20 mL of 0.25% bupivacaine was injected into the fascial plane between the internal intercostal and transversus thoracic muscles, observing real-time craniocaudal spread and downward pleural movement. The procedure was repeated contralaterally, with approximately 10 mL of 0.25% bupivacaine injected around the chest tubes.

Intraoperative parameters: Heart rate (ECG) and mean arterial pressure (NIBP) were monitored. A rise in blood pressure ≥20% above baseline was treated with fentanyl 1 mcg/kg intraoperatively. At the end of surgery, all patients received fentanyl 2 mcg/kg and were shifted for elective post-operative ventilation.

Post-operative parameters: Once awake, the VAS score was recorded, along with the time of demand for first rescue analgesia, total 24-hour fentanyl infusion dose and the VAS score at 24 hours. Rescue analgesia (fentanyl) was administered only when the VAS score exceeded 4; a fentanyl infusion at 2 mcg/kg/hr was titrated down in steps of 0.2 mcg/kg/hr as the VAS score fell to 3.

Statistical analysis: Data were entered in Microsoft Excel and analysed using SPSS. Continuous variables were expressed as mean ± standard deviation and compared using the unpaired t-test; discrete variables were expressed as median with interquartile range and compared using the Mann–Whitney U test. Proportions were compared using the chi-square test. A p-value <0.05 was considered statistically significant.

RESULTS

Of 86 patients enrolled, 43 in Group P received ultrasound-guided pecto-intercostal fascial plane block and 43 in Group T received ultrasound-guided transversus thoracic muscle plane block, each with 20 mL of 0.25% bupivacaine. The two groups had comparable demographic profiles (age, BMI, sex distribution; p>0.05).

TABLE 1: BASELINE CHARACTERISTICS OF PARTICIPANTS (N=86).

Variable	Group P (n=43)	Group T (n=43)	P value
Age (years), mean ± SD	51.05 ± 12.05	48.98 ± 11.91	0.425
BMI (kg/m²), mean ± SD	29.51 ± 3.41	29.66 ± 3.25	0.841
Sex, Male : Female	28 : 15	27 : 16	0.822

The mean age was 51.05 years in Group P and 48.98 years in Group T (p=0.425). The mean BMI was 29.51 and 29.66 respectively (p=0.841), and the sex distribution was comparable between groups (p=0.822). None of these differences were statistically significant.

Hemodynamic parameters — pulse rate. Pre-operative pulse rate was similar between groups (p=0.992). During sternotomy and for the first six minutes thereafter, the pulse rate was significantly lower in Group P than Group T (p<0.001 to p<0.0001).

TABLE 2: COMPARISON OF PULSE RATE (BEATS/MIN) BETWEEN GROUP P AND GROUP T.

Time point	Group P (mean ± SD)	Group T (mean ± SD)	P value
Pre-operative	77.42 ± 11.49	77.40 ± 10.98	0.992
During sternotomy	76.60 ± 8.81	83.88 ± 10.62	0.001
1 min	73.72 ± 7.70	85.72 ± 9.21	<0.0001

2 min	72.16 ± 7.46	101.40 ± 4.63	<0.0001
3 min	75.91 ± 8.07	93.58 ± 7.74	<0.0001
4 min	73.58 ± 7.04	81.77 ± 6.54	<0.0001
5 min	73.72 ± 7.70	90.33 ± 8.71	<0.0001
6 min	77.42 ± 11.49	91.44 ± 6.57	<0.0001

Hemodynamic parameters — mean arterial pressure. Pre-operative MAP was comparable (p=0.314). During sternotomy and for the first six minutes thereafter, MAP was significantly lower in Group P than Group T (p<0.0001), indicating better intraoperative hemodynamic control with PIFB.

TABLE 3: COMPARISON OF MEAN ARTERIAL PRESSURE (MMHG) BETWEEN GROUP P AND GROUP T

Time point	Group P (mean ± SD)	Group T (mean ± SD)	P value
Pre-operative	96.05 ± 13.82	98.19 ± 0.76	0.314
During sternotomy	84.72 ± 10.42	102.65 ± 13.25	<0.0001
1 min	87.51 ± 6.02	122.56 ± 6.97	<0.0001
2 min	84.40 ± 6.55	111.07 ± 7.85	<0.0001
3 min	83.84 ± 6.46	101.28 ± 6.86	<0.0001

MAP during sternotomy was 84.72 ± 10.42 mmHg in Group P versus 102.65 ± 13.25 mmHg in Group T (p<0.0001). For the first six minutes after sternotomy, MAP ranged from 83.84 to 88.65 mmHg in Group P and from 101.28 to 122.56 mmHg in Group T (p<0.0001).

Intraoperative and post-operative outcomes. The duration of surgery was comparable between groups (p=0.448). Intraoperative fentanyl consumption was significantly lower in Group P. However, Group T demonstrated a substantially longer time to first rescue analgesia, lower immediate post-operative VAS and lower 24-hour analgesic consumption, while Group T had a higher VAS at 24 hours.

TABLE 4: COMPARISON OF INTRAOPERATIVE AND POST-OPERATIVE OUTCOMES BETWEEN GROUP P AND GROUP T.

Parameter	Group P	Group T	P value
Duration of surgery (min)	277.44 ± 49.04	270.70 ± 30.97	0.448
Intraoperative fentanyl (mcg)	351.05 ± 41.25	429.77 ± 36.81	<0.0001
Time to 1st rescue analgesia (min)	110.93 ± 34.00	514.42 ± 43.82	<0.0001
VAS, immediate post-op (median)	7.00 (6–7)	2.00 (2–3)	<0.0001
VAS at 24 hours (median)	3.00 (3–4)	5.00 (4–5)	<0.0001
Total 24-hour analgesic dose	42.00 ± 4.20	26.00 ± 1.20	<0.0001

Intraoperative fentanyl use was 351.05 ± 41.25 mcg in Group P versus 429.77 ± 36.81 mcg in Group T (p<0.0001). The mean time to first rescue analgesia was markedly longer in Group T (514.42 ± 43.82 min) than Group P (110.93 ± 34.00 min; p<0.0001). The median immediate post-operative VAS was lower in Group T (2 vs 7), while the median VAS at 24 hours was higher in Group T (5 vs 3); both differences were statistically significant (p<0.0001).

DISCUSSION

Sternotomy pain in the intraoperative and post-operative period is associated with increased morbidity, impaired quality of life, delayed recovery, prolonged hospital stays and adverse hemodynamic changes such as tachycardia and hypertension. These changes are especially detrimental in cardiac patients, prompting the development of various pain-control modalities.

Taylor and Phelan reviewed post-operative pain relief as a principal goal of care and concluded that opioids were the mainstay of control. In the era of fast-track cardiac care—which aims at early tracheal extubation (within eight hours), reduced ICU stay and shorter hospitalisation—liberal opioid use significantly delays recovery, drawing interest towards regional analgesia and, in particular, thoracic epidural analgesia.

Kirno and colleagues studied thoracic epidural analgesia (TEA) on cardiac sympathetic activity and hemodynamics in 20 CABG patients, demonstrating excellent attenuation of the stress response. However, despite its benefits, TEA carries risks of epidural haematoma from systemic heparinisation and infection due to its invasive nature. Ultrasound-guided fascial plane blocks that target nerves supplying the anterior chest and sternum have since gained rapid acceptance as safer alternatives.

Ueshima et al. originally described the transversus thoracic muscle plane block, and Liu et al. reported T1–T6 coverage for post-sternotomy analgesia using the pecto-intercostal fascial plane block. Fujii, Vissa and colleagues reported post-operative analgesia lasting up to 480 ± 38.7 minutes with TTMPB; in the present study the mean duration was 514.42 ± 43.82 minutes, likely reflecting the larger 20 mL volume of 0.25% bupivacaine used. Similarly, Xue Jian-jun et al. reported a mean analgesic duration of 463 ± 24 minutes for TTMPB, again shorter than in this study.

Cengiz Kaya and associates (2022) compared TTMPB and PIFB for 24-hour morphine consumption and pain scores and found both blocks similarly effective. In the present study, immediate post-operative VAS was lower in the TTMPB group (median 2 vs 7) while the 24-hour VAS favoured PIFB less clearly, consistent with a longer-lasting effect of TTMPB.

Mariana AbdElsayed Mansour et al. (2024) found that the PIFB group had a longer time to first rescue analgesia than the TTMPB group in their cohort; the present study observed the opposite, with a markedly longer duration in the TTMPB group. Differences in drug volume, technique and outcome definitions likely account for this variation.

I. M. Elbardan et al. compared the perioperative effectiveness of TTMPB and PIFB and reported significantly lower fentanyl consumption and later first rescue analgesia in the TTMPB group, with comparable ICU stay—broadly consistent with the superior post-operative analgesic profile of TTMPB observed here. In the present study, intraoperative fentanyl requirement was lower and intraoperative hemodynamic control was better in the PIFB group, whereas the TTMPB group required rescue analgesia later and consumed less analgesia post-operatively.

SUMMARY

This prospective double-blind comparative study evaluated the analgesic efficacy of ultrasound-guided pecto-intercostal fascial plane block and transversus thoracic muscle plane block in 86 patients undergoing cardiac surgery requiring median sternotomy under general anaesthesia. The primary objective was to compare hemodynamic changes during and after sternotomy (pulse rate and MAP); the secondary objective was to compare 24-hour analgesic requirement using VAS at immediate and 24-hour post-operative time points.

The pulse rate during sternotomy was significantly lower in Group P (76.60 ± 8.81) than Group T (83.88 ± 10.62; p=0.001), and this pattern persisted for the first six minutes after sternotomy. Intraoperative opioid consumption was lower in Group P (351.05 ± 41.25) than Group T (429.77 ± 36.81; p<0.0001). Conversely, the median immediate post-operative VAS was lower in Group T (2 vs 7), and the total 24-hour analgesic dose was significantly lower in the TTMPB group (p<0.0001). Overall, PIFB was more effective in controlling intraoperative hemodynamics, while TTMPB more effectively reduced post-operative opioid consumption.

CONCLUSION

The pecto-intercostal fascial plane block was effective in maintaining hemodynamic stability and providing better pain control during sternotomy and intraoperatively, compared with the transversus thoracic muscle plane block. In the immediate post-operative period, however, the transversus thoracic muscle plane block provided superior analgesia with a longer duration and reduced the need for rescue analgesia.

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