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Original Research Article

Ultrasound Guided Bilateral Transverse Thoracic Plane Block for Patient Undergoing Cardiac Surgery

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Abstract:

Background and Objectives: The management of postoperative pain in patients following cardiac surgery mostly relied on opioids. However, the desired outcomes could not be attained due to the adverse consequences associated with opioids. The implementation of the multimodal analgesic strategy has been developed to mitigate the undesirable consequences of opioids and provide optimal pain relief. The objective of this study was to assess the impact of ultrasound-guided bilateral thoracic plane block on patients having cardiac surgery.

Material and Methods: This prospective, randomized, double-blind study was conducted in the Department of Anesthesiology and Critical Care, Sri Aurobindo Institute of Medical Sciences Hospital, Indore (M.P) among 100 Patients of 18-70 years scheduled for elective cardiac surgeries. After explaining the protocol to all patients, a written and informed consent was taken from all patients. The patients were allocated into two groups using computer-generated random numbers: the Intervention group [Group T], that had a bilateral transversus thoracic muscle plane block guided by ultrasonography with 20ml of 0.25% ropivacaine, and the Control group [Group C], which underwent a sham block. Primary outcome was to observe the pain score and first need of rescue analgesic inj. Tramadol. The secondary outcomes were pain score, Total analgesic requirement in 24 hr, time to extubation, and ICU stays.

Results: The control group had a considerably shorter time prior to the first request for pain management (median 3 hours) compared to group T (median 14 hours). Within the 0.5-24 hour period after surgery, the group T observed a decrease of 1.86 units in pain scores at rest. The estimated decrease was -1.80, with a 95% confidence interval ranging from -2.14 to -1.45. The t-value was -10.323, and the p-value was less than 0.0001. Postoperative tramadol consumption was found to be significantly lower in Group T ($p < 0.001$).

Conclusion: The bilateral transversus thoracic muscle plane block (TTMPB) is a very promising and successful method for minimizing opioid consumption and managing post-sternotomy pain in patients who underwent cardiac surgery.

Keywords: Cardiac surgery; Postoperative analgesia; Post-sternotomy pain; Transversus thoracic muscle plane block.

Introduction

Following cardiac surgery, a number of variables, including preoperative stress and anxiety, inflammatory reactions, direct tissue injury, and the individual's sensitivity to pain, and the administration of pain relief throughout the perioperative period, affect how much pain is felt. [1] Debilitating postoperative pain can have a lot of negative repercussions, such as problems with respiration, reduced mobility, anxiety, a weakened immune system, mental instability, postoperative psychosis, and a higher chance of mortality. [2] The medical management of pain after surgery relied mostly on opioids; however, the desired outcomes could not be attained due to the adverse consequences associated with opioids. [3] The multimodal analgesic strategy has been developed to prevent the negative consequences of opioids and produce effective pain relief; one of its elements is the use of fascial plane blocks. [4] A number of techniques, including paravertebral nerve block, pecto intercostal fascial (PIF) block, [15] serratus anterior block, erector spinae plane block, and transversus thoracic muscle plane (TTMP) block, [4] have been studied for cardiac surgery via a median sternotomy. Ueshima et al. [5] published the first report on the TTMP block.

Numerous anterior branches of the intercostal nerves (T2–6), [6] which regulate the internal mammary region, including the sternum, might be blocked by it. [7]

Our hypothesis was that bilateral TTMP block would offer superior and longer-lasting pain reduction following sternotomy-related cardiac surgery, thereby rendering it a viable approach for multimodal opioid-sparing analgesia.

Aim and Objectives:

The purpose of the current study was to assess the impact of bilateral thoracic plane blocks guided by ultrasonography on patients having cardiac surgery.

Primary Objective:

- VAS score of pain
- First need of rescue analgesic inj. Tramadol

Secondary Objectives:

- Total analgesic requirement in 24 hr.
- Time of extubation from end of surgery.
- ICU stay in hours

Material and Methods:

This prospective, randomized, double-blind study was conducted in the Department of Anesthesiology and Critical Care, Sri Aurobindo Institute of Medical Sciences Hospital, Indore (M.P). After explaining the protocol to all patients, a written and informed consent was taken from all patients. A total of 100 patients age 18-70 years scheduled for elective cardiac surgeries were selected randomly.

Inclusion criteria:

- Patients undergoing major cardiac surgery.
- Age 18-70 years

Exclusion criteria:

- Patients not extubated in first 24hr
- A repeat cardiac surgical procedure
- Coagulation disorders
- Poor left ventricular function (LVEF <35%) preoperatively
- Neuromuscular problems
- Infections at the injection site or systemically
- Any known allergy to the drug used
- Emergency surgery
- Patient with psychiatric illness and opioid dependant patient

All the selected patients had undergone thorough pre-anaesthetic evaluation prior to surgery. Routine investigations were done as per hospital protocol and patients were advised nil orally for a period of 6-8 hours prior to surgery. Patients will be allocated into two groups using computer-generated random numbers in a randomised manner.

1. Group T - The intervention group received bilateral transversus thoracic muscle plane blocks guided by ultrasonography.

2. Group C - The control group, which had a sham block procedure.

In group T 20ml of 0.25% ropivacaine was injected bilaterally under ultrasound guidance while in group C, ultrasound assessment of the plane was done but no injection was injected.

Group allotment was concealed to be revealed only after patient induction. All blocks were accomplished with the same anaesthesiologist. Similar monitoring and induction protocol was followed. In post-operative protocol time of extubation was looked for. The observer who had collected post-operative data was not aware of group allocated.

Methodology:

Preoperatively, all patients had a thorough examination and investigation, including a complete blood count, coagulation profile, assessment of renal functions, and evaluation of electrolyte levels. CXR, ECG and echocardiography were performed as part of a regular procedure. Coronary angiography may be requested when needed. A five-lead electrocardiography device was used to track and record heart rate, rhythm, and ST segments, particularly in leads II and V5, prior to the administration of anaesthesia.

A peripheral venous cannula has been inserted and a pulse oximeter probe was attached. Under local anaesthesia, a 20-gauge cannula was inserted into the left or right radial artery in order to take blood samples and measure arterial pressure. Following pre-oxygenation, the administration of general anaesthesia was initiated with midazolam at a dose of 2 mg, fentanyl at a dose of 10µg/kg, propofol at a dose of 3mg/Kg, and subsequently atracurium at a dose of 0.5 mg/kg. The trachea was intubated, and patients were subjected to mechanical ventilation using oxygen-enriched air. The ventilation settings were modified to attain normocarbia. The anaesthesia was sustained by the inhalation of Isoflurane at a concentration of 0.4% to 1%, along with a continuous infusion of atracurium at a rate of 0.5 mg/kg/h to maintain muscular relaxation.

In the operating room, the anesthesiologist prepared the research solution, which consisted of 20ml of either 0.25% ropivacaine or normal saline. A povidone-iodine solution was used to prepare the skin around the sternum on both sides before performing the bilateral block. Then, on the left and right sides, a linear ultrasonography probe was placed 3 cm from the midsternum. The intermediate plane, which included the ribs,

intercostal muscles, and pectoralis major muscle, was identified as the subcutaneous tissue. The lung, pleura, and transverse thoracic muscle were all located in the deep plane.

In **Group T**, the TTMP was blocked on both sides. A 22-gauge needle with a short bevel was placed between the fourth and fifth ribs, connecting to the sternum, after the anatomical plane between the internal intercostal and transversus thoracic muscles was identified. The whole length of the needle and the position of its tip between the two muscles were observed to confirm the placement of the needle. A negative aspiration was then followed by the administration of 1 mL of anaesthetic liquid. By injecting 20 mL of 0.25% ropivacaine, the TTMP block was achieved, and the same procedure was repeated on the other side. The local anaesthetic is recommended to be injected deep into the costal cartilages, causing the pleura to be displaced downwards.

Group C patients had a sham block procedure where 20 mL of 0.9% saline solution was administered on both sides.

All patients were transferred to the Intensive Care Unit (ICU) for postoperative care and management. The patient underwent tracheal extubation once they fulfilled the following conditions: being awake and responsive, hemodynamically stable, no on-going bleeding, warm extremities, and satisfactory arterial blood gas levels with a FIO2 less than 0.5. Additionally, the pressure support on the ventilator was reduced to 10 Cm H2O, the Positive End Expiratory Pressure was set between 5-7 CmH2O, there were no electrolyte imbalances, minimal need for inotropic support. Analgesia was administered to both groups in the ICU postoperatively. Before extubation, inj. Paracetamol 1gm was given to all the patients. The first need of rescue analgesic inj. Tramadol and total 24 hrs Tramadol consumption was recorded.

Outcome measures:

Primary outcome was to observe the pain score and first need of rescue analgesic inj. Tramadol. The secondary outcomes were pain score, Total analgesic requirement in 24 hr, time to extubation, and ICU stays.

Statistical Analysis:

Version 22 of the SPSS programme was used to arrange, tabulate, and statistically analyse the data (SPSS Inc, USA). To evaluate the variations in mean data (age, BMI, and tramadol consumption) among the two groups, we used a two-sample t-test. In addition, we compared the medians for the skewed endpoints (the time of extubation & ICU stay) using a Mann-Whitney U-test. The statistical significance was determined using the chi-squared test, and the qualitative results were reported as percentages and numbers.

In order to account for the repeated pain score measures, linear mixed models were used. The Kaplan-Meier estimator was used to assess the initial request for an analgesic. The Log rank test was used to compare the various study groups, and the median time and its associated 95% confidence interval (CI) were calculated. A statistically significant P-value was defined as one that was less than 0.05.

Results:

Between the two groups, there was no statistically significant difference in their demographic characteristics. [Table 1]

Table 1: Patient demographics

Variables	Group T (n=50)	Group C (n=50)	P-value
Age (years)	66.36±6.71	65.18±4.91	0.123 (NS)
Weight (kg)	79.83±9.61	82.38±14.71	0.073 (NS)
Height (cm)	174.23±7.71	176.08±8.11	0.859 (NS)
ASA (I, II)	21.7%, 78.3%	8.7%, 91.3%	0.095 (NS)

NS- Not Significant. No block-related complications were reported. Furthermore, there was no statistically significant disparity seen between the two groups in terms of surgical data, postoperative nausea and vomiting (PONV) score, as well as the duration of stay in the intensive care unit (ICU) or the hospital. [Table 2] The mean (± standard deviation) total consumption of Tramadol within the initial 24 hours was considerably lesser in group T compared to group C; 208.71 ± 88.91 mg vs. 442.18 ± 64.01 mg ; $p < 0.001$. [Table 2]

Table 2: Operative data, analgesic requirements, and PONV scores

Variables	Group T (n=50)	Group C (n=50)	P-value
Anesthesia time (min)	164.57±37.91	142.38±36.11	0.667 (NS)
Surgery time (min)	135.66±31.51	120.44±28.61	0.384 (NS)
Tramadol consumption (mg)	208.71±88.91	442.18±64.01	**<0.001 (S)**
PONV scores	1.18±0.81	1.27±0.81	0.672 (NS)
Median Time of extubation (IQR) (hours)	5 (4-6)	6 (5-6)	(NS)
Median ICU stay(IQR) (hours)	36 (36-48)	36 (36-60)	(NS)

IQR – Interquartile range, NS- Not Significant, S-Significant

The median estimated time for the first analgesic request was significantly longer in the block group (14 hours, 95% confidence interval [CI] = 12.17–15.84) compared to the control group (3 hours, 95% CI = 1.72–4.28), with a p< 0.0001.Utilizing a mixed effect model throughout the post-operative period (0.5–24 hours), it was observed that group T had pain scores at rest that were 1.86 units lower than group C. The estimated difference was -1.80, with a 95% confidence interval ranging from -2.14 to -1.45. The t-value was -10.323, indicating a statistically significant difference (p < 0.0001). [Figure 1]

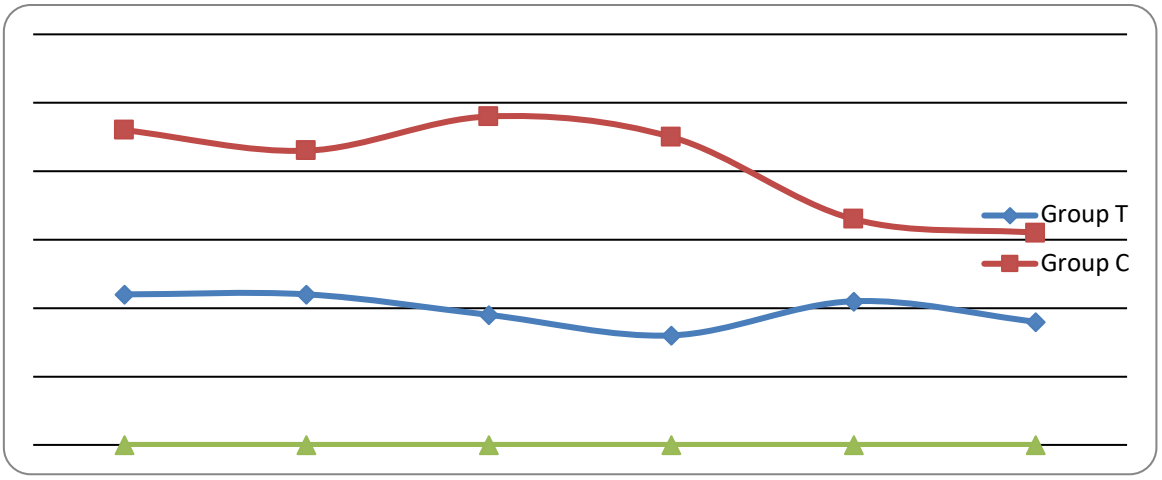

Figure 1: VAS score at different time interval postoperatively

Discussion

Our study demonstrated a notable reduction in the amount of Tramadol consumption during a 24-hour period, along with a substantial increase in the time it took for the first request for pain relief in the group that had the block intervention compared to the control group.

Furthermore, we observed a significant decrease in pain levels, as measured by the Visual Analogue Scale (VAS), during rest following extubation in the group that received the block intervention compared to the control group. The TTMP block can alleviate post-sternotomy discomfort by specifically targeting the several anterior branches of the intercostal nerves (T2–6). Aydin et al [8] found that adult patients who got TTMP block saw a notable reduction in 24-hour opioid intake compared to the control group. Furthermore, several trials have documented the effectiveness of TTMP block in decreasing opioid usage following paediatric heart surgery. [9-11]

However, Fujii et al [12] found that the 24-hour opioid requirement was comparable in patients who received the block and those who did not. There are a couple of reasons for this. Firstly, their study was a pilot study with a small sample size of only 19 patients, which is insufficient to establish a significant difference. Secondly, they did not have control over the use of opioids during surgery and in the intensive care unit, which could have influenced postoperative pain scores and opioid requirement. Additionally, 60% of their patients underwent coronary artery bypass grafting (CABG) with internal mammary artery (IMA) harvesting. Harvesting the internal mammary artery (IMA) will cause precise disruption of the thoracodorsal nerve block plane and unequal distribution of the injected substance over the intended thoracic levels. Patients may not experience any advantages from the TTMP block on that particular side. [13] Our findings indicate that the TTMP block had a substantial and consistent effect in reducing pain levels, as measured by VAS ratings, at all-time intervals within the first 24 hours following extubation. Multiple researches have consistently produced similar findings. [9-11]

Nevertheless, Aydin et al [8] observed decreased Visual Analogue Scale (VAS) ratings exclusively within the initial 12-hour period following extubation. However, there was no discernible distinction in VAS scores between the block and non-block groups at the 24-hour mark. This outcome might be ascribed to the timing of the block administration, as the TTMP block was administered before to the surgery. No disparity in extubation time was observed between the two groups. Conversely, research in the field of paediatrics discovered that individuals who underwent the block experienced a reduced duration of extubation. [9-11] The extubation process is influenced by elements beyond pain management, including hemodynamic stability and the full reversal of neuromuscular blockade (NMB). These factors might impact the timing of extubation.

No block-related problems were reported. In their investigations, Aydin et al [8] and Fujii et al [12] reported no problems associated to the block.

Nevertheless, in a study involving 299 consecutive cases of TTMP block, Ueshima et al [14] reported that two patients had infection in the vicinity of the injection site. The results of our study indicate that there were no notable disparities in length of stay (LOS) between the two groups. Furthermore, Aydin et al [8] and Cakmak and Isik [11] have also reached the same conclusion. Conversely, I.I. Abdelbaser and Mageed [9] as well as Zhang et al [10] demonstrated a reduced length of stay (LOS) in the block groups as compared to the non-block groups.

Limitations of the study: Median sternotomy is not the sole origin of pain after cardiac surgery; chest tubes and visceral discomfort are recognized as other significant causes. This study specifically focused on post-sternotomy discomfort, which may account for why patients in the block group sought medication for pain.

Once again, the scarcity of accessible clinical studies posed a challenge for conducting comparisons. Notwithstanding these constraints, our findings emphasize the effective function of TTMP block in decreasing pain and opioids consumption after median sternotomy.

Conclusion

The TTMP block effectively reduces the amount of opioids utilized after surgery, increases the duration before the first request for pain relief, and lowers pain scores. It possesses an opioid-sparing property and can be employed as a component of a multimodal analgesia plan in a patient having cardiac surgery by median sternotomy. We suggest doing more clinical studies on a large population to confirm the clinical efficacy of TTMP block as a separate component of the multimodal analgesic regimen. Additionally, additional research is necessary to assess the feasibility and effectiveness of catheter placement for administering multiple injections.

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