ORIGINAL ARTICLE

Comparison between Two volumes in Bilateral Ultrasound Guided Erector Spinae Plan Block for Cardiac Surgery Analgesia

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Abstract

Background: ***If the postoperative pain from open heart surgery is not effectively managed, it can be quite severe. Surgical incisions, sternotomies, drains, thoracic back discomfort, distension of the costotransverse and costovertebral joints, and other postoperative complications can lead to severe pain following cardiac surgery.***

Aim and objectives: ***This study aimed to evaluate the efficacy of bupivacaine and lidocaine at varying doses for sternotomy pain relief using an ultrasound-guided erector spinae plane block (ESPB.***

Subjects and methods: ***The Al-Azhar University Hospitals carried out this prospective, single-blind, controlled, randomized study after receiving approval from the relevant institutional and departmental ethical committees. Sixty patients were prepared for open cardiac surgery using a midline sternotomy after receiving their informed consent.***

Results: ***A highly statistically significant (P<0.001) difference between the studied groups regarding intraoperative MAP in group I, where there is a decrease in MAP compared to group II of low volume after 30 minutes. 60min .120 min. Highly statistically significant (P<0.001) increase in intraoperative pulse in group I, where the pulse is less than that of group II, with 20 a total volume of local anesthetic.***

Conclusion: ***Higher volume (40ml) of local anesthetic in the ESPB provides more stable hemodynamics, including reduced heart rate variability and lower mean arterial pressure fluctuations, both intraoperatively and postoperatively. There was a correlation between the bigger volume block and improved pain control; this was seen by lower VAS scores and a delayed requirement for rescue analgesia as compared to the 20 ml block.***

Keywords: Cardiac surgery analgesia; Bilateral ultrasound; ESPB

1. Introduction

While present multimodal analgesia has demonstrated promising results for resting pain after surgery, it has not yet achieved complete pain reduction.[1] During rehabilitation and everyday exercise programs, patients experience breakthrough pain episodes that limit their mobility. Nausea, vomiting, pruritus, respiratory depression, and persistent use after surgery are some of the well-known adverse effects of perioperative opioid use. After open-heart surgery, opioids aren't the best choice for an improved rehabilitation program.[2]

It appears that regional analgesia is the superior alternative at this time.[3] On the other hand, paravertebral blocks and thoracic epidural anesthesia also have risks that should be considered.[3]

Injecting a local anesthetic into a plane beneath the iliocostalis, longissimus, and spinalis muscles is known as the Erector Spinae Plane Block (ESPB). This technique is an inter-fascial plane block. The local anesthetic seems to have an impact via penetrating the paravertebral area and acting on the dorsal and ventral rami of the spinal nerves in the thoracic spine.[4]

In a recent study, Krishna and colleagues found that systemic analgesia was ineffective in alleviating resting pain in the first 24 hours following open heart surgery compared to a bilateral single-shot ESPB.[4]

The aim of this study was to compare the effect of different volumes of local anesthetic (bupivacaine and lidocaine) in single injection ultrasound guided ESPB in analgesia for cardiac surgeries performed via midline sternotomy.

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2. Patients and methods

The Al-Azhar University Hospitals carried out this prospective, single-blind, controlled randomized study after receiving approval from the relevant institutional and departmental ethical committees. This study included 60 patients who met the following criteria and were undergoing open-heart surgery.

Inclusion criteria:

Patients aged from 21 to 60 years old, both sexes, ASA III,[5] undergo open heart surgery, and body mass index (BMI) ≤30 kg/m2.

Exclusion criteria:

This list includes patients who are unable to communicate effectively after surgery, those who are experiencing acute or chronic pain prior to surgery, those who have a bleeding disorder or infection at the injection site, those who are having emergency surgery, those who have severe valvular disease or poor left ventricular function, patients having coronary artery bypass surgery, and those who have a history of allergies to local anesthetics.

Study Groups:

Between March 2022 and December 2023, a total of 60 patients undergoing open heart surgery were divided into two equal groups. One group received 40 millilitres of local anesthetic, while the other group received 20 millilitres.

Sample size:

Using the G*Power© software version 3.1.9.2 from the Institute of Experimental Psychology at Heinrich Heine University in Düsseldorf, Germany, the sample size was determined. The sample size was determined using the Mann-Whitney U-test, which was utilized to evaluate the main hypothesis in the preliminary study, which was—VAS scores at rest in the first postoperative hour. It is recommended to include at least 50 people in the study, based on the preliminary results, to ensure a two-sided (two tails) type I error of 0.05, 80% power (1-β=0.8), and an effect size (d) factor of 0.84. The German Institute of Experimental Psychology at Heinrich Heine University in Düsseldorf used the G*Power© software version 3.1.9.2 to determine the post hoc power.

In order to test the null hypothesis of this study (VAS rest first hour), the power was determined using the Mann-Whitney U-test. Assuming a two-tailed, type I error of 0.05 and an effect size (d) factor of 1.16, the post hoc power was determined to be 99.99 percent based on prior research. An analysis of the data was carried out using SPSS for Windows, version 22.0, developed by SPSS Inc. of Chicago, IL, USA.[6]

Using the Kolmogorov-Smirnov test, we were able to ascertain if the distribution of continuous data followed a normal distribution. We checked for variance homogeneity using the Levene test. Assuming normal distributions, continuous data were presented as mean SD unless otherwise noted. In cases of skewed distributions, the median (Q1: first quartile, third quartile) was used. The number of cases (%) was used to characterize the categorical data. To compare regularly distributed variables across the two groups, we used Student's t-test; for non-normally distributed data, we used the Mann-Whitney U-test. At the p-value level, we used either Fisher's exact test or Pearson's chi-square test to compare categorical variables.

Preoperative Assessment:

A thorough evaluation of each patient's medical history, as well as their vital signs, electrocardiogram, and other diagnostic tests, were used to determine each patient's appropriateness for anesthesia. Every patient was educated on the use of the visual analogue scale (VAS) to measure pain, as well as the various analgesic methods, their benefits and drawbacks.

Anesthetic Technique:

When the patient arrived at the operating room, basic monitoring equipment such as an electrocardiography (ECG), invasive blood pressure (IBP) monitor, and pulse oximeter were connected and started. Prior to the start of the surgical procedure, the patient sat in a specific position and underwent blocks under US guidance. All patients underwent standardized general anesthesia procedures, including 3-minute preoxygenation, 1.5 mcg/kg of fentanyl, 0.5 mcg/kg of propofol, 0.1 mcg/kg of midazolam over 90 seconds, and 0.5 mcg/kg of atracurium intravenously to facilitate endotracheal intubation.

A 7 mm internal diameter endotracheal tube was selected for females and an 8 mm internal diameter for males. During the surgery, the cuff was inflated with air, ocular lubricant was used, and 0.5 mg/kg atracurium was given as needed to relax the muscles. Anesthesia maintenance was achieved with the use of a single MAC sevoflurane. Optimal settings included a 60% oxygen/air combination, a tidal volume of 7 ml/kg, a respiratory rate of 12/min, and a flow rate of 3/5 L/min. Using an aseptic approach and ultrasound guidance, a central venous line was inserted into the right internal jugular vein; it was then secured at 12 cm with inotropes connected to a stopcock, and the line was left patent.

The obstruction in the neuromuscular pathways will be tracked using a Train of Four (TOF). Before the aortic annuloplasty procedure, all patients were given full heparinization. All patients with a coagulation level greater than 450 were given cross-clamped antegrade cardioplegia at a dosage of 20 ml/kg. After administering Custodiol® - HTK Solution, patients underwent cardiopulmonary bypass and were weaned at the conclusion of the surgery. All patients were intubated and ventilated before being extubated as soon as feasible when the weaning requirements were met. On demand, they were given a rescue analgesic of 0.03 mg/kg morphine.

For the purpose of reducing patient anxiety, block treatments were carried out prior to general anesthesia and the skin incision. Two milligrams of Dormicum is administered to patients while they are tended to for their comfort. Patients were positioned in a sitting position before blocks were administered under US supervision prior to the introduction of anesthesia. Sterile drapes were used to cover the region where the needle was inserted after stringent skin antisepsis. Local infiltration was then administered, with three cc of lidocaine on each side. Every single patient in every single group used a sterile-covered, high-frequency 6-18 MHz linear probe (MyLab six, Esaote, Genoa, Italy) with a 20-gauge cannula that was compatible with the US system.

Using the in-plane approach, the nerve block needle was advanced under the erector spinae muscles until it reached the interfacial space. Thirty subjects in Group I and twenty in Group II received 40 and 20 millilitres, respectively, of 0.25% bupivacaine injections following hydrodissection with 2 millilitres of normal saline. The patient was given 0.03 mg/kg of morphine as a rescue medication and as-needed analgesics following surgery, according to the normal analgesic regimen.

Materials:

A SONOSITE M-Turbo Portable Ultrasound Machine with a linear array ultrasound probe was utilized for the scanning process. The echogenic needle used by ESPB is a 20 G, 120 mm Vygon product from Rue Adeline in Ecouen, France. Medication: 0.2 percent lidocaine and 0.5 percent bupivacaine in a vial. Monitoring of vital signs with a noninvasive system (e.g., Drager Infinity, Drager vista120, or vista XL-USA) and an anesthetic machine (e.g., Drager Primus, USA or Drager Fabius plus, Germany).

Measured Parameters:

Intraoperative Measurements:

Prior to surgery, haemodynamic parameters such as heart rate and mean arterial blood pressure were recorded. These parameters were checked every 30 minutes until the end of the procedure. SpO2, end-tidal CO2, invasive blood pressure, cardiac output monitoring, total analgesic consumption, perioperative glucose level, perioperative cortisone level, and patient satisfaction score were also recorded.

Postoperative Measurements:

Time to tracheal extubation, time to eye opening, and time to verbal command following were the recovery profile features measured. These times begin once the intubation procedure is complete. 2) Total amount of morphine taken on the first day after surgery.

On the visual analogue scale, 0 indicates no pain and 10 indicates very severe pain; this is the VAS pain score. To determine the severity of postoperative pain, patients were instructed to draw a 10-centimetre horizontal line with the words "no pain" on one end and "the worst pain ever" on the other. Here we can see the mark that represents the patient's current level of pain. An objective measure of pain intensity was the centimetre-long distance between the patient's mark and the VAS's lowest point. If the patient needs more than two doses of rescue analgesia in the first hour after surgery, the block is said to have failed.

The time it took for the patient to feel better after the operation was complete was measured by how long it took until they asked for more pain medication. Postoperative haemodynamic measures were monitored, including heart rate and mean arterial blood pressure. An impartial anesthesiologist, who was not privy to the study groups, documented postoperative haemodynamics and discomfort at2,4,8, and 12 hours.

Postoperatively, at 24 and 48 hours, we checked in with patients to see how they were doing. On a scale from 1 (very unhappy), 2 (fair), 3 (good), and 4 (very satisfied), patients' levels of satisfaction were evaluated.

Statistical analysis:

We used SPSS 25 (Statistical Package for the Social Sciences) to analyze the data. Qualitative data were presented using percentages and frequencies. Mean plus or minus standard deviation (Mean ± SD) was the way continuous quantitative data were presented. The middle value of a discrete set of integers, calculated by dividing the sum of values by the number of values, is called the mean or average. A measure of the dispersion of a set of values is standard deviation (SD). If the standard deviation is small, then the values are clustered around the set mean, and if it's large, then the values are more dispersed. We regarded a probability (P-value) to be significant if it was less than 0.05, highly significant if it was less than 0.001, and insignificant if it was greater than 0.05.

When comparing two groups (for continuous quantitative data), the independent sample T-test (T) is used. A paired sample T-test is used to compare sets of consecutive quantitative data from the same group. For continuous quantitative data, a one-way analysis of variance (F) is used when comparing more than two groups. Non-parametric categorical data were compared using a chi-square test.

3. Results

Table 1. Demographic data of the studied patients.

		GROUP-I	GROUP-II	P-VALUE
AGE	Mean ± SD	48.37+12.64	44.47+13.95	0.237
	min	26	26	
	max	68	68	
SEX	male	8(13.3%)	20(33.3%)	0.758
	Female	22(36.7%)	10(16.7%)	
WEIGHT (KG)	Mean ± SD	89.07+16.7	89.01+16.16	0.959
	min	60	60	
	max	119	119	
HIGHT (CM)	Mean ± SD	169.87+11.19	168.33+13.55	0.620
	min	150	150	
	max	188	188	
BMI	Mean ± SD	31.34+7.43	31.89+6.9	0.935
	range	26	29.1	
	min	18		
	max	46		

As regard gender, there were 28-males (46.6%) and 32-females (53.4%) in all studied patients. The mean age was (35.4±11.9) years with range of (16-60) years in all studied patients. The mean height was (169.87+11.19) cm with range of (150-188) cm in all studied patients. The mean weight was (89.07+16.7) kilogram with range of (60-119) kilogram in all studied patients. The mean bmi was (31.34+7.43) with range of (18-46) kilogram in all studied patients, (table 1).

Table 2. VAS of the studied groups.

	GROUP-I	GROUP-II	P-VALUE
VAS AFTER EXTUBATION	5.37+1.3	2.37+0.9	<0.01
VAS 2H AFTER EXTUBATION	4.70+0.8	2.17+0.8	<0.01
VAS 6H AFTER EXTUBATION	4.07+0.7	1.5+0.5	<0.01
VAS 12H AFTER EXTUBATION	4.07+09	2+0.5	<0.01
VAS 24H AFTER EXTUBATION	4.5+1.4	2.03+1.2	<0.01

VAS was low in group-II and it was significantly different at 2h,6h, 12h, and 24h between both groups based on P-value levels (>0.05), (table 2; figure 1).

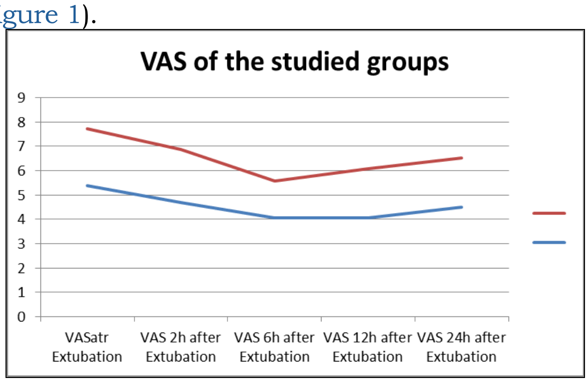

Figure 1. Comparison of all studied groups as regard vas score intraoperative.

Table 3. Intraoperative means arterial pressure of the studied groups (mmHg).

	GROUP-I	GROUP-II	P-VALUE
BASELINE	73.8+13.8	71.6+9.2	0.98
MAP AT INDUCTION	84.5+9.3	84.7+8.8	0.97
INTRAOPERATIVE MAP 15	84.8+7.9	86.6+5.1	<0.01
INTRAOPERATIVE MAP 30	82.9+9.4	68.6+6.4	<0.01
INTRAOPERATIVE MAP 60	82.6+8.6	73.7+6.4	<0.01
INTRAOPERATIVE MAP 120	85.0+9.2	75.1+5.1	<0.01

High statistically significant (P<0.001) difference between studied groups as regard intraoperative MAP in group-I where there is decrease in MAP than group-II of low volume after 30min. 60min .120 min, (table 3; figure 2).

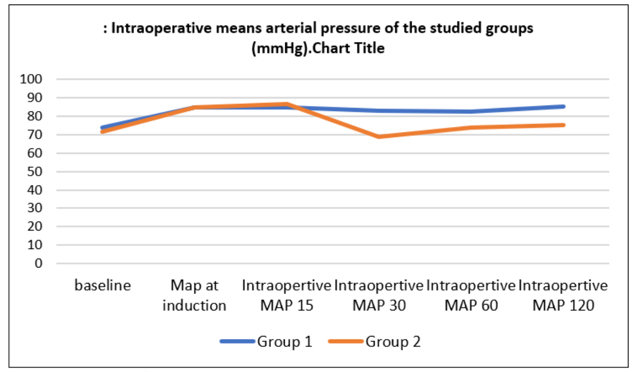

Figure 2. Comparison of all studied groups as regard intraoperative mean arterial pressure.

Table 4. Intraoperative heart rate of the studied groups (Beats/Min).

	GROUP-I	GROUP-II	P-VALUE
BASELINE	74.5+9.10	73.0+8.9	0.399
INTRAOPERATIVE 15 MIN	99.6+8.75	78.8+6.86	<0.01
INTRAOPERATIVE 30 MIN	102.6+9.7	78.5+7.8	<0.01
INTRAOPERATIVE 60 MIN	106.2+10.7	78.9+5.9	<0.01
INTRAOPERATIVE 120 MIN	109+10.14	82.7+6.17	<0.01

data are presented as mean ± SD; T: independent sample T test;

NS: P>0.05 is considered non-significant;X2: Chi-square test.

High statistically significant (P<0.001) increased in intraoperative pulse in group-I where pulse is less than that of group-II with 20 ml total volume of local anesthetic, (table 4; figure 3).

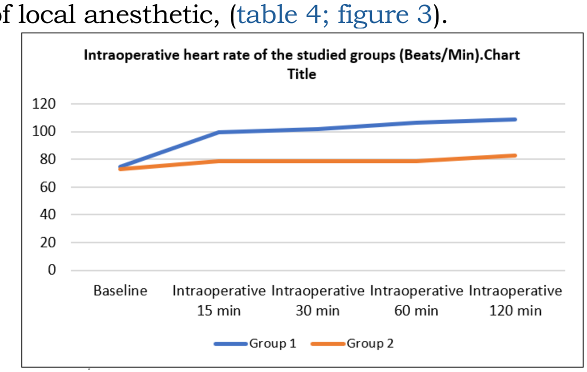

Figure 3. Intraoperative heart rate of the studied groups (Beats/Min).

4. Discussion

Effective analgesia in cardiac surgery is crucial for optimizing postoperative recovery, improving patient comfort, and minimizing complications. Cardiac surgical procedures, including sternotomy, thoracotomy, and minimally invasive approaches, induce significant pain due to extensive tissue trauma, nerve injury, and inflammation. The choice of analgesic technique should be tailored to individual patient needs, balancing pain relief with hemodynamic stability and minimizing opioid-related side effects.[7]

In order to improve pain control and decrease narcotic consumption, a multimodal strategy is commonly recommended during heart surgery. The goal of this approach is to produce synergistic effects by combining analgesic drugs and methods that operate through diverse pathways. The main components of multimodal analgesia in cardiac surgery include regional anesthesia techniques, systemic analgesics, and advanced pain management strategies.[8]

We discovered demographic information in the form of in the present investigation. Between the two groups, there was no statistically significant difference in age, sex, weight, height, body mass index, ASA physical status, or surgical length.

Compared to group 1, which had an increase in both heart rate and mean arterial blood pressure, group 2, which had a volume of 40 ml, showed significantly lower changes at 15 minutes, 30 minutes, 60 minutes, 120 minutes, and the end of surgery. At baseline, there was no significant difference in intraoperative heart rate as well as mean arterial blood pressure between the two groups.

Forero et al.,[9] documented that larger volumes in ESP blocks produce a wider and deeper spread, reaching the paravertebral and epidural spaces, which helps control sympathetic tone and stabilize hemodynamics during high-stress surgeries like sternotomies spread not only ensures better coverage of thoracic spinal nerves but also impacts sympathetic chain modulation as noted by Chin,[10] who emphasized that ESP blocks at higher volumes could reduce heart rate variability and prevent intraoperative hypertension by blocking sympathetic fibers directly.

In the present study we found that, postoperative VAS score was significantly different at two h, four h, 12h and 24h between both groups where group-II of 40 ml have less change in VAS than group-I of 20 ml which have increase in VAS score and was significantly higher and there is significance difference between two groups in glucose level at 12h and 24 h where group-I there is increase in the level which support our result about no stress response in group-II.

First rescue analgesia is a significant difference between the two groups, where in group-II, the first rescue is more than in group-I, and group-II has less than the first rescue analgesia than group-I.

Krishna,[11] corroborates this result, noting that higher volumes in ESP blocks lead to more comprehensive sensory blockade, which is particularly effective in reducing postoperative pain scores in thoracic and cardiac surgeries.

According to Chin et al.,[10] the ESP block's high-volume approach can improve pain control by extending its reach to multiple thoracic segments, thereby providing broader analgesia across the surgical field.

Tulgar et al.,[12] observed that increasing anesthetic volume beyond 20 ml did not significantly enhance analgesic efficacy in terms of VAS scores, suggesting that the relationship between volume and pain relief might not be linear and may vary based on patient anatomy and procedural factors.[10]

Limitations: Reliability of the findings for a bigger population may be compromised if the sample size is small. Single institution, which might introduce variability in results due to differences in surgical techniques, patient population, or clinician experience. Short-term follow-up, potential observer bias, limited blinding, and a homogeneous patient population were also considered limitations for this study.

4. Conclusion

Higher volume (40ml) of local anesthetic in the ESPB provides more stable hemodynamics, including reduced heart rate variability and lower mean arterial pressure fluctuations, both intraoperatively and postoperatively. In comparison to the 20 ml block, the higher volume block improved pain control as shown by lower VAS scores and a delayed requirement for rescue analgesics.

In conclusion, these results add to the increasing amount of data that the ESPB is a viable, less intrusive substitute for conventional methods of pain management following cardiac surgery, especially when dealing with larger volumes of patients.

Disclosure

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Authorship

All authors have a substantial contribution to the article

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Conflicts of interest

There are no conflicts of interest.

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