Analgaesic Effect of Erector Spinae Plane Block in Coronary Surgery: A Randomised Controlled Trial

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ABSTRACT

Objective: To investigate the effect of preemptive erector spinae plane (ESP) block application on postoperative pain scores and opioid demand in off-pump coronary artery bypass graft (CABG) surgery.

Study Design: Randomised-controlled trial.

Place and Duration of the Study: Department of Anaesthesiology and Reanimation, Abant Izzet Baysal University (AIBU) Medical School, Bolu, Turkiye, from November 2020 to April 2021.

Methodology: Fifty patients between the ages of 50 and 75 years, received CABG surgery. These participants who were at risk of the American Society of Anesthesiologists (ASA) III were randomly divided into two groups: ESP (Group E) and Control (Group C). Intervention in Group E was performed bilaterally at the T5 level before the operation. In the study, the primary outcome was postoperative opioid demand while the secondary outcomes consisted of intraoperative opioid demand, visual analogue scale scores, and the duration of hospital stay.

Results: Tramadol demand was significantly decreased in Group E at 0–1, 1–12, 12–24, and 0-48 hours ($p < 0.05$). Intraoperative fentanyl demand for Group E was also statistically significantly decreased ($p = 0.001$). In Group E, the visual analogue scale scores at 30 minutes, 1st, 2nd, 4th, 8th, 12th hour, and 16th hour after postoperative extubation were observed to be significantly lower than those of Group C ($p < 0.05$).

Conclusion: Preemptive ESP block application in CABG surgery patients reduced postoperative tramadol demand, intraoperative fentanyl demand, and postoperative pain scores.

Key Words: *Coronary artery bypass surgery, Erector spinae plane block, Acute postoperative pain.*

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INTRODUCTION

Coronary artery bypass graft (CABG) surgery has been applied for many years for revascularisation in coronary artery patients. Postoperative pain might develop due to sternotomy, graft excision, and drainage cannulas in CABG surgery. In addition, rapid shallow breathing might occur due to postoperative pain. If inadequate coughing because of the pain follows, pulmonary complications — especially atelectasis — might occur. It is also known that postoperative pain can lead to cardiovascular events such as cardiac ischaemia and arrhythmia.[1]

The erector spinae plane (ESP) block is defined for thoracic analgaesia and can provide adequate analgaesia in cardiac surgery patients with CABG.[2]

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In a cadaver study, comparing ESP blocks and retrolaminar blocks, the radiocontrast dye was given at the T5 level. It was shown in this study that the dye spread in the T3–T7 epidural space, T3–T6 neural foramina, and T1–T10 intercostal space in cadavers that underwent ESP block. In addition, C5–L1 craniocaudal spreading and 10 cm lateral spreading from the midline were seen in MR imaging.[3] In another cadaver study, it was observed that the radiocontrast dye given at the T5 level spread deep into the erector spinae muscle, behind the transverse process, into the intercostal and paravertebral field, and up to the paravertebral chain. It was reported that 20 ml of radiocontrast dye had an average of 4-6 intercostal space craniocaudal spreading.[4] Both of these cadaver studies showed that ESP block application provides adequate dermatomal spread for postoperative pain management in CABG operations. In the treatment of pain after CABG operation except for pharmacological methods, regional techniques can also be used to a limited extent.

Although serratus anterior block can relieve tube-induced chest pain in patients undergoing median sternotomy, it might be insufficient for analgaesia around the sternum.[5] While bilateral parasternal block provides analgaesia in median sternotomy, it does not provide an analgaesic effect for chest tubes placed on

the lateral side of the chest wall.[6] If these two techniques are combined, adequate analgaesia can be achieved; however, the requirement of multiple interventions might affect the success rate and patient comfort. Thoracic epidural anaesthesia and paravertebral anaesthesia can provide adequate analgaesia, but the use of anticoagulants might limit these interventions.[7,8]

ESP block was reported to be a safe practice as it is a superficial attempt.[9] Introduced in 2016 for chronic pain, it can be used in postoperative pain control in many types of surgery such as thoracotomy, breast surgery, cholecystectomy, and lumbar spinal surgery.[10] It can be inferred that reaching such a wide area of use in a short time depends on the fact that it is an effective, reliable and superficial block.

This study was designed as a randomised trial to test the efficacy of preemptive ESP block application in patients having CABG operation. The aim of this study was to apply preemptive ESP block to patients undergoing CABG surgery to offer effective analgaesia and reduce postoperative opioid demand.

METHODOLOGY

Abant Izzet Baysal University Clinical Research Ethics Committee confirmed this prospective, randomised study which was also recorded with ClinicalTrials.gov under the number NCT05312957. All patients who agreed to participate in the study were informed about the intervention and anaesthesia to be applied, and their written consents were obtained. Patients between the ages of 50 and 75 years who were at the American Society of Anesthesiologists (ASA) III risk and scheduled off-pump CABG surgery were invited for the trial, between November 2020 and April 2021. Preoperative exclusion was applied to those volunteers who had allergic reactions to drugs to be used in the research, liver and kidney failure, bleeding disorders, and who rejected to take part in the research. Intraoperative exclusion was made for participants who required aortic balloon pump support; for the postoperative exclusion, patients who required re-exploration and whose extubation lasted longer than four hours in the phase were removed from the analysis.

The groups were randomly divided into two, Group E and C, using a computer random number generator named the Ramdom.org application (http://www.random.org/lists/?mode=advanced). All patients' demographic data including gender, height, age, weight, and body mass index (BMI) were registered. Without any premedication, the patients were brought to the operating room with monitored heart rate (HR), peripheral oxygen saturation (SpO_2), and electrocardiography (ECG) data. After the Allen Test, a cannula was applied to the radial artery. With two peripheral vascular cannulas (18-gauge), vascular accesses were established.

Group E patients, after the ESP block in the prone position, were given general anaesthesia. Traditional asepsis-antisepsis rules were applied. For the intervention, a SonoSite-180 Plus model USG was used. An adjusted linear probe with a frequency of 10-15 MHz and a depth of 2-5 cm was employed. The probe was positioned 3 cm laterally to the T5 spinous process in the parasagittal plane, craniocaudally. Transverse process of the T5 vertebrae was identified. The in-plane method was used for the intervention. Before the interventional procedure, a local aneasthetic was injected into the structures where the block needle would pass through with USG. After the block needle reached the transverse process, a test dose of 1 ml of 0.9% saline was administered. After observing the diffusion of fluid between the erector spinae muscle and the transverse process into this area, 20 ml of 0.25% bupivacaine (Buvacin 0.5% VEM Pharmaceuticals, Istanbul, Turkiye) was injected. The same process was repeated on the opposite side to complete the intervention. Block success was assessed by loss of cold sensation. The Group C patients received no preoperative procedure.

General anaesthesia was applied to all patients, and then central venous access was provided. All patients had intermittent arterial blood gas monitoring during anaesthesia. Prior to the thoracic incision, fentanyl (0.5-2 mcg/kg) was given. Patients with a 20% heart rate or blood pressure rise received additional 1-2 mcg/kg of intravenous (IV) fentanyl. Following induction, 0.25 mg/kg of rocuronium and 1 mcg/kg of fentanyl were given to each group at every half-hour interval. Systolic blood pressure was aimed to be less than 100 mmHg before cross-clamping the ascending aorta. Fentanyl (1-2 mcg/kg) was added to patients whose systolic blood pressures were higher than 100 mmHg. The demand for fentanyl intraoperatively was noted. The patients' durations of anaesthesia and operation were noted, and they were moved to the intensive care unit (ICU) while intubated. The patients were extubated until the 4^{th} postoperative hour. Patients whose extubation time exceeded 4 hours were excluded from the study. After extubation, all patients were administered patient-controlled analgaesia devices. The device was set to deliver a bolus at 5 mg/ml concentration iv bolus tramadol each time the patient pressed the button. The device was set to a lock time of 20 minutes and a maximal tramadol dose of 400 mg in 24 hours. The total amount of tramadol used by the patient was recorded. VAS values were noted after extubation at the 1^{st}, 2^{nd}, 4^{th}, 8^{th}, 12^{th}, 18^{th}, 24^{th}, 36^{th}, and 48^{th} postoperative hours. Throughout the 0–1, 1–12, 12–24, 24–36, and 36–48 time zones, systolic, diastolic and mean blood pressure, heart rate, peripheral oxygen saturation, and tramadol demand were recorded. Following the extubation, the patient was monitored for side-effects such as nausea, vomiting, pruritus, desaturation, and urine retention. In the postoperative period, IV 0.05 mg/kg morphine was planned to be administered as a rescue analgaesic to patients with a VAS score above 4. The discharge time from extubation and intensive care of the groups were noted.

The primary output of this study was tramadol demand. To determine the sample size, Altıparmak *et al*. study (control group tramadol demand 143 ± 18.6; α error margin 0. 05, power 99%) was taken as a basis.[11] To reduce the amount of tramadol by 15%, 25 patients in each group were calculated with a 20% exclusion rate. The G Power 3 Calculator programme was used to calculate the sample size.

The descriptive statistics of the data used the mean values, lowest and highest values, standard deviation, frequency, and ratio values. Whether the data showed normal distribution or not was assessed using the Kolmogorov–Smirnov test. In comparison between the groups, if the parameters were normally distributed, the independent sample t-test was used while the Mann–Whitney U test was used for those that were not normally distributed. The Chi-square test was used to compare the qualitative data. The Statistical Package for the Social Sciences (SPSS) 20.0 (SPSS Inc., Chicago, Illinois, USA) programme was used in the analysis, and $p < 0.05$ was considered significant.

RESULTS

Sixty-five participants were invited to participate in the study. Sixty participants who met the criteria were randomised and divided into two groups. Ten participants were removed from the study intraoperatively and postoperatively during the follow-up since they did not match the inclusion criteria. Therefore, 50 participants were analysed and excluded patients were shown in the CONSORT flow diagram (Figure 1).

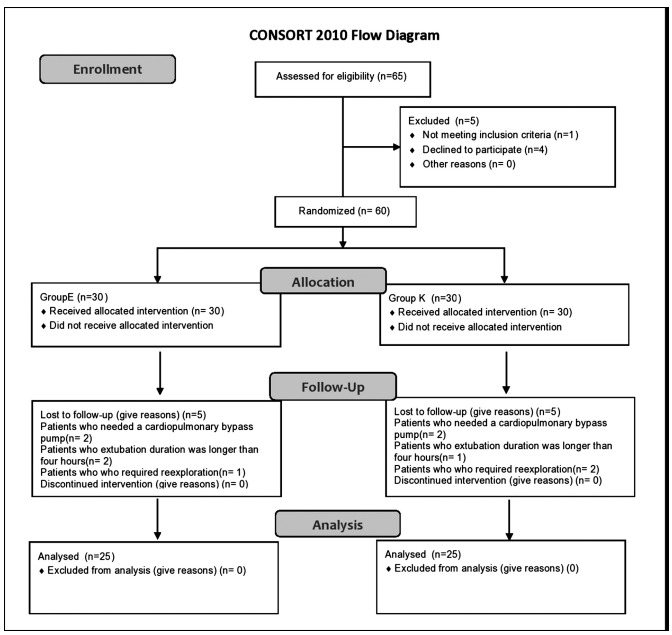

Figure 1: Consort flow diagram.

In comparison between groups, there were no statistically significant differences in the demographic data, the length of the surgery, and anaesthesia duration ($p > 0.05$). When the groups were compared in terms of postoperative HR, MBP, SBP, DBP, and SpO_2, no statistically significant difference was observed ($p > 0.05$). When the groups were compared in terms of intraoperative fentanyl demand, Group E's demand decreased statistically significantly ($p = 0.001$) (Figure 2).

The groups were compared in terms of VAS values after the extubation, the 30th-minute, 1st, 2nd, 4th, 8th, 12th and 18th-hour VAS values were found to be statistically significantly lower in Group E ($p < 0.05$, Table I). The groups were compared in terms of tramadol demand after extubation, the decrease in Group E was statistically significant in the 0–1, 1–12, and 12–24-hour intervals and the total 48-hour period ($p < 0.05$, Table II). The groups were compared in terms of the need for rescue analgaesia in 48 hours after the extubation, the number of patients who needed rescue analgaesia was statistically less in Group E ($p < 0.05$, Table II). Moreover, the extubation time, length of ICU stay, patient satisfaction, and postoperative side-effects were statistically similar in both the groups ($p > 0.05$).

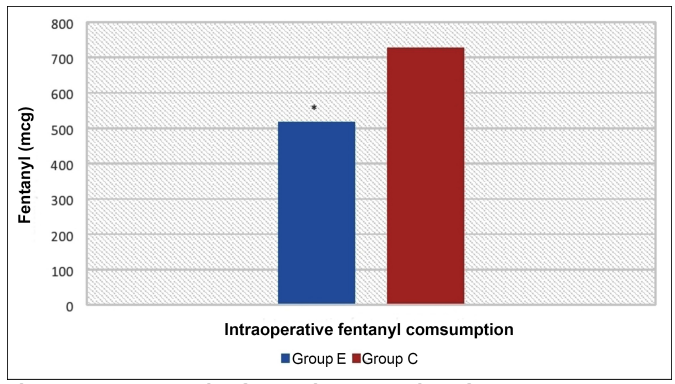

Figure 2: Intraoperative fentanyl consumption of groups. *Comparison between groups, $p < 0.05$.

Table I: Comparison of VAS values after extubation between the groups.

Time	Group E (n=25)	Group C (n=25)	p-value
30min	2 (1-3)	3 (1-5)	0.001*
1h	2 (1-3)	3 (2-6)	0.001*
2h	2 (1-4)	3 (2-5)	0.001*
4h	2 (1-3)	3 (2-6)	0.001*
8h	2 (1-3)	3 (2-6)	0.001*
12h	2 (1-5)	3 (2-6)	0.001*
18h	2 (1-5)	3 (2-5)	0.001*
24h	3 (2-4)	3 (2-5)	0.886
36h	3 (2-4)	2 (1-3)	0.091
48h	2 (1-3)	2 (1-3)	0.507

n = Number of patients, values are presented as median (min-max).
**There was a statistically significant difference between the groups ($p < 0.05$).*

Table II: Comparison of opioid consumption between the groups.

Time	Group E (n=25)	Group C (n=25)	p-value
Intergroup comparison of tramadol consumption after extubation (mg)			
0-1 h	17.60 ± 16.65	32.00 ± 20.0	0.008*
1-12 h	99.20 ± 41.02	157.60 ± 44.09	0.001*
12-24 h	120.80 ± 48.12	175.20 ± 40.11	0.001*
24-36 h	140.80 ± 34.87	160.80 ± 38.93	0.066
36-48 h	137.60 ± 31.26	152.80 ± 36.00	0.171
0-48 h	516.00 ± 130.51	678.40 ± 90.35	0.001*
The number of patients who needed rescue analgaesia after extubation (n)			
0-48 h	4/25	12/25	0.032*
Intraoperative fentanyl consumption (mcg)			
	516.0 ± 102.79	726.0 ± 183.78	0.001*

n = Number of patients, values are presented as mean ± standard deviation.
**There was a statistically significant difference between groups ($p < 0.05$).*

DISCUSSION

This study showed that preemptive ESP block application reduced intraoperative and postoperative opioid demand and the first 18-hour VAS values in the period following surgery in patients having off-pump CABG surgery.

Moderate to severe postoperative pain occurs in patients undergoing cardiac surgery. Multimodal analgaesia methods are frequently used for the treatment of pain after CABG.[12] Opioids used as a component of multimodal analgaesia have many side-effects.[13] In this study, the primary outcome was the reduction of opioid demand, and the secondary outcomes were the reduction of VAS scores and the length of hospital stays.

ESP block that was first used to treat chronic pain, has found a place in the treatment of postoperative pain recently. While it is commonly applied at the thoracic level for the adult population, it is increasingly used in abdominal surgeries.[9] In the literature, ESP block studies in cardiovascular surgery patients are limited. Macaire *et al.* applied ESP block after catheterisation in open cardiac surgery patients.[14] According to their findings, the ESP group with a catheter consumed much less morphine in the first 48 hours following surgery compared to the control group. Another study investigated intraoperative and postoperative fentanyl demand in 80 paediatric patients with cyanotic heart disease by administering ESP block at the T3 level to half of the patients. They found that intraoperative fentanyl demand was similar for the two groups while postoperative fentanyl demand was significantly reduced in the ESP group.[15] In a study by Karacaer *et al*., bilateral ESP block was performed in 20 out of 40 paediatric patients who underwent cardiac surgery with median sternotomy.[16] No block was applied to the control group. They reported that morphine demand was significantly reduced by providing effective analgaesia in the ESP block group. The current study found that tramadol demand decreased significantly in the ESP group in the postoperative 24-hour period.

Preemptive analgaesic methods provide more stable anaesthesia and reduce the need for intraoperative analgaesic medicines.[17] Elyazed *et al.* applied bilateral ESP in patients who had epigastric hernia surgery.[18] They reported less intraoperative fentanyl demand and less need for rescue analgaesia in the ESP group. In another study, they reduced intraoperative fentanyl demand by applying ESP block in patients undergoing cardiac surgery with cardiopulmonary bypass.[2]Similarly, in this study, ESP block application significantly reduced intraoperative fentanyl demand and it also significantly reduced the need for rescue analgaesia.

Another important parameter of the study was the comparison of VAS scores. Krishna *et al*. analysed the effects of ESP block on numerical rating scale (NRS) scores in patients who underwent cardiac surgery.[2] They reported that patients' NRS scores decreased significantly in the first 12 hours after the extubation in the ESP group. Nagaraja *et al*. divided 50 patients who would undergo cardiac surgery with median sternotomy into two groups as ESP group and the thoracic epidural group.[19] Catheters were inserted in both groups. They showed that there was no statistical difference in terms of VAS scores at rest and coughing in the first 12 hours. Although the VAS scores at rest and coughing were statistically lower in the epidural group in the following hours (24, 36, 48 h), they reported that the VAS score was ≤4 in both groups. In another study conducted on 67 patients who had open-heart surgery, a bilateral catheter was placed at the T4 level in patients in the ESP group. They examined the resting VAS values two hours after the removal of the postoperative chest tube and the resting VAS values one month after the operation, and they found significantly lower VAS values in the ESP group.[14] The current study evaluated the short-term VAS scores and found that patients' VAS scores in the first 18 hours were significantly lower and in favour of ESP. In addition, the study consisted of a homogeneous group of patients who underwent CABG and did not use a cardiopulmonary pump.

It is important to provide early extubation in patients undergoing cardiac surgery and to reduce the length of stay in the ICU. Studies comparing the duration of extubation and intensive care stay by applying ESP block in patients undergoing cardiac surgery are limited. Former studies reported that extubation and ICU length of stay decreased in the ESP group.[2,15] Krishna *et al*. applied ESP in adult patients who had cardiac surgery and reported that the extubation time was shortened and the length of stay in the ICU was reduced.[2] For patients undergoing on-pump cardiac surgery, the negative effects of cardiopulmonary pump such as complement activation, coagulation disorders, and platelet and leukocyte activation might prolong hospitalisation, and the length of stay in the ICU is longer as compared to off-pump cardiac surgery.[20] In this study, off-pump CABG surgery was performed and no significant difference was found between the two groups in terms of extubation time and length of stay in the ICU.

The main limitation of the current study was the low number of participants. These patients could not describe their pain until they were extubated, and their VAS scores could not be evaluated during this period. In addition, block formation could not be tested in all regions related to drug spread after ESP block application. The lack of a gold standard test to measure how far the local anaesthetic solution spread and data including only the postoperative 48-hour period are other limitations. Prospective, randomised and controlled studies involving more patients will be required. The strength of this study was that it consisted of a homogeneous patient group who underwent off-pump CABG surgery.

CONCLUSION

USG-guided preemptive ESP block application decreased postoperative pain scores in coronary artery bypass graft surgery patients. It was observed that a decrease in opioid demand in the intraoperative and postoperative periods. Preemptive ESP block can be used as an alternative analgaesia method in coronary artery bypass graft surgery.

DISCLOSURE:
The manuscript has been presented in IX. Abant Anestezi Sempozyumu (orally) 23-25 May 2022 Bolu/Turkiye.

ETHICAL APPROVAL:
This prospective, random study was approved by Turkiye-Bolu Abant Izzet Baysal University Clinical Research Ethics Committee (dated: 13.10.2020, Decision No: 2020/2043).

PATIENTS' CONSENT:
The invasive procedure to be performed was explained to the patients and their written consents were obtained.

COMPETING INTEREST:
All authors declared that there is no competing interest.

AUTHORS' CONTRIBUTION:
AD: Conception and design, drafting of the manuscript.
MB: Guidance and revision of the manuscript and critical analysis.
MT: Data analysis and collection.
ERU: Material preparation and literature search.
All authors approved the final version of the manuscript to be published.

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