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The effect of erector spinae plane block on arterial grafts in coronary artery bypass grafting

Koroner arter baypas greftlemede erektör spina plan blokunun arter greftlerine etkisi

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ABSTRACT

Background: This study aims to evaluate the sympathectomy effects of erector spinae plane block on the diameters and cross-sectional areas of the left and right internal mammary arteries and of the radial arteries.

Methods: This prospective study included a total of 25 patients (14 males, 11 females; median age: 67 years; range, 23 to 75 years) who underwent erector spinae plane block categorized as the American Society of Anesthesiologists Class III and underwent off-pump coronary artery bypass grafting between June 01, 2020 and March 01, 2021. The effects of erector spinae plane block on the diameters and cross-sectional areas of the left and right internal mammary arteries and radial arteries were assessed using ultrasonography images taken both before and 45 min after the procedure, from the third, fourth, and fifth intercostal spaces for the left and right internal mammary arteries and from 3 cm proximal to the wrist for the radial arteries.

Results: The diameters and cross-sectional areas of the left and right internal mammary arteries and radial arteries significantly increased compared to baseline values after the erector spinae plane block ($p<0.05$). There was no significant difference in the pre- and post-procedural heart rate and mean arterial pressure values ($p>0.05$).

Conclusion: The bilateral erector spinae plane block, which was performed at the T5 level, provided vasodilatation of the left and right internal mammary arteries and radial arteries without causing any significant difference in the heart rate and mean arterial pressure. These findings indicate that the sympathetic block produced by the erector spinae plane block may facilitate better surgical conditions by preventing arterial spasms. Thus, bilateral erector spinae plane block may be a promising technique to achieve regional anesthesia for off-pump coronary artery bypass grafting.

Keywords: Erector spinae plane block, left internal mammary artery, off-pump coronary artery bypass grafting, radial artery, right internal mammary artery; sympathectomy, vasodilatation.

ÖZ

Amaç: Bu çalışmada erektör spina plan blokunun sol ve sağ internal mamaryan arterlerin ve radial arterlerin çapı ve kesit alanı üzerine sempatektomi etkileri değerlendirildi.

Çalışma planı: Bu prospektif çalışmaya 01.06.2020 - 01.03.2021 tarihleri arasında off-pump koroner arter baypas greftleme yapılan ve Amerikan Anestezi Derneği Sınıf III olarak sınıflandırılan erektör spina plan bloku gerçekleştirilen toplam 25 hasta (14 erkek, 11 kadın; medyan yaş: 67 yıl; dağılım, 23-75 yıl) alındı. Sol ve sağ internal mamaryan arterler ve radial arterlerin çapı ve kesit alanı üzerine erektör spina plan blokunun etkileri, işlemden 45 dk. önce ve sonra sol ve sağ internal mamaryan arterler için üçüncü, dördüncü ve beşinci interkostal aralıktan ve radial arterler için el bileğinin 3 cm proksimalinden alınan ultrasonografi görüntüleri kullanılarak değerlendirildi.

Bulgular: Başlangıç değerlerine kıyasla, erektör spina plan blokundan sonra sol ve sağ internal mamaryan arterlerin ve radial arterlerin çapı ve kesit alanlarında anlamlı düzeyde artış izlendi ($p<0.05$). İşlem öncesi ve sonrası kalp hızı ve ortalama arteriyel basınç değerleri arasında anlamlı bir fark yoktu ($p>0.05$).

Sonuç: T5 seviyesinde uygulanan bilateral erektör spina plan bloku, kalp hızı ve ortalama arteriyel basınçta anlamlı bir farka yol açmaksızın, sol ve sağ internal mamaryan arterler ve radial arterlerde vazodilatasyona neden oldu. Bu bulgular, erektör spina plan bloku ile sağlanan sempatik blokun arteriyel spazmları önleyerek daha iyi cerrahi koşullar sağlayabileceğini göstermektedir. Bu nedenle, bilateral erektör spina plan bloku off-pump koroner arter baypas greftlemede rejyonel anesteziyi sağlamak için ümit verici bir teknik olabilir.

Anahtar sözcükler: Erektör spina plan blok, sol internal mamaryan arter, off-pump koroner arter baypas greftleme; radial arter, sağ internal mamaryan arter, sempatektomi, vazodilatasyon.

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Different regional anesthesia techniques, including fascial plane blocks, have been used to treat postoperative pain after cardiac surgery. Fascial plane blocks provide certain advantages such as ease of use, analgesic efficiency, and reduced risk of complications.[1] The erector spinae plane block (ESPB) procedure, one of the fascial plane block applications, was first introduced by Forero et al.[2] in 2016 for the management of chronic thoracic neuropathic pain and postoperative pain in thoracic surgery. It has also been used to treat postoperative pain following cardiac surgery.[3]

Off-pump coronary artery bypass grafting (OPCABG) surgery is a bypass technique administered on the beating heart. In general, the left internal mammary artery (LIMA), right internal mammary artery (RIMA), and left and right radial arteries (RAs) are selected for the anastomoses in OPCABG. One of the primary factors that increase surgical success is the prevention of arterial vasospasm, which occurs during the harvesting of vessels used in grafting.

In the present study, we aimed to evaluate the effects of sympathectomy in ESPB on the vascular diameter and cross-sectional areas of the LIMA, RIMA, and right and left RAs in patients undergoing OPCABG.

PATIENTS AND METHODS

This single-center, prospective study was conducted at Koç University Faculty of Medicine, Department of Anaesthesiology and Reanimation between June 01, 2020 and March 01, 2021. Patients aged 18 to 75 years who underwent elective OPCABG surgery and were classified as the American Society of Anesthesiologists (ASA) Physical Status Classification System III were included in this study. Exclusion criteria were having an allergy to a medication used in the treatment, chronic use of opioids or opioid receptor agonists, and inability to communicate or cooperate. Finally, a total of 25 patients (14 males, 11 females; median age: 67 years; range, 23 to 75 years) who met the inclusion criteria were recruited.

All patients were admitted to a preoperative holding area and performed the standardized monitoring procedure (electrocardiography measurements, pulse oximetry monitorization, and non-invasive blood pressure monitoring). All blocks and measurements were performed in the preoperative holding area. The images were taken via ultrasonography (USG) (GE Healthcare, Logic P 9 New York, USA) from the 3rd, 4th, and 5th intercostal spaces for the LIMA and RIMA, and from 3 cm proximal to the wrist for the right and left RAs (Figure 1). While the patient was in a sitting position, a high-frequency linear USG transducer was placed in a longitudinal position 3 cm lateral to the T5 spinous process. Three muscles were identified: trapezius, rhomboid major, and erector spinae. A 22-gauge, 80-mm block needle (B. Braun Stimuplex® Ultra 360®, Melsungen, Germany) was inserted in the cephalic direction from the caudad. Accurate local anesthetic distribution was demonstrated by the visible cauda-cranial spread of local anesthetics at the interfascial plane between the erector spinae muscle and transverse process. The ESPB was performed on both the right and left sides using 20 mL of 0.25% bupivacaine for each side. The heart rate (HR), mean arterial pressure (MAP), and peripheral oxygen saturation (SpO_2) values were recorded both before and 45 min after the ESPB procedure. The ESPB was performed by a single anesthesiologist with extensive experience in ESPB. Additionally, all USG measurements were performed by a single experienced investigator both before and 45 min after the ESPB procedure from the recorded arterial images. These images were, then, evaluated by two investigators who were blind to the patients. They measured the diameters and cross-sectional areas of relevant vessels and determined whether the images were recorded at pre- or post-ESPB period. The mean value of the measurements performed by the two investigators was used for the analyses.

Statistical analysis

The sample size was calculated using the Clicalc online (https://clincalc.com/). A pilot analysis with 10 patients revealed that the mean percent difference between pre- and postoperative measurements was 39.7±15.8. Final sample size calculations with the assumption that the actual difference should be

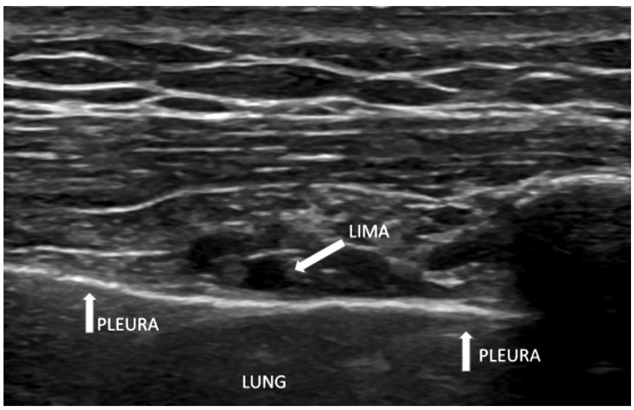

Figure 1. Ultrasonographic view of the left internal mammary artery.

Table 1. Hemodynamics parameters of patients

	Pre-ESPB	Post-ESPB	
	Mean±SD	Mean±SD	*p*
HR (bpm)	65.8±10.3	65.5±9.8	0.94
MAP (mmHg)	83.5±13.6	83.3±13.6	0.60

ESPB: Erector spinae plane block; SD: Standard deviation; HR: Heart rate; bpm: Beat per minute; MAP: Mean arterial pressure.

30% revealed that 21 patients would be adequate to achieve an 80% study power with a type 1 error of 5% and a two-sided hypothesis design. Accordingly, 25 patients were included in the study, four more than the minimum sample size of 21, taking into account that some patients may drop out from the study.

Statistical analysis was performed using the SPSS version 25.0 software (IBM Corp., Armonk, NY, USA). Descriptive data were expressed in mean ± standard deviation (SD), median (min-max) or number and frequency, where applicable. The Wilcoxon test was used to compare the continuous data between dependent groups. A *p* value of <0.05 was considered statistically significant.

RESULTS

The mean body mass index (BMI) was calculated as 28.2±3.3 (range, 25 to 34) kg/m^2. The hemodynamic characteristics of the patients are given in Table 1.

There was no significant difference between the patients' pre-ESPB and post-ESPB HR and MAP values (p>0.05 for both). The pre-ESPB and post-ESPB LIMA and RIMA measurements are given in Table 2. Both the LIMA diameter and the LIMA cross-sectional area measured at the third intercostal space significantly increased from 2.6 to 3 mm (p<0.001) and from 5.7 to 7.1 mm^2, respectively. The LIMA diameter and the LIMA cross-sectional area measured at the fourth and fifth intercostal spaces also significantly increased from 2.5 to 3 mm (p=0.001) and 4.7 to 6.8 mm^2 (p<0.001) and from 2.2 to 2.8 mm (p<0.001) and 4.3 to 5.8 mm^2 (p<0.001), respectively. Similarly, the diameter and area of RIMA also increased following the ESPB procedure. The RIMA diameter and area increased

Table 2. Pre-ESPB and post-ESPB measurements of LIMA and RIMA

	3rd intercostal space			4th intercostal space			5th intercostal space		
	Pre-ESPB	Post-ESPB		Pre-ESP	Post-ESPB		Pre-ESP	Post-ESPB	
	Mean±SD	Mean±SD	*p*	Mean±SD	Mean±SD	*p*	Mean±SD	Mean±SD	*p*
LIMA									
Diameter (mm)	2.6±0.4	3±0.3	<0.001	2.5±0.3	3±0.4	0.001	2.2±0.4	2.8±0.3	<0.001
Cross sectional area (mm^2)	5.7±1.5	7.1±1.3	0.001	4.7±1	6.8±1.5	<0.001	4.3±1.6	5.8±1.6	<0.001
RIMA									
Diameter (mm)	3±0.5	3.3±0.5	0.017	2.8±0.5	3.1±0.4	0.003	2.6±0.6	3±0.3	0.002
Cross sectional area (mm^2)	7.4±2.5	9.4±3.2	0.003	6.8±2.1	8±2.2	0.005	5.9±2.1	7.7±2.2	<0.001

ESPB: Erector spinae plane block; LIMA: Left internal mammary artery; RIMA: Right internal mammary artery; SD: Standard deviation.

Table 3. Pre-ESPB and post-ESPB measurements of left and right radial arteries

	Pre-ESPB	Post-ESPB	
	Mean±SD	Mean±SD	*p*
Left radial artery			
Diameter (mm)	2.9±0.5	3.6±0.5	<0.001
Cross sectional area (mm^2)	6.9±2.1	9.4±2.4	<0.001
Right radial artery			
Diameter (mm)	2.9±0.5	3.2±0.5	<0.001
Cross sectional area (mm^2)	6.6±2.1	8.4±2.5	<0.001

ESPB: Erector spinae plane block; SD: Standard deviation.

in all measurements whether measured at the third (3 to 3.3 mm, p=0.017, and 7.4 to 9.4 mm^2, p=0.003), fourth (2.8 to 3.1 mm, p=0.003, and 6.8 to 8 mm^2, p=0.005), or fifth (2.6 to 3 mm, p=0.002, and 5.9 to 7.7 mm^2, p<0.001) intercostal spaces (Table 2).

Post-ESPB measurements performed on the left and the right RAs also revealed significant increases compared to the pre-ESPB measurements. Accordingly, the left RA diameter and left RA area increased from 2.9 mm to 3.6 mm (p<0.001) and from 6.9 mm^2 to 9.4 mm^2 (p<0.001), respectively. Similarly, the right RA diameter and right RA area increased from 2.9 mm to 3.2 mm (p<0.001) and from 6.6 mm^2 to 8.4 mm^2 (p<0.001), respectively (Table 3).

DISCUSSION

Inadequate pain management following coronary artery bypass grafting (CABG) may result in adverse hemodynamic effects, delayed recovery and prolonged hospitalization, chronic pain, and decreased patient satisfaction.[4] A relatively new approach to control pain in cardiac surgeries is the ESPB. In ESPB, the anesthetic agent is administered between the two superficial erector spinae muscles. Analgesic efficacy of ESPB following cardiac surgery has been demonstrated.[2-6] However, there is some controversy over the mechanism of action of ESPB.[5] The ESPB provides a blockade of dorsal and ventral rami of the thoracic spinal nerves and sympathetic nerve fibers.[7] In this way, ESPB is expected to provide successful pain control and cause vasodilation on the vessels used in the OPCABG procedure via sympathetic block. In our study comparison of the diameters and cross-sectional areas of these vessels before and after the ESPB procedure have indicated that ESPB has, indeed, a statistically significant beneficial vasodilator effect on the LIMA, RIMA, and left and right RAs. Sympathectomy in patients with refractory angina has been shown to be an effective method for pain relief, and several mechanisms have been proposed for its mechanism of action.[8] Coronary arteries have both sympathetic and parasympathetic innervation. The parasympathetic system dilates the vessels; on the other hand, sympathetic stimuli cause vasoconstriction over the alpha (α)-adrenergic system and vasodilation over beta (β)-adrenergic activation.[9] It has been demonstrated that the cardiac sympathetic block at the T1-5 level directly dilates the stenotic coronary arteries, thereby exerting anti-ischemic effects.[10] These mechanisms have suggested that thoracic blockade in ESPB may also provide sympathectomy, providing a beneficial vasodilator effect in cardiac surgeries. All vessels evaluated in this study were dilated significantly after ESPB administration, supportive of the aforementioned hypothesis.

Arterial grafts are primarily used for myocardial revascularization.[4] The LIMA and RA are the most commonly preferred arterial grafts for revascularization. The main drawback of arterial ducts is perioperative graft spasm. The exact mechanism of perioperative graft spasm is not clear. Endothelial damage, changes in temperature, local manipulation of the artery, and release of vasoconstrictor substances have been blamed for its pathogenesis.[11] In the early postoperative period, natural coronary artery spasm may occur due to systemic hypothermia, α-adrenergic activity, endothelial dysfunction, increased blood pH, local manipulation of the artery, increased platelet activity, the release of vasoconstrictor substances and histamine, and increased plasma vasopressin and potassium levels.[9] The LIMA is less prone to spasm, as its medial layer thickness is less than that of RA's.[12] During the perioperative period, different medications, such as calcium channel blockers, papaverine, and nitrates, have been used in the management of arterial vasospasm. The ESPB, which has been recently used for postoperative pain, may also play an important role in the management of arterial vasospasm. Prevention of arterial graft occlusion may contribute to the success of the surgery.

Yildirim et al.[13] demonstrated that preemptive satellite ganglion block increases the RA blood flow and prevents RA spasm, thereby improving the surgical outcomes in patients undergoing CABG. A significant increase in the RA blood flow was demonstrated with the use of a pulsed-wave Doppler USG blood flow meter, which was attributed to the cervical sympathetic block. Measurements of the diameters of LIMA, RIMA, right and left RAs by USG in this study indicated an increase in all arterial diameters following ESPB, supporting the mechanism suggested by Yildirim et al.[13] on vessel diameters.

The ESPB has been suggested as an alternative approach to thoracic epidural anesthesia (TEA).[14] The effectiveness of ESPB has been evaluated in various types of surgeries, including thoracic wall surgeries, and favorable outcomes were reported with no exception. In parallel, ESPB has been increasingly used as a regional anesthesia technique in cardiac surgeries, leading to promising results.[15] The evidence available on the effect of ESPB is predominantly about the pain control aspect.[5,16,17] To the best of our knowledge, this is the first study to evaluate the effect of ESPB on vessel dynamics and show that the vessels used for the OPCABG procedure are significantly dilated.

In the current study, we anticipated that cardiac sympathetic inhibition and systemic hypotension would occur after sufficient sympathectomy was performed to dilate the RA. In contrast, there was no statistically significant change in the systemic blood pressure values. The main reason may be that the low concentration and low volume of the local anesthetic resulted in its diffusion only to limited levels of the paravertebral space, thereby reducing the blockage of cardiac sympathetic fibers.

Sympathetic block has been shown to have a similar positive effect following the use of TEA, which is also known to have favorable hemodynamic effects, including increased coronary perfusion.[18-20] The TEA provides coronary vasodilatation and internal thoracic arterial dilatation and decreases the incidence of arrhythmias both during intraoperative cardiac manipulations and postoperative periods.[21,22] These favorable effects of TEA make it an ideal approach for OPCABG procedures.[23] The most feared complication of TEA is epidural hematoma, which is the primary reason for its limited use in cardiac surgery.[19] Compared to TEA, the absence of potential epidural hematoma complications makes ESPB a good option for cardiac surgery patients. In line with the evidence available in the literature, the findings of this study indicate that ESPB is a promising option for use in beating-heart surgeries.

One of the limitations of this study is that the actual LIMA, RIMA, and right and left RA blood flows were not measured. Second, the diameters of the anastomoses were not measured in the postoperative period. Additionally, the duration of the vasodilator effect of ESPB was not been examined. The analgesic effect of ESPB was beyond the scope of this study and, therefore, it was not recorded.

In conclusion, this is the first study to evaluate the effects of erector spinae plane block on vascular dynamics in patients undergoing elective off-pump coronary artery bypass grafting. The results of this study indicate that erector spinae plane block has a significant vasodilator effect in arterial grafts, which is a preferred result for anastomosis in coronary artery bypass grafting. As the next step, further randomized-controlled studies can be carried out on the sympathectomy effect of erector spinae plane block, which is usually used for postoperative pain.

Ethics Committee Approval: The study protocol was approved by the Koç University Faculty of Medicine ethical committee (date: 13.02.2020, approval number 2020.056. IRB1.013). The clinical trial registration for the study was obtained through the following website of clinicaltrials.gov on June 1st, 2020 (registration number NCT04447560 and Unique Protocol ID: ESPCVS01). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Patient Consent for Publication: A written informed consent was obtained from each patient.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Idea/concept, writing the article, references and fundings, analysis and/or interpretation: K.D.; Design: K.D., M.A.K.; Control/supervision: Y.G., A.K.; Data collection and/or processing: Y.Y., K.D., M.Ş.A.; Literature review: S.Ç.; Critical review: K.D., M.A.K.

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