Ultrasound-guided erector spinae plane block for postoperative analgesia in patients undergoing minimally invasive direct coronary artery bypass surgery: a double-blinded randomized controlled trial

Bloc échoguidé du plan des muscles érecteurs du rachis pour l'analgésie postopératoire des patient·es bénéficiant d'une chirurgie minimalement invasive de pontage aortocoronarien direct : une étude randomisée contrôlée à double insu

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Abstract

Purpose *Minimally invasive direct coronary artery bypass (MIDCAB) surgery is associated with significant postoperative pain. We aimed to investigate the efficacy of ultrasound-guided erector spinae plane block (ESPB) for analgesia after MIDCAB.*

Methods *We conducted randomized controlled trial in 60 patients undergoing MIDCAB who received either a single-shot ESPB with 30 mL of ropivacaine 0.5% (ESPB group, n = 30) or normal saline 0.9% (control group, n = 30). The primary outcome was numerical rating scale (NRS) pain scores at rest within 48 hr postoperatively. The secondary outcomes included postoperative NRS pain scores on deep inspiration within 48 hr, hydromorphone consumption, and quality of recovery-15 (QoR-15) score at 24 and 48 hr.*

Results *Compared with the control group, the ESPB group had lower NRS pain scores at rest at 6 hr (estimated mean difference, –2.1; 99% confidence interval [CI], –2.7 to –1.5; P < 0.001), 12 hr (–1.9; 99% CI, –2.6 to –1.2; P < 0.001), and 18 hr (–1.2; 99% CI, –1.8 to –0.6; P < 0.001) after surgery. The ESPB group also showed lower pain scores on deep inspiration at 6 hr (–2.9; 99% CI, –3.6 to –2.1; P < 0.001), 12 hr (–2.3; 99% CI, –3.1 to –1.5; P < 0.001), and 18 hr (–1.0; 99% CI, –1.8 to –0.2; P = 0.01) postoperatively. Patients in the ESPB group had lower total intraoperative fentanyl use, lower 24-hr hydromorphone consumption, a shorter time to extubation, and a shorter time to intensive care unit (ICU) discharge.*

Conclusion *Erector spinae plane block provided early effective postoperative analgesia and reduced opioid consumption, time to extubation, and ICU discharge in patients undergoing MIDCAB.*

Trial registration *www.chictr.org.cn (ChiCTR2100052810); registered 5 November 2021.*

Résumé

Objectif *La chirurgie minimalement invasive de pontage aortocoronarien direct (MIDCAB) est associée à une douleur postopératoire importante. Notre objectif était d'étudier l'efficacité du bloc échoguidé du plan des muscles érecteurs du rachis (ESPB) pour l'analgésie après une MIDCAB.*

Méthode *Nous avons réalisé une étude randomisée contrôlée chez 60 patient·es bénéficiant d'une MIDCAB et ayant reçu soit une dose unique d'ESPB avec 30 mL de ropivacaïne à 0,5 % (groupe ESPB, n = 30), soit une solution de normal salin à 0,9 % (groupe témoin, n = 30). Le critère d'évaluation principal était les scores de douleur au repos sur l'échelle d'évaluation numérique (EEN) dans*

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les 48 heures postopératoires. Les critères d'évaluation secondaires comprenaient les scores de douleur postopératoires sur l'EEN en inspiration profonde dans les 48 heures, la consommation d'hydromorphone et le score de qualité de la récupération 15 (QoR-15) à 24 et 48 heures.

Résultats *Par rapport au groupe témoin, le groupe ESPB avait des scores de douleur au repos sur l'EEN plus faibles à 6 heures (différence moyenne estimée, −2,1; intervalle de confiance [IC] à 99 %, −2,7 à −1,5; P < 0,001), 12 h (−1,9; IC 99 %, −2,6 à −1,2; P < 0,001) et 18 h (−1,2; IC à 99 %, −1,8 à −0,6; P < 0,001) après la chirurgie. Le groupe ESPB a également affiché des scores de douleur plus faibles en inspiration profonde à 6 heures (−2,9; IC à 99 %, −3,6 à −2,1; P < 0,001), 12 h (−2,3; IC à 99 %, −3,1 à −1,5; P < 0,001) et 18 h (−1,0; IC à 99 %, −1,8 à −0,2; P = 0,01) postopératoire. Les patient·es du groupe ESPB avaient une consommation totale de fentanyl peropératoire plus faible, une consommation d'hydromorphone plus faible sur 24 heures, un délai d'extubation plus court et un délai plus court jusqu'au congé de l'unité de soins intensifs (USI).*

Conclusion *Le bloc du plan des muscles érecteurs du rachis a fourni une analgésie postopératoire rapide et efficace et une réduction de la consommation d'opioïdes, du délai d'extubation et du congé de l'unité de soins intensifs chez les patient·es bénéficiant d'une MIDCAB.*

Enregistrement de l'étude *www.chictr.org.cn (ChiCTR2100052810); enregistré le 5 novembre 2021.*

Minimally invasive direct coronary artery bypass (MIDCAB) surgery through an anterior-lateral mini-thoracotomy approach has become more common through the evolution of hybrid coronary revascularization with smaller skin incision compared with conventional midline sternotomy coronary artery bypass surgery.[1,2] This less-invasive approach aims to achieve early extubation, early mobilization, and rapid patient recovery with possibly no increased morbidity or mortality.[3] Nevertheless, it can still result in substantial acute pain after surgery.[4] A possible explanation for this pain is the intercostal nerve damage caused by thoracotomy, rib spreader, and placement of chest tubes. Poorly controlled acute pain may interfere with normal breathing and lead to severe postoperative pulmonary complications, extended intensive care unit (ICU) length of stay, and extended hospital length of stay.[5,6] Moreover,

severe postoperative acute pain has been correlated with persistent postsurgical pain, which could affect the patient's quality of life.[7] Therefore, finding the optimum method for postoperative analgesia is of critical importance in patients undergoing MIDCAB.

Cardiac anesthesia has been based on high doses of opioids, to provide hemodynamic stability and adequate analgesia. Nevertheless, nausea and vomiting, urinary retention, respiratory depression, and other unwanted side effects may impede patient recovery.[8] Although regional nerve blocks have been introduced as part of multimodal analgesia in many surgical settings, techniques such as thoracic epidural analgesia and paravertebral block are not routinely performed in cardiac surgery because of the need for heparinization, which may potentially increase the risk of serious bleeding or hematoma.[9] Therefore, ultrasound-guided superficial interfascial plane blocks may be a possible alternative.[10]

Erector spinae plane blocks (ESPBs) are used in a variety of surgical settings and have been proven to reduce postoperative pain and improve quality of recovery.[11–14] Nevertheless, to our knowledge, no randomized controlled trials (RCTs) have investigated the analgesic effects of ESPB in MIDCAB. The impact of ESPB on patient recovery remains unknown. We therefore hypothesized that ultrasound-guided ESPB could provide short-term analgesic benefits compared with placebo in patients undergoing MIDCAB.

Methods

Study design and population

The Review Board of Peking University People's Hospital approved the study protocol (No. 2021PHB237-001). We prospectively registered the study prior to patient enrolment at the Chinese Clinical Trials Registry (ChiCTR2100052810)[A] on 5 November 2021. This study was performed in accordance with the Helsinki Declaration and the manuscript follows the guidelines of Consolidated Standards of Reporting Trials (CONSORT). Written informed consent was obtained from patients before participation in the study. The patients were allowed to withdraw their consent and cease participation in the study at any time.

The inclusion criteria were patients from 18 to 75 yr of either sex who were scheduled for MIDCAB. The exclusion criteria were a New York Heart Association functional classification of IV, a preoperative ejection

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fraction of $< 40\%$, a body mass index of < 18 or > 35 kg·m^{-2}, redo or emergency cases, coagulopathy, localized infection at the block site, allergy or intolerance to local anesthetics, hepatic or renal insufficiency, diagnosed mental disorder, history of chronic pain conditions requiring regular opioids, and refusal to participate.

After provision of written informed consent, 60 participants were enrolled in the study between November 2021 and June 2022.

Randomization and blinding

Randomization was conducted in a 1:1 ratio according to computer-generated randomized numbers. A nurse anesthetist who had no involvement in the collection of perioperative data or statistical analysis performed the randomization and sealed the group assignments in sequentially numbered opaque envelopes. The envelope was opened by the nurse anesthetist one hour before surgery and then a 30-mL syringe of the study medication was prepared according to the allocation number in the envelope. The patients randomly allocated to the ESPB group received 0.5% ropivacaine, whereas the control group received 0.9% normal saline. Both syringes were identical and labelled as "study medication" to ensure blinding. All patients, anesthesiologists who performed the block and provided patient care, nursing staff, cardiac surgeons, and investigators were unaware of the group allocations.

Interventions

All the ESPBs were performed by the same experienced attending anesthesiologist before general anesthesia induction. The patient was set in the right lateral position under sedation by *iv* midazolam (1–2 mg). After aseptic preparation of the skin area with chlorhexidine gluconate, a low-frequency linear transducer (Logiq™ *e*, GE HealthCare, Chicago, IL, USA) in a sterile cover was placed in the paramedian sagittal plane at the T5 level, approximately 2–3 cm lateral to the posterior midline. Then, the probe was adjusted to visualize the transverse process with acoustic shadow and the erector spinae muscle above it. A block needle (22G, 100 mm, Plexufix®, B. Braun SE, Melsungen, Germany) was then introduced from the cephalad to caudad under local anesthetic infiltration using the in-plane technique. The needle target was the interfascial space between the transverse process and erector spinae muscle. The correct placement of the needle tip was verified by 1–2 mL 0.9% saline, which was confirmed as interfascial spread of injectate lifting the erector spinae muscle. Then, 30 mL of 0.5% ropivacaine or 0.9% normal saline was injected.

Perioperative management

Patients were monitored with 5-lead electrocardiogram, pulse oxygen saturation, and invasive blood pressure monitoring. General anesthesia induction included a combination of *iv* midazolam (0.03–0.05 mg·kg^{-1}), etomidate (0.15–0.2 mg·kg^{-1}), cis-atracurium (0.15–0.2 mg·kg^{-1}), and fentanyl (3–5 μg·kg^{-1}). Then, a left-side double-lumen tube with appropriate size was inserted. After induction, a 7-Fr central venous catheter with triple-lumen was placed under ultrasound guidance. Propofol (3–5 mg·kg^{-1}·hr^{-1}), cisatracurium (0.1–0.2 mg·kg^{-1}·hr^{-1}), and dexmedetomidine (0.5–0.8 μg·kg^{-1}·hr^{-1}) were used for anesthesia maintenance to achieve a bispectral index between 40 and 60. In case of hypertension (defined as a blood pressure > 20% of baseline value), the anesthesia depth of the patient was checked, then propofol infusion rate was adjusted and/or fentanyl boluses (1–2 μg·kg^{-1}) were administered by the attending anesthesiologist. A phenylephrine or dopamine bolus and/or infusion was used if the blood pressure was < 20% of the baseline value though decreasing propofol infusion rate or fluid volume loading was applied. No other opioids except fentanyl were used during surgery. The anesthesiologists who provided intraoperative care were not otherwise involved in the data collection for this study.

All *iv* anesthetic infusions were stopped once surgery was completed, and the patient was transferred to the cardiac ICU. The medical staff in the ICU performed extubation once the patient fulfilled weaning criteria. No analgesic infusions were administered in the cardiac ICU until the patient was extubated.

Patient-controlled analgesia (PCA) with *iv* hydromorphone was prescribed with no basal infusion and an intermittent bolus dose of 0.2 mg and a lock-out period of ten minutes. Intravenous tropisetron 5 mg was given to all patients after completion of surgery. After being transferred to the ward, further analgesic treatment with oxycodone and acetaminophen was prescribed if necessary.

Surgical procedure

The same cardiac surgical team performed all the procedures. Thoracotomy was performed with the patient positioned supine and the left shoulder elevated at 30°, then a 5–6-cm curvilinear incision was performed between the fourth and fifth ribs on the left anterolateral chest wall. The internal mammary artery was obtained using a retractor system via direct vision. With the employment of Octopus® Nuvo Tissue Stabilizer (Medtronic, Dublin, Ireland) and Starfish™ NS Heart Positioner (Medtronic, Dublin, Ireland) to achieve stabilization, the anastomosis between the distal graft and the target vessel was performed on the beating heart.[15]

Outcomes

Our primary outcome was the numerical rating scale (NRS) pain scores at rest within 48 hr postoperatively (i.e., after skin closure; assessed at six hours, 12 hr [used for sample size calculation; cf. *Statistical analysis* below], 18 hr, 24 hr, and 48 hr). The secondary outcomes were NRS pain scores on deep inspiration at the same time points after skin closure, postoperative hydromorphone consumption, and quality of recovery-15 (QoR-15) scores at 24 hr and 48 hr after surgery. Other outcomes included total fentanyl use, time to tracheal extubation and chest tube removal after surgery, ICU length of stay, and time to hospital discharge. Adverse events including postoperative nausea and vomiting (PONV), atrial fibrillation, pleural effusion, pericarditis, and block-related complications such as hematoma, pneumothorax, infection, and 30-day mortality were recorded.

The magnitude of postoperative pain was evaluated at six hours, 12 hr, 18 hr, 24 hr, and 48 hr by a follow-up investigator who was blinded to the study group allocations using the NRS score (0 = no pain, while 10 = worst pain ever). Analgesic consumption and the QoR-15 score were collected at 24 hr and 48 hr after surgery. We used the Chinese version of the QoR-15 questionnaire as a patient-centred measurement of recovery quality. This questionnaire contains the following domains: physical comfort and independence, pain, psychological state, and emotional state.[16] A QoR-15 score of 0 represents poor recovery while a score of 150 represents excellent recovery. Adverse events, postoperative complications, and patient progression were traced by visiting the patients daily or reviewing electronic medical records during their entire hospital stay. A telephone interview was performed at one month after surgery to assess 30-day mortality.

Statistical analysis

The sample size was calculated with PASS power analysis and sample size software (NCSS LLC., Kaysville, UT, USA). Based on results from a pilot study of ten patients, the mean and standard deviation (SD) of postoperative NRS scores at 12 hr in patients using *iv* hydromorphone PCA were 3.7 and 1.9, respectively. Thus, to identify a relevant clinical difference of 1.5 in the NRS score with a two-sided 5% significance level, 23 patients were calculated in each group to have 90% power using a repeated measures analysis of variance (ANOVA) method with five observations on the same subject. Autocorrelation between repeated observations on each subject was assumed to be 0.6. Considering possible dropouts, we increased the sample size to 30 patients for each study group.

Statistical analysis was performed using IBM SPSS Statistics for Windows version 24.0 (IBM Corp., Armonk, NY, USA). Before analysis, the Shapiro–Wilk test was employed to analyze the normality of data distribution. Continuous data are presented as mean (SD) or median [interquartile range (IQR)]. Dichotomous and polytomous data are presented as counts and percentages. For NRS scores, between-group differences at all time points after surgery were analyzed using two-way repeated measures ANOVA with Bonferroni correction. Confidence intervals (CIs) and *P* values are reported after Bonferroni adjustment for the 5-time comparisons, so are presented as 99% CIs. For the other outcomes, the Mann–Whitney *U* test or independent samples *t* test was adopted to compare continuous variables. Categorical data were analyzed by the Chi square or Fisher's exact test when necessary. All *P* values were two sided and an adjusted *P* value less than 0.05 was considered statistically significant for the primary outcomes. For secondary outcomes, a $P < 0.05$ was considered significant.

Results

Seventy-one patients were initially screened for eligibility from November 2021 to June 2022. Ten patients did not fit the inclusion criteria and one refused to participate. Finally, data of 60 patients were collected (Fig. 1). Table 1 shows the baseline characteristics and perioperative data for the two study groups.

For NRS scores, repeated measures ANOVA showed significant interaction between treatment groups and time both at rest and on deep inspiration (both $P < 0.001$). Patients in the ESPB group reported lower NRS pain scores at rest than the control group at six hours, 12 hr, and 18 hr postoperatively (Table 2, Fig. 2A). Numerical rating scale pain scores on deep inspiration were also lower in the ESPB group at six hours, 12 hr, and 18 hr (Table 2, Fig. 2B). There were no statistical differences between groups in NRS scores at rest and on deep inspiration at 24 hr and 48 hr .

Compared with placebo, cumulative hydromorphone consumption at 24 hr and total intraoperative fentanyl use were significantly reduced by ESPB ($P = 0.04$ and $P = 0.004$, respectively; Table 2). Patients in the ESPB group also had a shorter time to tracheal extubation and ICU discharge. We observed a lower incidence of PONV on postoperative day 1 in the ESPB group than in the control group ($P = 0.001$).

We did not find any statistically significant differences between the groups regarding PCA hydromorphone consumption at 48 hr, QoR-15 scores, time to chest tube removal, and hospital discharge (Table 2). The rate of
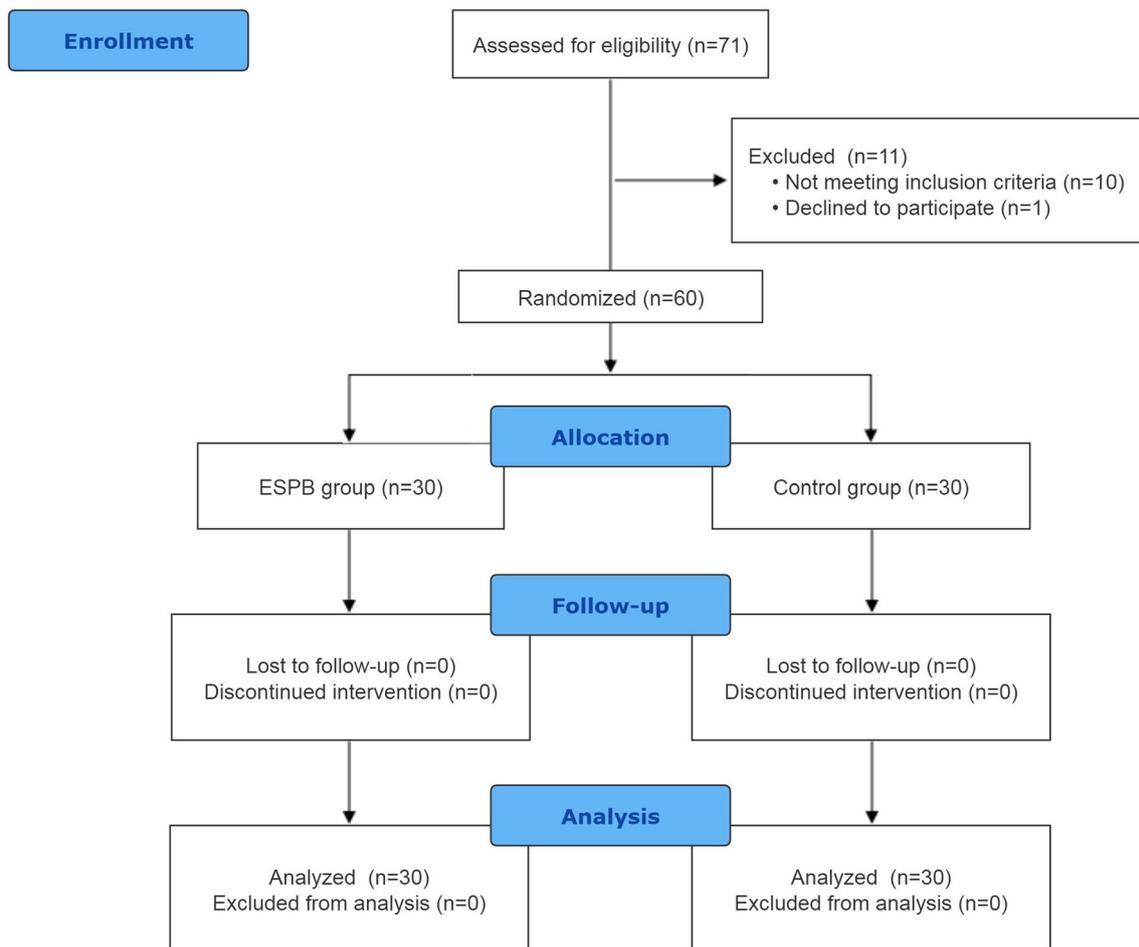
Fig. 1 Consolidated standards of reporting trials (CONSORT) flowchart of the study
ESPB = erector spinae plane block

adverse events was low and comparable between the two groups with no block-related complications reported. No participants died within 30 days.

Discussion

In this double-blind RCT, we found that a single-shot ESPB reduced NRS scores at rest and on deep inspiration during the first 18 hr after MIDCAB compared with saline placebo. Erector spinae plane blockade also significantly reduced perioperative opioid consumption, time to tracheal extubation, and time to ICU discharge. Our findings indicate that ESPB may be an effective approach to provide early analgesia in MIDCAB surgery.

A sensory blockade of thoracic intercostal nerves could provide pain relief for anterolateral incision of the chest wall. Nevertheless, multiple intercostal nerve block injections may be required to cover the extensive surgical field.[17] Furthermore, the coagulation issues associated with

thoracic epidural analgesia and paravertebral block make them a less preferred choice in cardiovascular surgeries. Thus, the ease of performance, real-time visualization under ultrasound-guidance, and decreased risk of hematoma and local anesthetic toxicity makes ESPB a reasonable alternative for analgesia after MIDCAB.

An RCT by Fiorelli et al. compared single-shot ESPB with intercostal nerve block in patients undergoing mini-thoracotomy.[18] The static and dynamic NRS scores were significantly lower in the ESPB group than the intercostal nerve block group at all time points in the 48-hr follow-up period. Nevertheless, differences between both resting and dynamic NRS scores in our study start to become nonsignificant after 18 hr. The difference in our findings may be attributed to different procedures (lung resection vs MIDCAB) or to the higher concentration of local anesthetic (ropivacaine 0.75%) used by Fiorelli et al. compared with ropivacaine 0.5% used in our study.

Continuous infusion or intermittent bolus of ESPB through a catheter has been reported in several studies.[19–21]

Table 1 Patient characteristics and intraoperative data

	ESPB group N = 30	Control group N = 30
Age (yr), mean (SD)	61 (6)	60 (11)
Females, n/total N (%)	7/30 (23%)	6/30 (20%)
Height (cm), mean (SD)	168 (6)	168 (6)
Weight (kg), mean (SD)	72 (10)	73 (11)
BMI (kg·m^{-2}), mean (SD)	25.4 (3.2)	25.9 (2.7)
EF (%), median [IQR]	64.8 [61.3–69.8]	64.0 [58.8–68.5]
NYHA classification, n/total N (%)		
I	10/30 (33%)	8/30 (27%)
II	12/30 (40%)	17/30 (57%)
III	8/30 (27%)	5/30 (17%)
Acute myocardial infarction < 90 days, n/total N (%)	6/30 (20%)	3/30 (10%)
Duration of OLV (min), median [IQR]	142 [116–178]	138 [123–189]
Duration of surgery (min), median [IQR]	173 [145–224]	172 [158–212]
Duration of anesthesia (min), median [IQR]	250 [215–281]	249 [222–299]
Intraoperative infusion volume (mL), mean (SD)	1,930 (382)	1,803 (510)
Blood loss (mL), median [IQR]	100 [100–300]	100 [100–200]
Urine output (mL), median [IQR]	300 [238–800]	350 [250–512]

Data are displayed as mean (SD), median [IQR], or n/total N (%)

BMI = body mass index; EF = ejection fraction; ESPB = erector spinae plane block; IQR = interquartile range; NYHA = New York Heart Association; OLV = one-lung ventilation; SD = standard deviation

Duration of analgesia after a single-shot ESPB may depend on the concentration and absorption of the local anesthetics, but can be prolonged with a catheter.[22] Moreover, the use of intermittent bolus administration of local anesthetics may achieve better analgesia than a continuous infusion.[23] On the other hand, the catheter technique is more resource intensive.[21] The ESPB catheter is a relatively new technique and we do not have much experience with it in our centre; therefore, we adopted a single-shot ESPB in this study.[24]

In cardiac surgery, the use of multimodal analgesia may reduce opioid use. A previous work showed that intraoperative opioid consumption was inversely associated with the number of interventions used perioperatively. In particular, dexmedetomidine, regional analgesia, and preoperative gabapentin were independent factors associated with low opioid administration.[25] We used intraoperative dexmedetomidine and regional nerve blockade in our study to reduce opioid use.

In a before-and-after study, opioid-sparing analgesia with continuous ESPB decreased perioperative opioid consumption in open cardiac surgery with a fast-track recovery protocol.[26] Median [IQR] morphine consumption in the initial 48 hr after surgery was 0 [0–0] mg in patients receiving an ESPB. Unfortunately, an enhanced recovery program has not been applied for cardiac surgery in our centre. In addition, this outcome could be influenced by variability in patient compliance, different surgical types, or other unmeasured confounders.

Borys *et al.* compared single-shot ESPB with no block in patients undergoing mitral and/or tricuspid valve repair via right mini-thoracotomy.[27] Similar to our study, fewer days in the ICU were observed in the ESPB group. Nevertheless, they did not find a statistically significant difference in total postoperative oxycodone use during the first 24 hr period between the ESPB and the control group.

Our study has several limitations. First, we did not test the dermatomal distribution of ESPB by thermal or pinprick testing to avoid unblinding of the study personnel. Nevertheless, there are still controversies on the ESPB mechanisms of action and anatomical spread. A study of healthy volunteers has suggested that the ventral branches of spinal nerves were not blocked.[28] A recent magnetic resonance imaging study has also shown that the injectate spread to the paravertebral space and the sympathetic chain was highly variable.[29] Second, as a relatively novel block, the optimal dosing regimens of ESPB have not been established. The literature describes volumes from 20 to 30 mL. We chose a high concentration of ropivacaine 0.5% with a volume of 30 mL to provide adequate block effect. In the present study, patients in ESPB group did not present significant hypotension or bradycardia, which suggests that using a high concentration of ropivacaine is not a major risk in those patients.

Table 2 Primary and secondary outcomes

	ESPB group N = 30	Control group N = 30	Difference in means (99% CI)	P value
Primary outcomes				
Rest NRS pain score at 6 hr, mean (SD)	1.2 (0.8)	3.3 (1.3)	−2.1 (−2.7 to −1.5)	< 0.001[a]
Rest NRS pain score at 12 hr, mean (SD)	1.2 (1.3)	3.1 (1.5)	−1.9 (−2.6 to −1.2)	< 0.001[a]
Rest NRS pain score at 18 hr, mean (SD)	1.4 (0.9)	2.5 (1.3)	−1.2 (−1.8 to −0.6)	< 0.001[a]
Rest NRS pain score at 24 hr, mean (SD)	1.7 (0.8)	2.0 (1.0)	−0.3 (−0.8 to 0.2)	0.21[a]
Rest NRS pain score at 48 hr, mean (SD)	1.7 (0.7)	1.8 (0.8)	−0.1 (−0.5 to 0.3)	0.62[a]
Secondary outcomes				
Inspiration NRS pain score at 6 hr, mean (SD)	2.4 (1.2)	5.3 (1.7)	−2.9 (−3.6 to −2.1)	< 0.001[a]
Inspiration NRS pain score at 12 hr, mean (SD)	2.9 (1.3)	5.2 (1.8)	−2.3 (−3.1 to −1.5)	< 0.001[a]
Inspiration NRS pain score at 18 hr, mean (SD)	3.1 (1.2)	4.1 (1.8)	−1.0 (−1.8 to −0.2)	0.01[a]
Inspiration NRS pain score at 24 hr, mean (SD)	2.8 (1.0)	3.2 (1.6)	−0.4 (−1.1 to 0.3)	0.25[a]
Inspiration NRS pain score at 48 hr, mean (SD)	2.7 (1.1)	3.1 (1.3)	−0.4 (−1.0 to 0.2)	0.21[a]
			Difference in means (95% CI)	
QoR-15 score at 24 hr, mean (SD)	110 (15)	108 (20)	3 (−6 to 12)	0.57[b]
QoR-15 score at 48 hr, mean (SD)	118 (19)	110 (19)	8 (−2 to 18)	0.12[b]
			Difference in medians (95% CI)	
Cumulative hydromorphone consumption at 24 hr (mg), median [IQR]	1.6 [0.8–2.6]	2.3 [1.4–6.3]	−1.0 (−3.0 to −0.1)	0.04[c]
Cumulative hydromorphone consumption at 48 hr (mg), median [IQR]	3.0 [1.8–4.5]	4.9 [2.1–10.7]	−1.6 (−4.0 to 0.0)	0.06[c]
Total fentanyl use (μg), median [IQR]	400 [300–525]	625 [400–800]	−200 (−300 to −50)	0.004[c]
Extubation time (hr), median [IQR]	2.0 [0.0–3.6]	3.8 [1.0–6.0]	−1.0 (−3.0 to 0.0)	0.05[c]
Time to chest tube removal (days), median [IQR]	3 [3, 4]	3 [3–3]	0 (0 to 0)	0.32[c]
ICU length of stay (hr), median [IQR]	21.0 [12.0–22.2]	23.0 [21.0–34.0]	−4.5 (−16.0 to −1.0)	0.005[c]
Hospital discharge time (days), median [IQR]	7 [7, 8]	7 [6–8]	0 (0 to 1)	0.71[c]
			Relative risk (95% CI)	
PONV on POD 1, *n*/total *N* (%)	0/30 (0%)	10/30 (33%)	–	0.001[d]
PONV on POD 2, *n*/total *N* (%)	0/30 (0%)	3/30 (10%)	–	0.24[d]
Occurrence of postoperative complication, *n*/total *N* (%)	3/30 (10%)	3/30 (10%)	1.0 (0.22 to 4.6)	1.0[e]

Data are displayed as mean (SD), median [IQR], or *n*/total *N* (%). Effect sizes are presented as the difference in means (99% or 95% CI), the Hodges–Lehmann estimation of difference in medians (Hodges–Lehmann 95% CI), or relative risk (95% CI). Differences are (ESPB group – control group); relative risks are for ESPB group relative to control group

[a]Two-way repeated measures ANOVA with Bonferroni correction

[b]Independent *t* test

[c]Mann–Whitney U test

[d]Chi square test

[e]Fisher's exact test

ANOVA = analysis of variance; CI = confidence interval; ESPB = erector spinae plane block; ICU = intensive care unit; IQR = interquartile range; NRS = numerical rating scale; POD = postoperative day; PONV = postoperative nausea and vomiting; QoR = quality of recovery; SD = standard deviation

Third, preoperative gabapentin and nonsteroidal anti-inflammatory drugs such as acetaminophen and ketorolac have been used as supplements to reduce opioid consumption after cardiac surgery.[30,31] Nevertheless, those medications are not routinely used in cardiac surgery in our centre. Although this study does not reflect the current standard practice of multimodal analgesia, it actually allows the investigators to tease out a more accurate estimate of the analgesic effect of ESPB in MIDCAB. Fourth, the anesthesiologists providing
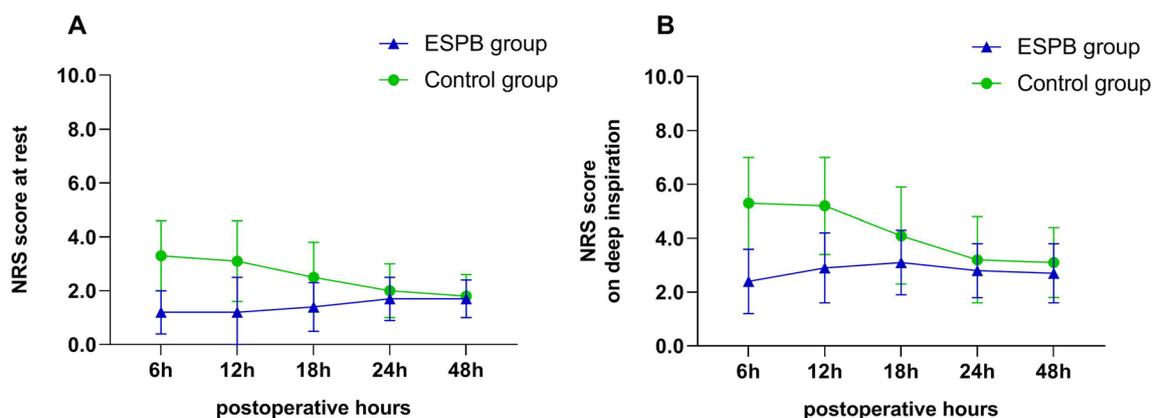
Fig. 2 Numerical rating scale pain scores at rest (A) and on deep inspiration (B) during 48 hr after skin closure. There was a significant time-by-group interaction at rest and on deep inspiration (both $P < 0.001$). The error bars represent standard deviations.
ESPB = erector spinae plane block; NRS = numeric rating scale

intraoperative care might have been aware of the group allocation because of the difference in intraoperative fentanyl dosage. Hence, risk of bias due to a possibility of unblinding should be taken into consideration. Nevertheless, all the intraoperative care providers were not involved in outcome assessment, data collection, or data analysis. Fifth, we did not ask about chronic postthoracotomy pain in our patients. Finally, this is a single-centre study, which may not represent practice at other centres.

In conclusion, the results of our study suggest that single-shot ESPB can reduce postoperative pain scores during the first 18 hr, decrease perioperative opioid consumption, and shorten time to tracheal extubation and ICU discharge in patients undergoing MIDCAB surgery.

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