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Efficacy of pectoral nerve block *versus* thoracic paravertebral block for postoperative analgesia after radical mastectomy: a randomized controlled trial†

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Abstract

Background: Pectoral nerve (PecS) block is a recently introduced technique for providing surgical anaesthesia and postoperative analgesia during breast surgery. The present study was planned to compare the efficacy and safety of ultrasound-guided PecS II block with thoracic paravertebral block (TPVB) for postoperative analgesia after modified radical mastectomy.

Methods: Forty adult female patients undergoing radical mastectomy were randomly allocated into two groups. Group 1 patients received a TPVB with ropivacaine 0.5%, 25 ml, whereas Group 2 patents received a PecS II block using same volume of ropivacaine 0.5% before induction of anaesthesia. Patient-controlled morphine analgesia was used for postoperative pain relief.

Results: The duration of analgesia was significantly prolonged in patients receiving the PecS II block compared with TPVB [mean (SD), 294.5 (52.76) *vs* 197.5 (31.35) min in the PecS II and TPVB group, respectively; $P<0.0001$]. The 24 h morphine consumption was also less in the PecS II block group [mean (SD), 3.90 (0.79) *vs* 5.30 (0.98) mg in PecS II and TPVB group, respectively; $P<0.0001$]. Postoperative pain scores were lower in the PecS II group compared with the TVPB group in the initial 2 h after surgery [median (IQR), 2 (2–2.5) *vs* 4 (3–4) in the Pecs II and TPVB group, respectively; $P<0.0001$]. Seventeen patients in the PecS II block group had T2 dermatomal spread compared with four patients in the TPVB group ($P<0.001$). No block-related complication was recorded.

Conclusions: We found that the PecS II block provided superior postoperative analgesia than the TPVB in patients undergoing modified radical mastectomy without causing any adverse effect.

Clinical trial registration: CTRI/2014/06/004692.

Key words: anaesthesia technique, paravertebral block, pectoral nerve block; postoperative analgesia; radical mastectomy

Modified radical mastectomy, usually performed for the treatment of breast cancer, is associated with considerable acute postoperative pain and restricted shoulder mobility.[1] Although the thoracic paravertebral block (TPVB) is the most widely used technique to provide postoperative analgesia after breast surgeries,[2–6] patients having radical mastectomy under TPVB frequently complain of pain in the axilla and upper limb, because TPVB does not block medial and lateral pectoral nerves as effectively

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Editor's key points

- Regional techniques may be useful for pain control after mastectomy, with paravertebral block (PVB) commonly used.
- Pectoral nerve block (PecNB) may offer improved analgesia, particularly in the axilla and upper limb.
- Improved pain relief and reduced morphine consumption were found with PecNB compared with PVB.
- Pectoral nerve block may be a useful regional technique for radical mastectomy; further larger trials are needed.

as long thoracic and thoracodorsal nerves, leading to inadequate analgesia. The TPVB also involves the risk of pneumothorax, spinal cord trauma, sympathetic block, and hypotension.[7]

Pectoral nerve (PecS) block is a new technique for providing surgical anaesthesia and postoperative analgesia during breast surgery that relies upon the placement of local anaesthetic between the thoracic wall muscles[8 9] and is therefore devoid of major adverse effects. The PecS I block is a superficial block that has been used effectively for surgical procedures such as placement of breast expanders and subpectoral prosthesis, shoulder surgery with deltopectoral groove involvement, and insertion of a pacemaker or intercostal drain.[8] The PecS II block favours mastectomy and axillary clearance, because long thoracic and thoracodorsal nerves are also blocked in addition to the lateral branches of the intercostal nerves that exit at the level of the mid-axillary line to innervate the mammary gland and the skin from T2 to T6.[9] The aim of this study was to compare the efficacy and safety of an ultrasound-guided PecS II block with TPVB for postoperative analgesia after modified radical mastectomy.

Methods

The study was approved by the institutional ethics committee, reference no. NK/1130/MD/13532-533, dated September 10, 2013. After providing written informed consent, 40 ASA grade I–II female patients in the age group of 18–65 yr, who were undergoing modified radical mastectomy under general anaesthesia between April and December 2014, were included. Patients with pre-existing infection at the block site, coagulopathy, morbid obesity (BMI >40 kg m^{-2}), allergy to local anaesthetics, decreased pulmonary reserve, major cardiac disorders, renal dysfunction, pre-existing neurological deficits, and psychiatric illness were excluded. All patients were kept fasting overnight and premedicated with alprazolam 0.25 mg and ranitidine 150 mg orally the night before and 2 h before surgery.

Patients were randomly allocated into two groups using computer-generated random numbers. The group allocation numbers were concealed in sealed opaque envelopes that were opened after enrolment of the patients. Group 1 patients received TPVB, whereas Group 2 patients received PecS II block. Both the groups received ropivacaine 0.5%, 25 ml. The blocks were performed under all aseptic precautions in the preoperating room 30 min before surgery with a 22 gauge echogenic needle (Pajunk, sonoplex stim cannula, Geisingen, Germany; 80 mm) using the same ultrasound machine (Sonosite, Inc., Bothell, WA, USA) and linear array probe (38 mm, 7–12 MHz frequency) by an anaesthetist not involved in the preoperative or postoperative assessment of the patient, anaesthesia management, and data collection.

The TPVB was administered at the T3 level with the patient in the sitting position. The skin was infiltrated with lidocaine 2% down to the T2 transverse process (2.5 cm lateral to the T3 spinous process). The ultrasound probe was placed 5 cm from the midline in the craniocaudal direction and moved medially to identify the transverse process and parietal pleura. The superior costotransverse ligament was identified as a collection of homogeneous linear echogenic bands alternating with echo-poor areas running from one transverse process to the next. Ropivacaine 0.5%, 25 ml was deposited in the space between the pleura and the costotransverse ligament.

The PecS II block was performed on the side of surgery with the technique used by Blanco and colleagues.[9] The patient was placed in the supine position with the arm abducted. The ultrasound probe was placed at the midclavicular level inferolaterally to locate the axillary artery and vein, and then moved laterally until pectoralis minor and serratus anterior muscles were identified at level of the third rib. After skin infiltration with lidocaine 2%, the needle was advanced in the plane of probe from medial to lateral in an oblique manner until the tip entered the plane between pectoralis major and minor and ropivacaine 0.5%, 10 ml was injected. After depositing the local anaesthetic, the needle was advanced further until it lay in the potential space between pectoralis minor and serratus anterior muscles, and ropivacaine 0.5%, 15 ml was deposited in this space.

The patients were observed for 30 min after performing the block. The sensory level of block was assessed by a blinded observer with pin-prick sensation every 5 min in each dermatomal distribution from T1 to T8. The total number of dermatomes that had less pain to pin prick compared with opposite side were noted. If the pin-prick sensation did not decrease in any segment up to 30 min, it was considered as a block failure. The patient's ECG and oxygen saturation (Sp_{O_2}) were monitored continuously, and heart rate (HR) and non-invasive blood pressure were recorded at baseline, after performing the block, and every 5 min for 30 min. Any block-related complications, such as hypotension, vascular puncture, or Horner's syndrome, were recorded.

General anaesthesia was induced with injection of fentanyl 1 μg kg^{-1} i.v. followed by propofol 1.5–2 mg kg^{-1} i.v. until loss of verbal response. Vecuronium 0.1 mg kg^{-1} i.v. was used to facilitate tracheal intubation. Anaesthesia was maintained with nitrous oxide 60% in oxygen and isoflurane (minimal alveolar concentration 1–1.3). The patient's lungs were ventilated with positive pressure ventilation to maintain end-tidal carbon dioxide between 4.0 and 4.5 kPa. The patients were monitored for ECG, non-invasive blood pressure, Sp_{O_2}, and nasopharyngeal temperature during surgery. The HR and blood pressure were recorded before induction, after induction, after tracheal intubation, at skin incision, and then every 5 min until the end of surgery. All patients received a continuous infusion of normal saline at a rate of 5–8 ml kg^{-1} h^{-1} during surgery. If mean arterial pressure exceeded 120% of baseline for two consecutive readings, a fentanyl 1.0 μg kg^{-1} i.v. bolus was given. Hypotension (mean arterial pressure <80% of baseline) was treated with boluses of normal saline and, if required, mephentermine 3–6 mg i.v. Bradycardia (HR <40 beats min^{-1}) was treated with atropine i.v. 0.6 mg. All the patients received antiemetic prophylaxis with ondansetron 0.1 mg kg^{-1} i.v. before completion of surgery. The residual neuromuscular block was antagonized with neostigmine and atropine, and the trachea was extubated when the patients were fully awake and breathing adequately.

The patients were monitored for 24 h after surgery in the postoperative room. A patient-controlled analgesia pump, programmed to deliver morphine 2 mg boluses with a lockout interval of 10 min, was attached to the patient for rescue analgesia. No background infusion was allowed. The primary

outcome measures of the study were the duration of analgesia (time to first rescue analgesia after administration of block) and total analgesic consumption in 24 h after surgery. The secondary outcome measures were postoperative pain and adverse effects. Postoperative pain was assessed using a visual analog scale (VAS, 0–10; 0=no pain and 10=worst imaginable pain). The vital signs and pain score were recorded at 0, 0.5, 1, 2, 4, 6, 8, 12, and 24 h after surgery by an investigator blinded to the group allocation. Any adverse effects, such as hypotension, respiratory depression, shivering, and urinary retention, were recorded. Postoperative nausea and vomiting (PONV) was assessed using a four-point numerical scale (0=no PONV, 1=mild nausea, 2=severe nausea or vomiting once, and 3=vomiting more than once). The rescue antiemetic ondansetron 0.1 mg kg^{-1} was given i.v. if the score was 2 or more.

Statistical analysis

IBM SPSS software version 22.0 (SPSS Inc, Chicago, IL) was used to test the normality of data by Kolmogorov–Smirnov test. The normally distributed data were compared using Student's unpaired *t*-test, whereas non-parametric data were compared by χ^2 test for intergroup differences. Intraoperative haemodynamic data were compared with baseline by repeated-measures ANOVA followed by Student's paired *t*-test. *Post hoc* analysis with Bonferroni correction was applied for multiple comparisons. The pain scores, time to first rescue analgesia, and total 24 h morphine consumption were compared by using the Mann–Whitney *U*-test for pairwise comparisons. Confidence intervals were calculated for statistically significant differences. The sample size was calculated on the basis of a pilot study. Taking the mean morphine consumption as 6.1 mg with SD 1.9 mg, for 30% difference in the 24 h postoperative morphine consumption at a significance level of 0.05 and power of 0.8, we required a minimum of 18 patients in each group.

Results

The groups were comparable with respect to age, height, weight, ASA physical status, and the duration of surgery (Table 1). The duration of analgesia was significantly prolonged in patients receiving the PecS II block compared with TPVB [mean (SD), 197.5 (31.35) *vs* 294.5 (52.76) min in the PecS II and TPVB group, respectively; $P<0.0001$]. The total 24 h morphine consumption was also less the in PecS II block group [mean (SD), 3.90 (0.79) *vs* 5.30 (0.98) mg in the PecS II and TPVB group, respectively; $P<0.0001$; Table 2]. None of the patients required additional fentanyl during the intraoperative period. The VAS scores were lower in the PecS II block group compared with the TPVB group during the initial 2 h after surgery; thereafter, there was no significant difference in VAS scores between the groups (Table 3). Although the total dermatomal spread was comparable among groups [median (IQR), 3 (3–4) and 4 (3–4) segments in the TPVB and PecS II block group, respectively; $P=0.209$], 17 patients in the PecS II block group had T2 dermatomal spread compared with four patients in the TPVB group ($P<0.001$; Table 4).

There was no significant difference between the groups with respect to HR, Sp_{O_2}, and mean arterial pressure during the perioperative period. No block-related complications, such as pneumothorax, vascular puncture, or local anaesthetic toxicity, were recorded. One patient in the TPVB group developed intraoperative hypotension, which was managed with administration of fluids and mephentermine. One patient in each group had PONV grade 2 and received ondansetron.

Table 1 Patient characteristics. Data are expressed as the mean (range) or *number of patients in each group

Variable	Group 1 (*n*=20)	Group 2 (*n*=20)
Age (yr)	51 (30–65)	54 (37–65)
Height (cm)	161 (150–168)	163 (158–169)
Weight (kg)	65 (52–85)	67 (55–80)
ASA status (I:II)*	14:6	9:11
Duration of surgery (min)	58 (45–75)	66 (45–90)

Discussion

The PecS II block is a new approach that aims to block the pectoral, the intercostobrachial, the intercostals III and VI, and the long thoracic nerves. These nerves need to be blocked to provide complete analgesia during breast surgery. Blanco and colleagues[9] performed the PecS II block in 50 patients undergoing modified radical mastectomies and reported good postoperative analgesia for 8 h. In a recent study, Bashandy and Abbas[10] also showed lower VAS scores and less postoperative morphine consumption in patients receiving the PecS II block with general anaesthesia compared with the patients receiving only general anaesthesia.

The present study was conducted to compare the efficacy and safety of the PecS II block with TPVB for postoperative analgesia in patients undergoing modified radical mastectomy. We found that the patients receiving the PecS II block had a significantly prolonged duration of postoperative analgesia with less requirement of rescue analgesia. There was a 33.3% reduction in total morphine consumption in the PecS II block group compared with the TPVB group during the 24 h postoperative period.

In a recently published study, Wahba and Kamal[11] also reported a prolonged time to first rescue analgesia and reduced morphine consumption after breast cancer surgery in patients receiving a pectoral nerve block compared with a thoracic paravertebral block; however, they used a different volume of local anaesthetic among groups (30 ml in the PecS group and 15–20 ml at the T4 level in the TPVB group). The 24 h morphine consumption was much higher in their study in both the groups [21 (20–25) mg in the PecS group and 28 (22–31) mg in the TPVB group] compared with the present study. This may be because a lower concentration of local anaesthetic (levobupivacaine 0.25%) was used in their study.

Although various studies[2–6] have shown better pain relief and a significant reduction in opioid consumption when the TPVB was combined with general anaesthesia, patients having radical

Table 2 Duration of analgesia and total analgesic requirement. CI, confidence interval

Variable	Group 1 (*n*=20)	Group 2 (*n*=20)	Mean difference (95% CI)	*P*-value
Duration of analgesia [min; mean (SD)]	197.5 (31.35)	294.5 (52.76)	97 (86.98–107.02)	<0.0001
24 h morphine consumption [mg; mean (SD)]	5.30 (0.98)	3.90 (0.79)	1.4 (1.31–1.49)	<0.0001

Table 3 Postoperative pain scores (visual analog scale score). Data are expressed as the median (interquartile range)

Time (h)	Group 1 (*n*=20)	Group 2 (*n*=20)	*P*-value
0	2 (2–2)	1 (1–1.5)	<0.0001
0.5	2.5 (2–3)	1 (1–2)	<0.0001
1	4 (3–4)	2 (2–2.5)	<0.0001
2	3 (3–4)	3 (2–4)	0.046
4	4 (2–4)	4 (2–4)	0.810
6	2 (2–3.5)	2 (2–2.5)	0.282
8	3 (2–4)	4 (2–4)	0.143
12	2 (1–3.5)	1 (1–2)	0.118
24	1 (1–1)	1 (1–1)	0.382

Table 4 Sensory spread. Data are expressed as the number of patients in each group

Dermatome	Group 1 (*n*=20)	Group 2 (*n*=20)	*P*-value
T2	4	17	<0.0001
T3	20	20	1.000
T4	20	20	1.000
T5	20	15	0.047
T6	5	1	0.182

mastectomy under TPVB frequently complain of pain in the axilla and upper limb, because the TPVB does not block the medial and lateral pectoral nerves as effectively as the long thoracic and thoracodorsal nerves, leading to inadequate analgesia.[12] In contrast, the PecS II block leads to complete block of medial and lateral pectoral nerves along with long thoracic and thoracodorsal nerves as a result of deposition of local anaesthetic in the fascial planes where all these nerves are situated, leading to better pain relief. In our study, the pain scores were significantly lower in patients receiving the PecS II block in the immediate postoperative period for 2 h compared with the patients receiving TPVB ($P<0.0001$). Wahba and Kamal[11] also reported lower pain scores at rest at 1, 6, and 12 h and on movement at 1 h in the PecS group compared with the TPVB group ($P<0.001$). In another study, Sopena-Zubiria and colleagues[13] showed that pain scores were significantly lower after breast surgery when a pectoral nerve block was combined with TPVB.

In our study, the sensory spread in the PecS II group was both cephalad and caudal to the site of injection (T2–T5). Blanco and colleagues[9] also observed consistent dermatomal spread in T2–T4 segments, which varied up to T6 in patients receiving the PecS II block. For the TPVB, sensory spread was usually observed below the level of injection (T3–T6), with very limited cephalad spread.[14] However, the spread of local anaesthetic may also depend on various conditions, such as different positions of the body, the rapidity of drug injection, and the position of needle tip. In our study, the TPVB was administered in the sitting position, whereas the PecS II block was performed in the supine position, which might have influenced the spread of local anaesthestic drug. We administered the TPVB at the T3 level, as in most of the previous studies, using a single injection technique,[15] because the single injection TPVB provides analgesia of only three or four segments. However, in the multiple injection technique of TPVB, the higher levels, such as T1 and T2, can be used for providing better spread of local anaesthetic.[15]

The PecS II block is generally safe. Minor complications may include intravascular injection in the acromiothoracic artery and cephalic vein, and pneumothorax. In contrast, various complications, such as vascular puncture, hypotension, extensive epidural or intrathecal spread, accidental pleural puncture, pneumothorax, and nerve damage, have been reported with TPVB in previous studies.[7 15] Schnabel and colleagues[7] reported an overall failure rate of 6.1% with the TPVB. We used ultrasound guidance and an echogenic needle to perform of the blocks for better viewing of the structures and the spread of local anaesthetic to avoid undue complications. In our study, the block was effective in all the patients, and no block-related complication was reported in any group except that one patient in the TPVB group had transient hypotension. The TPVB can produce bradycardia and hypotension by blocking sympathetic fibres. We used ropivacaine 0.5%, 25 ml in both the groups to achieve an adequate sensory block. Ropivacaine has a faster onset, longer duration of action, and less central nervous system toxicity and cardiotoxicity compared with bupivacaine.

In the present study, the incidence of PONV was low in both the groups. This may be because of lower consumption of opioids as a result of adequate pain relief. Our patients also received prophylactic antiemetic before the completion of surgery. The main limitation of our study is that the patient and the anaesthetist performing the block were not blinded to the group assignment. However, the person involved in data collection was not aware of the group distribution.

In conclusion, the PecS II block is an effective and safe technique, which provides better pain relief compared with the TPVB and reduces postoperative opioid consumption. Therefore, the PecS II block can be used safely for postoperative analgesia in patients undergoing breast surgeries with axillary dissection. However, further studies are required to assess the efficacy of the PecS II block for preventing chronic postsurgical pain after radical mastectomy.

Authors' contributions

Study design: S.K., N.B., I.B., G.S.
Patient recruitment: I.B., G.S.
Administration of block: N.B., S.A.
Data collection: S.K.
Data analysis: S.K., S.A.
Writing up of the first draft of the paper: N.B.

Declaration of interest

None declared.

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