Original Article

Analgesic efficacy of superficial versus deep serratus plane block for modified radical mastectomy under general anaesthesia: A randomised comparative study

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ABSTRACT

Background and Aims: Serratus anterior plane (SAP) blocks can be given either superficial or deep to the serratus anterior muscle to block the branches of intercostal nerves providing analgesia to the anterolateral chest wall. This prospective randomised comparative study aimed to compare the analgesic efficacy of superficial and deep SAP block in breast surgeries. **Methods:** Forty female patients scheduled to undergo elective modified radical mastectomy under general anaesthesia (GA) were randomly assigned to receive ultrasound guided SAP block with 30 ml 0.375% ropivacaine either superficial (group S, n = 20) or deep (group D, n = 20) to the serratus anterior muscle, before the induction of GA. The primary outcome was post operative fentanyl requirement over 24 hours and secondary outcomes were comparison of numerical rating scale (NRS) scores for pain, sensory block mapping, time to perform the block, number of needle attempts, etc. **Results:** The post operative 24-hour fentanyl requirement was comparable between group S and D (318.75 ± 80.65 versus 272.5 ± 80.25 μg, $P = 0.07$). NRS pain scores were comparable between the groups. Sensory block mapping done at various levels showed T3–T7 block in most of the patients with no difference between the groups. Block performance time (6.05 ± 3.27 versus 8.35 ± 3.26 minutes, $P = 0.034$) and number of needle attempts was significantly lesser in group D. **Conclusion:** There was no difference in analgesic efficacy when SAP block was given superficial or deep to serratus anterior muscle for modified radical mastectomies. However, deep SAP block required less time and number of attempts to perform than superficial technique.

Key words: Mastectomy, nerve block, postoperative pain, serratus plane block, superficial, ultrasound

INTRODUCTION

Breast malignancy is a major cause of cancer morbidity and mortality in women throughout the world. An estimated 2.2 million new cases and 600,000 deaths due to breast cancer are reported worldwide on an annual basis.[1] Treatment options for breast cancer include chemotherapy, hormonal therapy, radiotherapy but surgical excision of the tumour and lymph nodes has more favourable prognosis compared with other options.[2]

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Breast cancer surgery includes wide local excision of lump with axillary lymph node sampling, simple mastectomy or modified radical mastectomy (MRM) with or without axillary lymph node clearing. These surgeries can result in significant acute post operative pain and progression to chronic pain.[3] Serratus anterior plane (SAP) block is an interfascial block which blocks the lateral branches of intercostal nerves providing analgesia for breast and thoracic surgeries.[4-6] SAP block was initially described by Blanco *et al*.,[7] wherein they identified two potential spaces – superficial and deep to serratus anterior muscle at the level of the fifth rib in the mid-axillary line. However, a preliminary study by the author showed that the deposition of local anaesthetic solution superficial to serratus anterior muscle is associated with long lasting analgesia compared to the injection deep to the muscle.[7] On the other hand, in a study by Fajardo *et al*.,[8] it was postulated that the space between serratus anterior muscle and external intercostal muscle is less distensible, resulting in wider drug spread with respiratory movements aiding in drug dispersion.

Therefore, we hypothesised that injection deep to the serratus anterior muscle would result in superior analgesia compared to injection superficial to the muscle. This study was conducted to compare the analgesic efficacy of the two different techniques of SAP block. The primary objective of the study was to compare the post operative opioid requirements in two different techniques of SAP block. The secondary objectives were: number of needle attempts, block performance time, sensory block mapping, pain scores in 24-hour post-operative period, patient satisfaction score, post operative nausea and vomiting (PONV) and complications.

METHODS

This randomised comparative study was under taken after obtaining clearance from the institutional ethics committee (IEC-548/02.12.2016) and was prospectively registered in Clinical Trial Registry of India (CTRI/2017/11/010578). The study was conducted at a tertiary care hospital between January 2018 and March 2021 in 40 female patients after taking informed written consent in accordance with the principles of the Declaration of Helsinki. Patients belonging to American Society of Anesthesiologists physical status I and II, aged between 25 and 65 years, and scheduled for elective unilateral MRM were included for the study. Patients were excluded if they had local skin infection at the site of block, chest wall deformity, body mass index ≥35 kg/m^2, any coagulopathy or bleeding disorder, sensitivity/allergy to local anaesthetics, pregnancy or mental retardation, history of opioid use and previous breast surgery. Using a computer-generated random number table, all the patients were randomly allocated into two groups – Group S (superficial): Ultrasound-guided injection of local anaesthetic was given above the serratus anterior muscle (n = 20) and Group D (deep): Ultrasound-guided injection of local anaesthetic done below the serratus anterior muscle (n = 20).

Allocation concealment was done by sequentially numbered, opaque, sealed envelopes. The enroled patients underwent a complete evaluation (history, physical examination, biochemical and haematological tests and 2D echocardiography, if history of neoadjuvant chemotherapy) and were instructed regarding use of numerical rating scale (NRS) for pain on a scale of 0–10 (0 – no pain and 10 – worst possible pain), and the use of patient-controlled analgesia (PCA) device. The patients were not aware of the group they were being allocated. All patients were premedicated with alprazolam 0.25 mg and pantoprazole 40 mg orally. All other medications being taken for concurrent medical illness were continued.

The patients were taken inside the operating room and monitors (electrocardiography, non-invasive blood pressure and pulse oximetry) were attached. After recording baseline haemodynamic parameters, intravenous (IV) access was secured and midazolam 1 mg IV was administered. A 22-gauge blunt tip, echogenic needle was used for conduct of the SAP block. A linear high frequency (6–13 MHz) ultrasound (US) probe (Sono Site M-Turbo™, Sono Site Inc., Bothell, United States of America) was used for guidance of the block. All the blocks were performed before the administration of general anaesthesia (GA) by two anaesthesiologists having experience in performing ultrasound guided SAP block

The patient was made to lie down in the supine position and skin sterilisation was done with 2% chlorhexidine. The ultrasound probe was placed over the mid-clavicular region of the thoracic cage in a sagittal plane and the ribs were counted inferiorly and laterally, until the fifth rib in the midaxillary line was identified [Figure 1]. The latissimus dorsi (superficial and posterior), teres major (superior) and

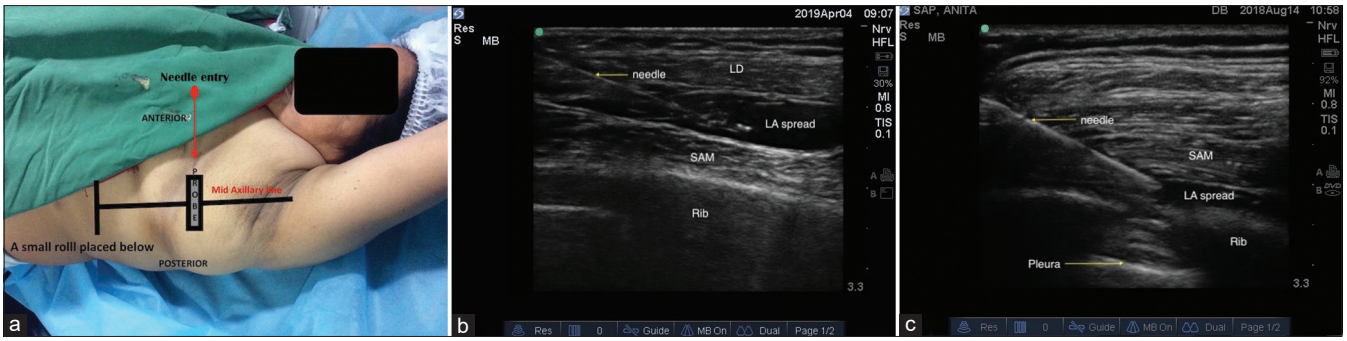

Figure 1: Conduct of block. (a) Placement of ultrasound probe and needle direction, (b) Superficial SAP block, (c) Deep SAP block. (SAM – serratus anterior muscle, LD – latissimus dorsi, LA – local anaesthetic)

serratus muscles (deep and inferior) were identified by ultrasound, overlying the fifth rib. After subcutaneous infiltration with 2% lignocaine, the block needle was inserted in the lateral to medial direction in an in-plane approach until the tip was placed above the serratus anterior muscle in group S and deep to serratus anterior muscle in group D [Figure 1]. Thirty ml of 0.375% ropivacaine was injected in the fascial plane after negative aspiration. The block performance time was noted which was measured from needle puncture to deposition of local anaesthetic. The number of changes of needle direction and attempts was also noted. After giving the block, sensory block was assessed by a 4-point scale along the mid-clavicular line (MCL), mid-axillary line (MAL) and posterior axillary line (PAL) at 30 minutes. It was evaluated using a cold spirit swab and blunt 26-gauge needle in the following grades: 0 = no block (patient can feel cold and pain both); 1 = patient can feel pain, but decreased coldness; 2 = patient can feel pain but no coldness; 3 = no pain. Failure of block was described if sensory loss did not occur over at least three dermatomes. A separate anaesthesiologist who was blinded to the group allocation noted the outcome parameters.

GA was given after the block with IV fentanyl 1 μg/kg and propofol in titrated doses (1.5–2.5 mg/kg) + atracurium 0.5 mg/kg followed by Proseal laryngeal mask (PLMA) insertion. Anaesthesia was maintained by isoflurane with oxygen/air mixture and positive pressure ventilation. Dexamethasone 0.15 mg/kg was given at the start of surgery. Fentanyl bolus of 25 μg was given if the blood pressure or heart rate exceeded 20% of the baseline and the total intra-operative fentanyl consumption was recorded. Injection paracetamol 1 gm and ondansetron 0.1 mg/kg were given IV 30 minutes before the end of surgery. The total surgical duration was noted. After the conclusion of surgery, neostigmine (50 μg/kg) with glycopyrrolate (10 μg/kg) was given when the patient demonstrated spontaneous respiratory efforts. The PLMA was removed and the patients were transferred to the post anaesthetic care unit (PACU) for monitoring vitals, pain assessment and providing analgesia. In the PACU, all patients were connected to a fentanyl IVPCA capable of delivering 25 μg bolus with a lock-out time of 10 minutes with a maximum dose of 150 μg/h. The first pain assessment was done as soon as the patient was awake, oriented and capable of following commands. In patients having NRS score ≥4, fentanyl 25 μg IV bolus was repeated every 10 minutes till the NRS was <3. NRS scoring was subsequently done at 1, 2, 4, 6, 12, 24 hours at both rest and the movement of the ipsilateral arm. All patients were encouraged to ambulate and resume oral intake early. Injection paracetamol 1 gram was given 6 hourly to all patients. Ondansetron 0.1 mg/kg was repeated 8-hourly in the post operative period. The number of episodes of PONV were recorded and rescue anti-emetic treatment was provided with metoclopramide 10 mg IV. Fentanyl consumption at 6 hours was also noted. On the next day, PCA was discontinued and the total amount of post operative fentanyl consumed was noted. All the patients were asked about their satisfaction score on a scale of 0–4 (0 – not satisfied; 4 – fully satisfied).

For sample size, it was decided to recruit 40 patients (20 in each group) by sample of convenience. For statistical analysis, normal distribution was tested by Shapiro-Wilk test. Continuous variables were compared with the independent-sample t-test for normally distributed data or the Mann–Whitney U test for skewed distribution. Chi-square or Fisher's exact test was used for categorical variables. All statistical analysis was performed with Statistical Package for Social Sciences 13.0 (SPSS Inc., Chicago IL, USA), and *P* values <0.05 were considered statistically significant.

RESULTS

A total of 45 patients were enroled for the study and 40 were included for the study as per the inclusion and exclusion criteria [Figure 2]. There were no differences between the two groups in terms of age, gender, height, weight, body mass index and surgical duration [Table 1]. There was no incidence of block failure.

The opioid requirement during the intraoperative and post operative period was higher in Group S but not statistically different compared to group D. The block performance time was significantly lower in Group D while needle attempts were similar. Patient satisfaction score was higher in Group D [Table 2].

There was no significant difference in the extent of dermatomal block between the two groups except at T3 level in MAL, where group D had higher grade of sensory blockade than group S [Grade 3 blockade; 10 vs 4 (P = 0.008), Figure 3]. No complications were seen in either of the groups.

Post operative pain scores at rest or movement also did not differ significantly in both the groups [Table 3].

Table 1: Demographic and baseline characteristics

Variable	Group S	Group D	*P*
Age (years), mean±SD	49.45±8.64	53.2±10.99	0.24
ASA I/II	10/10	7/13	0.52
Weight (kg), mean±SD	63.55±11.51	62.9±11.7	0.86
Height (cm), mean±SD	156.35±6.09	155.4 5.47	0.6
Body mass index (kg/m^2); mean±SD	25.93±4.06	25.99±4.48	0.96
Surgery duration (minutes); median (interquartile range)	157.5 (140-160)	138.25 (120-160)	0.15

ASA - American Society of Anesthesiologists; SD – standard deviation. Group S: Superficial group; Group D: Deep group

Table 2: Comparison of analgesic requirement and secondary objectives between the two groups

	Group S	Group D	*P*
Total post operative fentanyl (μg) mean±SD	318.75±80.65	272.5±80.25	0.07
Intraoperative fentanyl (μg) mean±SD	129±30.27	124.75±29.18	0.44
Time to first rescue (h); mean±SD	2.375±0.99	2.825±1.359	0.24
Number of PCA bolus (mean±SD)	12.75±3.23	10.9±3.21	0.07
Fentanyl requirement at 6 hours (μg) (mean±SD)	66.25±27.24	53.75±29.55	0.17
Number of needle attempts (*n*=number of patients)			
1 attempt	9	12	
2 attempt	9	8	0.46
3 attempt	2	0	
Block performance time (minutes) mean±SD	8.35±3.26	6.05±3.27	0.034
PONV (number of episodes)	7	5	0.49
Patient satisfaction score (mean±SD)	2.9±0.55	3.35±0.59	0.018

PONV – post operative nausea and vomiting; SD – standard deviation; PCA- Patient controlled analgesia; Data expressed as mean±SD or number; Group S: Superficial group; Group D: Deep group

Table 3: Post-operative pain scores

Time points	At rest			At movement		
	Group S	Group D	*P*	Group S	Group D	*P*
Immediate post-operative period	1.5 (0-2)	1.5 (0-2)	0.79	2 (0-3)	1 (0-3)	0.67
1 hour	2.5 (1.5-3)	2 (0.5-3)	0.30	3 (2-3.5)	1 (1-3)	0.28
2 hour	3 (2-3)	2.5 (1-3)	0.09	3 (2-4)	2 (1.5-4)	0.14
4 hour	3 (2-3)	3 (1.5-3)	0.18	3 (2-3)	3 (2-4)	0.71
6 hour	3 (2-3)	2 (2-3)	0.34	3 (3-4)	3 (2-4)	0.39
12 hour	2 (2-3)	2 (2-3)	0.96	3 (2.5-3.5)	3 (2-4)	0.82
24 hour	2 (2-3)	3 (2-3)	0.49	3 (2-3)	3 (2-4)	0.47

Group S: Superficial group; Group D: Deep group. Values are in median (interquartile range)

DISCUSSION

The results of our study show no difference between superficial and deep SAP block in terms of opioid consumption, pain scores or dermatomal coverage. Although the opioid consumption and pain scores were lower in deep injection, they did not reach statistical significance compared to superficial injection. Abdallah *et al*. in a retrospective cohort study (propensity matched) compared superficial and deep SAP block for breast cancer surgeries with 20–25 ml of local anaesthetic in 166 patients and did not find any difference in post operative opioid consumption or pain scores.[9] However, this study[9] is prone to bias because of its design and non-randomisation. In another randomised trial, deep SAP block was associated with less post-operative opioid consumption than superficial SAP block in patients undergoing mastectomies. This study had a significant heterogeneity in the patients included as they included both unilateral and bilateral surgeries, mastectomies with or without axillary clearance and different volumes of local anaesthetic were used. No sensory block mapping or analysis of drug spread was done.[10]

Other studies have analysed the spread of SAP block but not compared deep and superficial injection. In a cadaveric study by Biswas *et al*., it was found that 40 ml of drug results in greater area of spread and

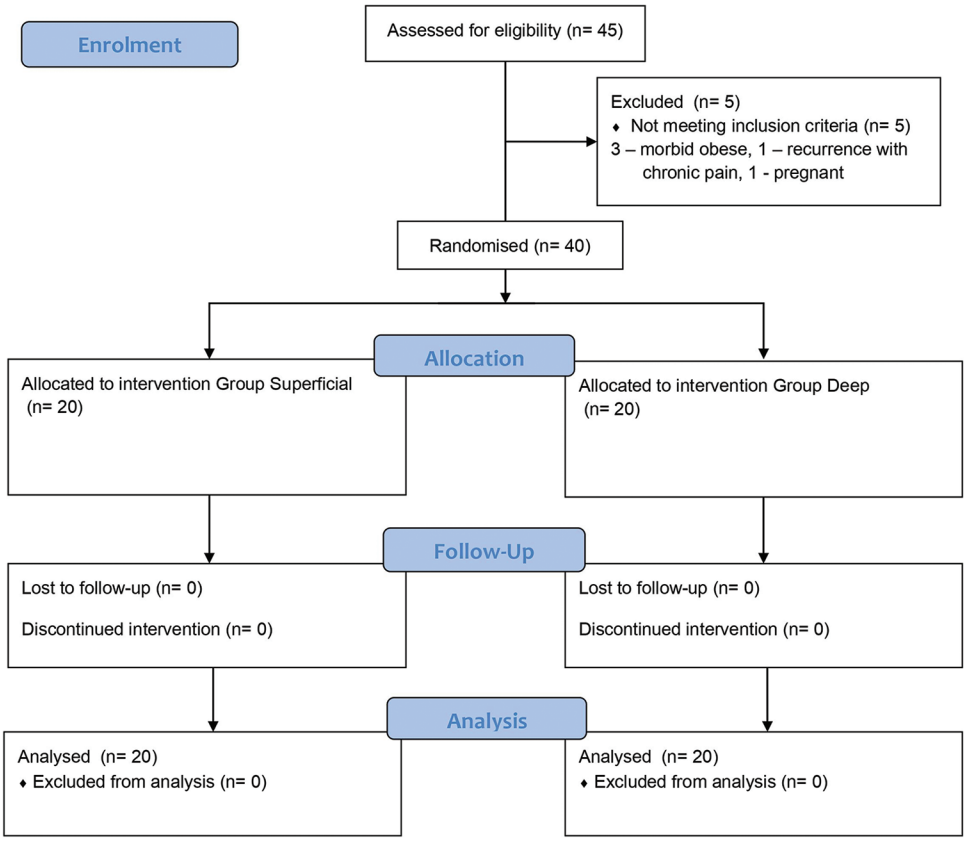

Figure 2: Consolidated Standards of Reporting Trials (CONSORT) participant flow diagram

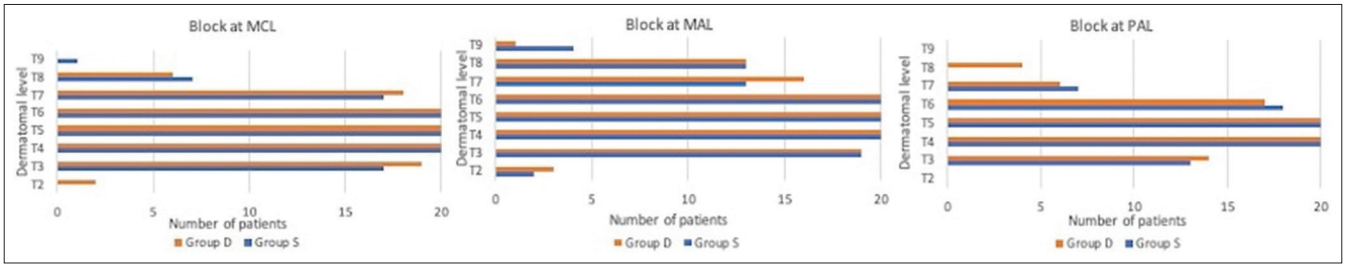

Figure 3: Sensory block mapping at various levels; MCL – mid-clavicular line, MAL – mid-axillary line, PAL – posterior axillary line

dermatomal coverage than 20 ml; however, there was no difference in spread between superficial and deep to serratus anterior muscle injection. They concluded that high volume injections result in favourable spread, irrespective of the plane of injection.[11] In another cadaveric study, the spread was evaluated by giving drug superior to the serratus. Forty ml of drug covered a mean of 5 dermatomes compared to 4 dermatomes while giving 20 ml of drug.[12] In a human study, 40 ml of drug blocked 6 dermatomes while 20 ml of drug blocked 4 dermatomes.[13] In study by Jain *et al*., 30 ml of drug deep to serratus anterior muscle consistently blocked T2–T5 dermatomes.[14] These studies correlate with our study as sensory block was seen from T3 to T7 (5 dermatomes) in a majority of patients. We chose 30 ml as the drug volume to be injected based on a previous study where 20–30 ml of drug was administered.[4]

The strength of this study is that it is a prospective randomised study comparing the two injection techniques with dermatomal coverage at different anatomical landmarks, which has not been studied before. Sensory blockade was noted in almost all the patients from T3 to T7 at MCL and MAL in both groups. Although the results were not significantly different in both groups, deep injection resulted in greater spread with some patients reporting T2 blockade. The dermatomal mapping performed in our study indicates that single injection SAP block provides reliable

sensory block in the required dermatomes for breast surgery, irrespective of the plane of drug deposition.

A potential disadvantage of superficial SAP block is that it might disrupt the surgical planes[9] causing hindrance to surgical removal of axillary lymph nodes. The local anaesthetic in this plane can result in blockade of the long thoracic and thoracodorsal nerves[7] which interferes in intra-operative stimulation in a bid to preserve them.[9] It has been seen that volumes as low as 20 ml can block these nerves.[12,15] The disadvantage with deep SAP block is that if the needle is not visualised between the serratus anterior and external intercostal muscle, the pleura may be punctured by going too deep.[16] However, this can be avoided by making the rib as the endpoint for injection.

There are also a few observations made by the authors during conduct of the block. The authors found it easier to perform the deep SAP block as needle manoeuvrability was easier. Superficial block required correct identification of two muscle planes and placing the needle between them while avoiding intramuscular injection. On the other hand, the needle can touch the periosteum and be slightly withdrawn while performing the deep block. Similar technical experience has also been observed by Piracha *et al*.,[17] describing their easiness of separating serratus anterior muscle off the rib as compared to intermuscular plane. This anatomical difference becomes more important in the obese population where muscle planes can be difficult to identify[18] and even reduced success rates of peripheral blocks may be seen.[19] In such cases, the bony acoustic shadow can be relatively easier to identify. This was evident by the fact that less time was required to perform the deep block compared to superficial in our study (8.35 versus 6.05 minutes). Fewer number of needle attempts were required in deep block though the difference was not significant. However, the patient satisfaction score was higher in deep block compared to superficial which cumulatively measures patient's perception on block conduct and the post operative period.

There were several limitations in our study. The major limitation was that the sample size was not estimated and was less which resulted in non-significant differences between the groups. The probability of true effect cannot be ruled out given the inadequate sample size which resulted in inadequate power. Also, both the techniques should be compared in overweight and obese population as deep block may be easier in this group and a significant difference might be obtained.

CONCLUSION

There was no difference in analgesic efficacy when SAP block was given superficial or deep to serratus anterior muscle for modified radical mastectomies. Deep SAP block required less time and was relatively easier to perform than superficial injection method, however, studies with larger sample size are required to determine which technique should be preferred while performing this regional anaesthesia block.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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