Efficacy of serratus anterior plane block versus thoracic paravertebral block for postoperative analgesia after breast cancer surgery - a randomized trial

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Abstract

Background: Breast cancer surgery is associated with considerable acute post-surgical pain and restricted mobility. Various regional and neuraxial anesthesia techniques have been used to alleviate post-mastectomy pain. Ultrasound-guided serratus anterior plane block (SAPB) has been considered a simple and safe technique. This randomized control study was performed to compare the efficacy of SAPB with the thoracic paravertebral block (TPVB) for postoperative analgesia after breast cancer surgery.

Methods: A total of 40 adult ASA physical status I - II female patients undergoing radical mastectomy were randomly allocated into two groups to receive either ultrasound-guided TPVB or SAPB with 0.4 mL.kg\textsuperscript{-1} 0.5% ropivacaine, 30 min before surgery. All patients received standardized general anesthesia for surgery, injection diclofenac and tramadol were used for postoperative rescue analgesia. The time to first rescue analgesia, total analgesic consumption in the first 24 hours, postoperative pain scores, and any adverse effects were recorded.

Results: The time to first rescue analgesia was significantly longer in the SAPB group (255.3 ± 47.8 min) as compared with the TPVB group (146.8 ± 30.4 min) (p < 0.001). Total diclofenac consumption in 24 hours was also less in the SAPB group (138.8 ± 44.0 mg vs 210.0 ± 39.2 mg in SAPB and TPVB group respectively, p < 0.001). Postoperative pain scores were significantly lower in the SAPB group as compared with TPVB group (p < 0.05). The incidence of PONV was also less in the SAPB group (p = 0.028). No block-related adverse effects were reported.

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Introduction

Modified radical mastectomy, a common surgical procedure in breast cancer patients, is associated with considerable acute postoperative pain and restricted shoulder mobility leading to delayed hospital discharge. Adequate post-surgical pain management is important for early mobilization and long-term well-being of these patients. Various regional anesthesia techniques have been used to provide postoperative analgesia in this group of patients including intercostal plane block, local anesthetic infiltration, brachial plexus block, thoracic epidural, thoracic paravertebral block (TPVB). Among these, TPVB is the most commonly used technique for controlling post-mastectomy pain but carries a high failure rate (6 - 10%) and the risk of hypotension, pneumothorax, and vascular puncture. Recently, thoracic wall blocks (Pecs I and II) have been evolved as less invasive alternatives to the paravertebral block for providing extended postoperative analgesia after breast surgery.

The serratus anterior plane block (SAPB) is a newer interfascial plane block of the chest wall and appears to be safe and easy to perform as serratus muscle is superficial and easily identifiable under ultrasound. Blanco et al. suggested that SAPB may target the thoracic nerves more selectively than pectoral blocks and provides predictable and effective anesthesia to the anterolateral chest wall. However, literature is scarce about the efficacy of SAPB for postoperative analgesia after breast cancer surgery. Therefore, the present study has been planned to compare the efficacy of ultrasound-guided SAPB with TPVB for the management of postoperative pain after total mastectomy and axillary clearance surgery in breast cancer patients. The primary objective of the study was to evaluate the duration of postoperative analgesia, and the secondary objectives were to observe the pain scores and rescue analgesic consumption for 24 hours postoperatively.

Methods

This randomized control trial was carried out after obtaining approval from the institutional ethics committee (reference number NK/1585/MD/10559-60) and written informed consent from the patients. The study was registered with the clinical trial registry (REF/2017/01/03128) and adheres to the applicable CONSORT guidelines. A total of 40 ASA (American Society of Anesthesiologists) physical status I - II female patients in the age group of 18 - 65 years, scheduled to undergo total mastectomy with axillary clearance under general anesthesia were included. The patients who had local infection at the block site, coagulopathy, morbid obesity (BMI > 40 kg.m⁻²), allergy to local anesthetics, decreased pulmonary reserve, uncontrolled hypertension or ischemic heart disease, renal dysfunction, and pre-existing neurological deficits and psychiatric illness were excluded. The patients were kept fasting overnight and pre-medicated with tablet alprazolam 0.25 mg and tablet ranitidine 150 mg orally the night before and two hours prior to surgery. They have explained the numeric rating scale (NRS, 0 - 10, where 0 stands for no pain and 10 stands for worst imaginable pain) for postoperative pain assessment.

The patients were randomly allocated into two groups using computer-generated random numbers which were kept in sealed opaque envelopes numbered sequentially and opened just before administration of the block. Group 1 patients received thoracic paravertebral block at T4 level (TPVB group) while group 2 patients received serratus anterior plane block at the level of the 5th intercostal space (SAPB group). The blocks were given 30 minutes before surgery by an experienced anesthesiologist (having experience of administration of more than 20 blocks each with the same technique) in the pre-operative room under all aseptic precautions and vital parameters monitoring. The anesthesiologist who performed the blocks did not participate in further management of the patients and data collection.

In TPVB group, the block was performed by placing the patient in a sitting position. The spinous processes of C7 to T6 vertebrae were marked with a permanent skin marker. Both cervical and thoracic paravertebral areas were prepared with 5% povidone-iodine solution and covered with sterile drapes. After covering the USG cable with a sterile ultrasound probe cover, a linear high frequency (5-10 MHz) ultrasound probe (Sonosite, Inc. Bothell, WA 98021 USA) was placed vertically 2.5 cm away from the midline in the sagittal paramedian plane at T4 level on the side of surgery. At this level, the probe was moved laterally and obliquely, until the typical double layer of the internal intercostal membrane (IM), the transverse process, superior costotransverse ligament, and the pleura were visualized in one image (Fig. 1). After infiltrating the skin with 3 - 5 mL of 2% lignocaine, a 22-G, 80-mm SonoPlex needle was inserted in-plane from caudal to cranial direction. Once the needle tip had reached in between the pleura and costotransverse ligament, 0.4 mL.kg⁻¹ of 0.5% ropivacaine was administered after negative aspiration. During the administration of the local anesthetic downward displacement of the pleura was observed.

In the SAPB group, patients were placed in a lateral position with the operating side up and the arm abducted. Under all antiseptic precautions, a linear high-frequency ultrasound probe was placed vertically in the mid-axillary line at the level of the 5th intercostal space. At this level, one can identify subcutaneous tissue and serratus anterior muscle in the superficial plane, the intercostal muscles (external, internal, and innermost) in the intermediate plane and

Conclusion: We found that the serratus anterior plane block was more effective than the thoracic paravertebral block for postoperative analgesia after breast cancer surgery.

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direction  

SonoPlex was  

After  

block  

superior  

pleura,  

dermatomal  

negative  

1  

patients  

the  

costotransverse  

serratus  

needle  

assessed  

Ultrasound  

Ultrasound  

transverse  

side  

is  

noted.  

and  

ligament  

anesthesiologist  

of  

(TP),  

parietal  

lung  

5-min  

was  

anterior  

and  

intercostal  

sensation  

minutes  

heart  

normality  

PONV  

given.  

and  

vasoconstriction.  

decrease  

in  

any  

segment  

until  

30-minutes  

after  

the  

block,  

then  

it  

was  

considered  

as  

a  

block  

failure.  

These  

patients  

were  

managed  

with  

additional  

(2 μg.kg⁻¹”  

during  

induction  

plus  

according  

to  

the  

requirement)  
doses  

of  
fentanyl  

for  

perioperative  
analgesia.  

Any  

block-related  

complications  

like  

hypotension,  

vascular  

puncture,  

Horner’s  

syndrome,  

and  
pneumothorax,  

were  

recorded.  

The  

patients  

were  

shifted  

to  

the  

operating  

room  

30-minutes  

after  

the  

procedure.  

Anesthesia  

was  

induced  

with  
fentanyl  

1 μg.kg⁻¹”  

followed  

by  

propofol  

2 - 3 mg.kg⁻¹  

until  

the  

loss  

of  

verbal  

response.  

Atracurium  

0.5 mg.kg⁻¹  

was  

used  

to  

facilitate  

tracheal  

intubation.  

Anesthesia  

was  

maintained  

with  

60%  

nitrous  

oxide  

in  

oxygen  

and  
isoflurane  

(MAC  

1 · 1.3).  

The  

patient’s  

lungs  

were  

ventilated  

with  

positive  

pressure  

ventilation  

to  

maintain  

capital  

carbon  

dioxide  

(ETCO₂)  

between  

32 - 36 mmHg.  

The  

patients  

received  
a  

continuous  

infusion  

of  
normal  
saline  
at  

the  

rate  

of  

5 · 8 mL.kg⁻¹.h⁻¹.  

An  

increase  

in  

mean  

arterial  

pressure  

(MAP)  

> 25%  
of  

baseline  

was  

considered  
as  

inadequate  
analgesia  

and  

1 μg.kg⁻¹”  
fentanyl  

was  

administered  
intra-  

venously.  

Any  

episode  
of  

hypotension  

(MAP < 25%  
of  

baseline)  

was  

treated  

with  

infusion  
of  
normal  
saline,  

and  

if  

required  
injection  

mephenemine  
in  
titrated  
doses.  

All  

patients  

received  
ondansetron  

0.1 mg.kg⁻¹  

30 minutes  

before  

the  

end  

of  

surgery  
to  

prevent  
postoperative  
nausea  

and  
vomiting.  

After  

completion  
of  
surgical  

residual  

neuromuscular  
blockade  
was  

reversed  

with  
intravenous  
neostigmine  

50 μg.kg⁻¹  

and  
glycopyrrolate  

10 μg.kg⁻¹  

and  
the  
endotracheal  
tube  
was  
removed  

once  

they  

were  

fully  

awake  

and  
breathing  
adequately.  

The  

patients  

were  

monitored  

for  

24-hours  

after  
surgery  
in  

the  

post-anesthesia  
care  
room.  

The  

vital  
parameters  

and  

pain  
scores  
(NRS)  

were  

recorded  
at  

0, ½,  1,  2,  4,  6,  8,  12,  
and  
24-hours  
by  
an  
investigator  
blinded  
to  
the  
group  
allocation.  

Patients  
with  
NRS  
more  
than  
3  or  
those  
demanding  
analgesics  
received  
diclofenac  
sodium  
75 mg intravenously.  

If  
NRS  
was  
remained  
high  
30 minutes  
after  
administration  
of  
diclofenac,  
then  
injection  
tramadol  
1 mg.kg⁻¹  
was  
given.  

Time  
for  
first  
rescue  
analgescia  
administration  
(i.e.,  
the  
time  
from  
administration  
of  
block  
to  
first  
requirement  
of  
diclofenac)  
and  
the  
total  
analgesic  
cost  
24 hours  
were  
recorded.  
Postoperative  
nausea  
and  
vomiting  
(PONV)  
were  
assessed  
using  

diclofenac  
4-point  
scale  
field  
(0 =  
no  
PONV,  
1 = mild  
nausea,  
2 = severe  
nausea,  
3 = vomiting)  
and  
treatment  

time  
for  
endotracheal  
4 mg)  
was  
given  
if  
the  
PONV  

time  
was  
> 1.  
Any  
other  
adverse  
effects  
like  
hypotension,  
respiratory  
depression,  
shivering  
and  
urinary  
retention  
were  
also  
recorded.  

Statistical  
analysis  

Statistical  
analysis  
was  
performed  
using  
SPSS  
version  
22  
(Sta-  

of  

Kolmogorov-Smirnov  
test  
of  
normality.  
Continuous  
and  
quantitative  
variables  
were  
expressed  
in  
mean  
and  
standard  
deviation  
when  
normally  
distributed,  
and  
as  
median  
and  
interquartile  
ranges  
when  
non-normally  
distributed.  
Cate-

gorical  
variables  
were  
expressed  
in  
absolute  
and  
relative  
frequencies.  
Normally  
distributed  
data  
were  
compared  
using  
unpaired  
t-test  
and  
for  
non-normally  
distributed  
data  
Mann-
Table 1  Demographic data.

| Parameters        | TPVB group (n = 20) | SAPB group (n = 20) |
|-------------------|---------------------|---------------------|
| Age (yr)          | 48.2 ± 9.8          | 50.8 ± 9.5          |
| Weight (kg)       | 59.8 ± 11.6         | 62.3 ± 9.6          |
| Height (cm)       | 157.9 ± 4.4         | 157.5 ± 4.4         |
| ASA 1 : 2 (n)     | 16:4                | 15:5                |
| Duration of surgery (min) | 71.3 ± 14.6 | 76.5 ± 15.7         |
| Drug (LA) volume (mL) | 23.7 ± 3.7        | 23.6 ± 3.9          |

Values are expressed as mean ± SD or number (n) of patients.

Whitney U test was used. The Chi-square test or Fisher’s exact test was applied for categorical data. Intragroup comparison of hemodynamic variables from baseline was done by repeated-measures ANOVA followed by Student’s t-test. Post-hoc analysis with Bonferroni correction was applied for multiple comparisons. The Kaplan-Meier survival curves were drawn with the time to first analgesic administration in the postoperative period, being considered as the event and log-rank analysis was performed for comparison between the groups. A p value < 0.05 was considered statistically significant.

The sample size was calculated based on a previous study by Kulhari et al., an increase in the duration of postoperative analgesia by 30 minutes with SAPB was considered a clinically relevant difference. For a significance level of 0.05 and power of 0.8, at least 18 patients in each group were needed. Therefore, 40 patients were included in the study.

Results

The groups were comparable regarding the patients’ age, weight, height, and ASA physical status (Table 1). There was no significant difference between the two groups in the duration of surgery and the total volume of local anesthetic used for the blocks. Although more patients in the SAPB group had sensory spread at the level of T1, T2, and T6 as compared to the TPVB group, it was not statistically significant (Table 2). One patient in the SAPB group had no sensory deficit and considered as block failure.

The Kaplan-Meier survival curves for the comparative cumulative probability of first rescue analgesic requirement in the postoperative period are shown in Fig. 3. Time to first rescue analgesia (duration of analgesia) was significantly longer in the SAPB group (255.3 ± 47.8 min) as compared with the TPVB group (146.8 ± 30.4 min) with a p value of < 0.001. The diclofenac consumption in the first 24 hours after surgery was significantly less in the SAPB group as compared to the TPVB group (p < 0.001) while tramadol requirement was comparable in both the groups (Table 3). Post-operative pain scores were significantly lower in the SAPB group as compared to the TPVB group (p < 0.05) during the first 2 hours and then at 6, 8, and 24 hours after surgery (Fig. 4). The intraoperative and postoperative hemodynamic variables were comparable in both groups except just after induction of anesthesia when MAP in the TPVB group was lower as compared to the SAPB group (p < 0.039). No episode of hypotension or bradycardia was reported in any group of patients. The incidence of PONV was significantly less in the SAPB group (p = 0.028). Eight patients in the TPVB group had PONV (grade > 2) and all received antiemetics whereas two patients in the SAPB group had PONV and only one of them required antiemetics. No block-related adverse effects were reported in any group of patients.

Discussion

In this randomized control study, we found that the patients who received SAPB had a longer duration of postoperative analgesia as compared to the patients who received TPVB. The SAPB group patients also showed lower postoperative pain scores and demanded less rescue analgesia in
Table 2  Dermatomal spread of sensory block.

| Dermatomal level | TPVB group (n = 20) | SAPB group (n = 20) | p-value |
|------------------|---------------------|---------------------|---------|
| T1               | 0                   | 4 (20%)             | -       |
| T2               | 4 (20%)             | 6 (30%)             | 0.465   |
| T3               | 20 (100%)           | 19 (95%)            | 1.000   |
| T4               | 20 (100%)           | 19 (95%)            | 1.000   |
| T5               | 20 (100%)           | 19 (95%)            | 1.000   |
| T6               | 14 (70%)            | 17 (85%)            | 0.451   |

Values are presented as the number (%) of patients.

Table 3  Duration of analgesia and rescue analgesic requirement.

| Parameters                  | TPVB group (n = 20) | SAPB group (n = 20) | p-value |
|-----------------------------|---------------------|---------------------|---------|
| Time to first rescue Analgesia (min) | 146.75 ± 30.361 | 255.26 ± 47.798 | < 0.001 |
| Total Diclofenac (mg)       | 210.00 ± 39.236    | 138.75 ± 44.036    | < 0.001 |
| Total Tramadol (mg)         | 92.86 ± 18.898     | 98 ± 12.46         | 0.626   |

Values are expressed as mean ± SD.

comparison to the TPVB group. The postoperative tramadol consumption was low in both groups.

Both SAPB and TPVB are attractive regional anesthesia options for providing postoperative analgesia after a radical mastectomy. Although the analgesic efficacy of TPVB versus placebo is well established in various thoracic surgeries, it carries theoretical risks of hypotension and pneumothorax, and not all providers have expertise and are comfortable with the technique. The SAPB has recently gained popularity because of its relative safety and the ease with which it is learnt and performed. SAPB is usually performed at the level of 5th or 6th rib in midaxillary line via deposition of local anesthetic superficial or deep to the serratus anterior muscle. Although both superficial and deep approaches have been found equally effective for providing postoperative analgesia after breast surgery, Abdulla et al. reported that deep SAPB is more advantageous from a surgical point of view than superficial SAPB. Also, this avoids the possibility of transitory palsy of the long thoracic nerve leading to a winged scapula that can be mistaken with a surgical lesion of this nerve.

SAPB has been used effectively for breast cancer surgery as well as video-assisted trans-thoracic surgery. A recent meta-analysis has shown that SAPB reduced postoperative pain scores, decreased opioid consumption in the first 24 hours after surgery, and prolonged time to first analgesia request as well as reduced the incidence of PONV and pruritus as compared with non-block care in breast and thoracic surgery patients. The block appeared safe with no study reporting any block-related complications. The preoperative administration of SAPB also improved the quality of recovery and patient satisfaction following breast cancer surgery.

However, the efficacy of SAPB in comparison with TPVB is not well established. Our results are supported by a recent study, which also found SAPB superior to TPVB in terms of the delayed requirement for the first rescue analgesia and 24 hours reduced analgesic consumption in patients undergoing breast cancer surgery. However, in a previous study, Hetta et al. found SAPB inferior to the TPVB in terms of duration of postoperative analgesia and rescue analgesic requirements. This may be due to multiple injection technique used in the TPVB group (at T2, T4, and T6 levels) in their study.

SAPB targets the lateral cutaneous branches of the intercostal nerves as they traverse between the fascial planes and provide extensive anesthesia of the anterolateral chest wall. Although TPVB targets the spinal nerves directly, the spread of local anesthetic is not predictable, it may spread either laterally to block the intercostal nerves or medially into the epidural space through the intervertebral foramina. A single level TPVB can block one to four dermatomes only. Therefore, a single-level injection of TPVB may not be enough to produce sufficient analgesia after extensive breast cancer surgeries.

In the present study, the duration of analgesia was 255.3 ± 47.8 minutes in SAPB group, which is comparable to the previous reports. Blanco et al. demonstrated 386 (±160) minutes paresthesia in 3-5 dermatomes after administration of deep SAPB with 0.4 mg.kg⁻¹ local anesthetic in volunteers. Rahimzadeh et al. reported the time to first rescue analgesia as 323.5 ± 49.7 minutes after SAPB in patients undergoing breast cancer surgery. In a recent meta-analysis, Chong et al. have also found the time to first analgesic request in SAPB as 379.2 minutes. However, a longer duration of postoperative analgesia (> 12 hours) has been reported after SAPB in patients undergoing partial or simple mastectomy. This may be because the axillary dissection usually requires analgesia up to T1 level while the spread of local anesthetic in the present study was mainly from T2 to T6 segments. Therefore, the pain caused by the axillary dissection might not be effectively controlled by the block. We used about 23 mL local anesthetic while up to 30 - 40 mL of local anesthetic has been used in previous studies.

Our success rate was 95% in the SAPB group and 100% in the TPVB group. We used echogenic needles to perform the blocks, as the use of echogenic needles under real-time ultrasound provides better visualization of the needle tip concerning the nearby structures and spread of local anes-
thetics, thus avoids complications. None of our patients had any block-related complications. The low incidence of PONV in patients receiving SAPB might be due to better pain relief (lower pain scores). Previous studies also reported a lower incidence of PONV in patients receiving SAPB. 17

The main limitation of our study is that the subjects and the anesthesiologist performing the block were not blinded to the group assignment, though the investigator who collected the data was not aware of the group allocation of the patients. In addition, we followed up the patients for only 24 hours after surgery. We did not assess the effect of the block on early hospital discharge and the incidence of chronic pain. Another limitation of this study is that it is a single-center study. Therefore, further multicenter studies are required to generalize our results.

In conclusion, we found SAPB superior to TPVB in terms of prolonged duration of postoperative analgesia and reduced rescue analgesic requirement after radical mastectomy in breast cancer patients. Therefore, SAPB may be a viable alternative to the TPVB, which is technically more challenging and have a higher potential for adverse effects. Further studies are required to compare the efficacy and safety of SAPB with other chest wall blocks. As SAPB usually provides 4-6 hours of postoperative analgesia in these patients, the role of additives can also be assessed.

Conflicts of interest

The authors declare no conflicts of interest.

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