Original Article

Enhancing needle visualization during parasagittal approach in paravertebral block for patients undergoing simple mastectomy using in-plane, multiangle ultrasound needle guidance system

ABSTRACT

Background: Ultrasound-guided paravertebral blocks during breast surgeries with in-plane needle approaches can be challenging due to difficult needle visualization. The purpose of this study was to assess the usefulness of using a needle guide while performing in-plane parasagittal approach paravertebral block for breast surgery.

Patients and Methods: Eighty patients, American Society of Anesthesiologists physical status I-III, aged 20-40 years with breast mass scheduled for simple mastectomy surgery, were involved in prospective, controlled, randomized study, and were randomly divided by closed envelope method into two groups: Group I (n = 40): Scheduled for ultrasound-guided paravertebral block or group II (n = 40): Scheduled for ultrasound-guided paravertebral block using the needle guide. Both techniques compared as regards: (i) Needle visibility and block performance time; (ii) number of needle passes; (iii) duration of the block; (iv) doctor and patient satisfaction; and (v) incidence of complications.

Results: Needle visibility score was better in group II (2.92 ± 0.26 vs. 1.9 ± 0.44, $P < 0.0001$). Block performance time was shorter in group II (90.92 ± 15 vs. 128.25 ± 16s, $P < 0.0001$). A number of needle passes were less in group II (1.27 ± 0.45 vs. 2.2 ± 0.68, $P < 0.0001$). Doctor and patient satisfaction were better in group II ($P = 0.015$). No differences were found regarding the duration of the block and incidence of complications between groups.

Conclusion: A needle guide can help reduce the time needed to perform a parasagittal in-plane thoracic paravertebral block, with a significant reduction in the block performance time, the number of needle passes, better needle visibility and better doctor and patient's satisfaction. However, there was no significant difference regarding the duration of the block or incidence of complications.

Key words: Breast surgeries; needle visualization; paravertebral block; regional anesthesia; ultrasound

Introduction

Promoting patient safety and increasing health care quality have dominated the health care landscape during the last 15 years. Health care regulators and payers are now tying patient safety outcomes and best practices to hospital reimbursement. Many health care leaders are searching for new technologies that not only make health care for patients safer but also reduce overall health care costs. New advances in ultrasonography have made this technology available to health care providers at the patient's bedside. Point-of-care

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ultrasound assistance now aids providers with real-time diagnosis and with visualization for procedural guidance.[1]

Thoracic paravertebral block (TPVB) is the technique of injecting local anesthetic adjacent to the intervertebral foramina, resulting in unilateral somatic and sympathetic nerve blockade. Previous studies have reported its effectiveness for thoracic surgery including breast surgery and relief of postoperative and chronic pain of unilateral origin from the chest and abdomen. The technique is relatively easy to learn and safer than a thoracic epidural. Its clinical advantages include the inhibition of stress and pressor responses to surgical stimuli, maintenance of hemodynamic stability, low incidence of complication, long duration of analgesia, and few contraindications. Recent advances in ultrasound technology can further increase the effectiveness and the safety of TPVB although identification of the nerve and needle is not still possible.[2]

Needle visualization is important for safe and successful ultrasound-guided peripheral nerve block. However, accurate and consistent visualization of the needle tip can be difficult to achieve.[3] It is also a fundamental skill required for competency in ultrasound-guided regional anesthesia.[4]

Ultrasound-guided regional anesthesia with in-plane needle approaches can be challenging due to difficult needle visualization. A needle guide can help reduce the time needed to complete a simulated nerve targeting procedure and enhance needle visualization for the novice sonographer in a phantom gel simulation.[5]

This study aimed to outline a solution to the technical challenge associated with impaired needle visualization while performing paravertebral block for breast surgeries.

Patients and Methods

A prospective, controlled, randomized study was carried out at Kasey El-Aini Hospital in the period from July 2014 to February 2015, after obtaining permission from the Local Ethical and Research Committee and an informed consent from the patient. Eighty patients, American Society of Anesthesiologists physical status I-III, aged 20-40 years with breast mass scheduled for simple mastectomy surgery. Patients with suspected difficult paravertebral block due to obesity (body mass index [BMI] >30 kg/m^2), back deformities or having a contradiction for the block were excluded. Patients were exposed to routine preoperative evaluation including history, examination, and investigations. No premedication was given to the patients since full cooperation during block performance was required. On arrival to the operating room, an intravenous (IV) catheter was placed in the upper limb contralateral to the surgical site, and saline solution started at 2 mL/kg/h. Standard anesthesia monitors (electrocardiography, oximeter, noninvasive blood pressure) were applied. Supplemental oxygen (via nasal prongs at 4 L/min) was also applied. Patients were randomly assigned to either group I ($n = 40$): Scheduled for ultrasound-guided paravertebral block or group II ($n = 40$): Scheduled for ultrasound-guided paravertebral block using the needle guidance system (CIVCO, Ultra-Pro II™) [Figure 1].

Randomization was carried out as follows: Prior to perform the block, the experienced anesthesiologist blindly chosen a slip of paper from a dark envelope that contained two slips, with each slip marked with one of the two patient groups. Whichever group was written on the paper determined the block technique that was to be used in that patient.

The patient (after being positioned) in a lateral position, the region was prepared and draped, The spinous process of the fourth thoracic vertebra was located, then local infiltration of the skin with Lidocaine 2% to raise a bleb over the selected point of entry had been done. An ultrasound machine (Siemens™, Acuson X300) A low-frequency ultrasound transducer (CH5-2, 2-5 MHz) was placed in the axial (transverse) plane at the selected level, with the transducer positioned just lateral to the spinous process [Figure 2]. The transverse processes and ribs were visualized as hyperechoic structures. The transducer was moved slightly caudad into the intercostal space between adjacent ribs to identify the thoracic paravertebral space (PVS) and the adjoining intercostal space. The PVS appears as a wedge-shaped hypoechoic layer demarcated by the hyperechoic reflections of the pleura below and the internal intercostals membrane above. The needle (B. Braun, Stimuloplex® Ultra, 22 gauge and 120 mm) was introduced in-plane with the transducer until a pop was felt as the needle penetrates the internal intercostal membrane, where the needle was, at that point, positioned in the PVS. Bupivacaine 0.25% in a dose of 20 ml was injected. Downward displacement of the pleura was seen with the injection, indicating proper spread of the local anesthetic.

Our primary outcome was the needle visibility score which was recorded on a scale from 1 to 3 (1 = poor, 2 = good, 3 = excellent). As we considered visualization of the whole needle or at least the tip of the needle adjacent to the target as an excellent, visualization of "non" of the needle as poor and the rest of partial views of the needle as good.[5] Other variables were also recorded, including procedure

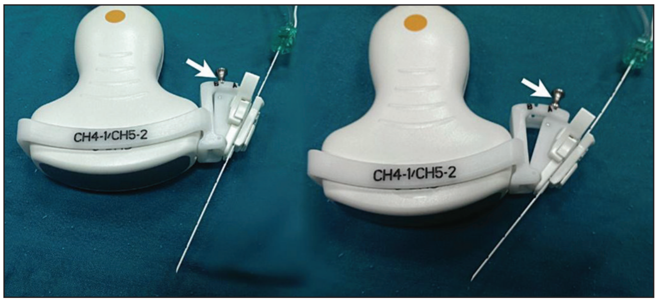

Figure 1: A low-frequency ultrasound transducer (CH5-2, 2-5 MHz) with the needle guidance system attached and the needle trajectory in a two different angles

performance time (time from applying the probe to the skin, till finishing the injection of the local anesthetic), number of needle passes, and incidence of complications.

Then induction of general anesthesia was accomplished using fentanyl 2 μg/kg, propofol 2-3 mg/kg, and rocuronium 0.6 mg/kg to facilitate endotracheal intubation. Anesthesia was maintained using isoflurane 1.5% in O_2/air mixture (FiO_2 0.4). If mean blood pressure or heart rate exceeded 20% of the preoperative value, increments of fentanyl 25 μg had been given IV. Incremental doses of ephedrine (5 mg) were used to treat hypotension (mean arterial blood pressure <60 mmHg).

After the completion of the surgery, patients received neostigmine and atropine for reversal of the muscle relaxant and had been extubated when the nerve stimulator showed a train-of-four ratio >0.75.

The quality of sensory block was assessed by bilateral application of ice over the breast area at 30 min postprocedure once the patient was alert and oriented in the recovery room. Bilateral assessments were done to rule out the epidural spread. Sensory level of analgesia was recorded and patient satisfaction with analgesia documented on a scale from 0 to 3 (0 = terrible, 1 = poor, 2 = good, 3 = excellent). Pain intensity was measured using visual analog scale (VAS) (1-10), starting 30 min after transfer to the recovery room and then repeated every hour till the patient requested analgesia, and then every 2 h in the first 24 h postoperatively. If VAS was >3, the patient had been given: 1 g paracetamol infusion over 20 min, and if the pain persisted after 20 min, 0.05 mg/kg morphine IV was given. If pain persisted after 20 min, another dose of morphine 0.025 mg/kg would be given.

Sample size report (power analysis)

Sample size was calculated with a statistical power of 80%, alfa error of 5%, the confidence interval of 95%, and significance when $P < 0.05$. According to similar studies, the minimum sample size for each of the two study groups was 37 patients. We enrolled 40 cases per group to accommodate

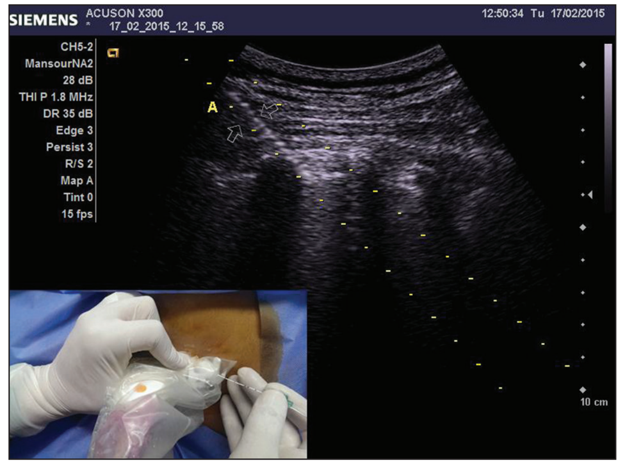

Figure 2: An ultrasound image of a needle approaching the paravertebral space while using the needle guidance system

for dropouts. Statistical analysis was done using the SPSS for Windows, version 15 (IBM, SPSS Inc., Chicago, IL, USA). Categorical data were expressed by number and percentages, while continuous data were expressed by mean ± standard deviation categorical data were compared using Chi-square or Fisher's exact test as appropriate. Continuous data were first tested for normality by Kolmogorov-Smirnov test. Comparison of continuous data was done using a unpaired *t*-test. A $P < 0.05$ was considered statistically significant.

Results

Our study included 80 patients with breast mass scheduled for simple mastectomy surgery, with 40 patients in each group. Patient characteristics and procedural data of the study population were shown in Table 1.

The two groups showed no statistically significant differences regarding age or BMI [Table 2].

Group II showed statistically significant better needle visibility score than group I (2.92 ± 0.26 vs. 1.9 ± 0.44) with a $P < 0.0001$ [Table 2 and Figure 3].

Group II was also associated with significant shorter block performance time than group I (90.92 ± 15 vs. 128.25 ± 16s) [Table 2].

Furthermore, the use of a needle guidance system while performing in-plane paravertebral block associated with a lesser number of needle passes (1.27 ± 0.45 vs. 2.2 ± 0.68) with a $P < 0.0001$ [Table 2].

Doctor and patient satisfaction were better in group II when compared to group I with a $P < 0.0001$ and = 0.001, respectively.

Table 1: Patient characteristics and procedural data of the study population

Parameter	n = 80
Age (years)	
Mean±SD	31.75±5
Range	21-39
BMI	
Mean±SD	25.92±2.4
Range	20-29
Block performance time (s)	
Mean±SD	109.58±24.8
Range	65-187
Needle visibility score (*n*, %)	
1	6 (7.5)
2	35 (43.8)
3	39 (48.8)
Mean±SD	2.41±0.63
Number of needle passes (*n*, %)	
1	34 (42.5)
2	34 (42.5)
3	11 (13.8)
4	1 (1.3)
Mean±SD	1.73±0.74
Duration of the block (h)	
Mean±SD	4.62±0.63
Range	3-6
Patient satisfaction score (*n*, %)	
1	2 (2.5)
2	28 (35)
3	50 (62.5)
Mean±SD	2.6±0.54
Doctor satisfaction score (*n*, %)	
2	18 (22.5)
3	62 (77.5)
Mean±SD	2.77±0.42
Complications (*n*, %)	2 (2.5)

SD: Standard deviation; BMI: Body mass index

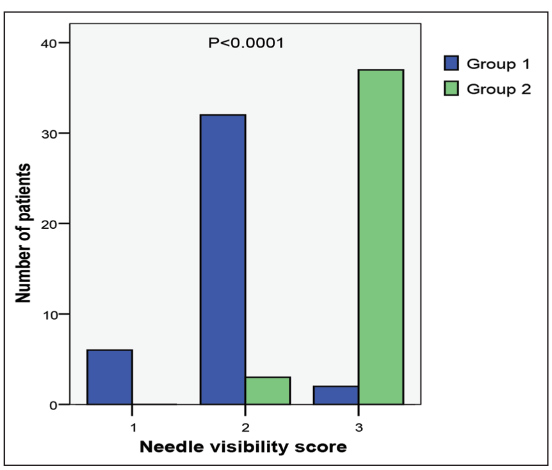

Figure 3: Needle visibility score among the two study groups

No differences were found regarding duration of the block (4.64 ± 0.61 vs.4.62 ± 0.63, P = 1.00). And incidence of complications (2 [2.5%] vs. 0, P = 0.49) between the two groups [Table 2].

Discussion

Needle visualization is important for safe and successful ultrasound-guided peripheral nerve block. However, accurate and consistent visualization of the needle tip can be difficult to achieve.[3]

Our study shows that a needle guide can help reduce the time needed to perform a parasagittal in-plane TPVB, with a significant reduction in the block performance time, the number of needle passes, and better doctor and patient's satisfaction.

In a study done by Kaur *et al*., evaluating a novel ultrasound machine with an electromagnetic-based needle guidance system for the placement of TPVB. The Sonix GPSTM needle guidance system (Ultrasonic, Richmond, BC, Canada) uses sensors in the needle and transducer to provide a real-time display of needle shaft and tip position relative to the ultrasound beam based on the needle trajectory. They concluded that the novel needle guidance technology provides an additional margin of certainty of needle and needle tip positioning during performance of TPVB, as with the ultrasound needle guidance system, real-time TPVBs were performed accurately and without clinical complications such as pleural puncture using in-plane and out-of-plane approaches.[6] But the unavailability and the high cost of that system make it unfeasible.

Another study by Tsui describing *in vitro* demonstration of the potential use of a readily available laser-line unit to assist with in-plane needle alignment with the ultrasound plane in order to ultimately improve needle visibility during ultrasound-guided peripheral nerve block. It requires minimum specialized training and may allow for maximum flexibility with freehand needle insertions in a sterile fashion as this optical guide provides a clear visual indication of precise needle-beam alignment, and may prove useful in teaching and developing bimanual coordination in novices. However, a portion of the needle shaft has to protrude from the skin surface at all time to allow alignment with the laser.[7] But that may require the use of longer block needles that can be more difficult to manipulate. This method is also unsuitable for continuous catheter techniques that require the probe (and laser) to be encased in a sterile sleeve.

Another study by Gupta *et al*., trying to improve needle visualization by novice residents during an in-plane ultrasound nerve block simulation using an in-plane multiangle needle guide, concluded that a needle guide can

Table 2: Comparison between the two study groups

Parameter	Group I ($n = 40$)	Group II ($n = 40$)	*P*
Age (years)	31.27±4.55	32.22±5.51	0.4
BMI	25.84±2.5	26±2.32	0.75
Block performance time (s)	128.25±16.64	90.92±15.95	<0.0001
Needle visibility score (*n*)			
1	6	0	<0.0001
2	32	3	
3	2	37	
Mean±SD	1.9±0.44	2.92±0.26	<0.0001
Number of needle passes (*n*)			
1	5	29	<0.0001
2	23	11	
3	11	0	
4	1	0	
Mean±SD	2.2±0.68	1.27±0.45	<0.0001
Duration of the block (h)	4.64±0.61	4.62±0.63	1.00
Patient satisfaction score (*n*)			
1	2	0	<0.0001
2	22	6	
3	16	34	
Mean±SD	2.35±0.57	2.85±0.36	<0.0001
Doctor satisfaction score (*n*)			
2	15	3	0.001
3	25	37	
Mean±SD	2.62±0.49	2.92±0.26	0.001
Complications (*n*, %)	2 (2.5)	0	0.49

SD: Standard deviation; BMI: Body mass index

help reduce the time needed to complete a simulation nerve targeting procedure and enhance needle visualization for the novice sonographers in a phantom gel simulation.[5] But the limitations of this study that it had been performed in-veto (on a phantom gel) by inexperienced residents.

In a review article by Chin *et al*. they tried to sort out challenges and solutions for needle visualization in ultrasound-guided regional anesthesia. They concluded that needle-beam alignment, echogenic needle design, needle manipulation, needle bevel orientation, surrogate markers of needle tip location, and ultrasound imaging technology can affect needle visualization.[3]

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Conflicts of interest

There are no conflicts of interest.

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