Comparison between Conventional and Ultrasound-Guided Supraclavicular Brachial Plexus Block in Upper Limb Surgeries

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Abstract

Introduction: Brachial plexus blockade is a time-tested technique for upper limb surgeries. The classical approach using paresthesia technique is a blind technique and may be associated with a higher failure rate and injury to the nerves and surrounding structures. To avoid some of these problems, use of peripheral nerve stimulator and ultrasound techniques were started which allowed better localization of the nerve/plexus. Ultrasound for supraclavicular brachial plexus block has improved the success rate of the block with excellent localization as well as improved safety margin. Hence, this study was planned for comparing the efficacy of conventional supraclavicular brachial plexus block with ultrasound-guided technique. Subjects and Methods: After obtaining the Institutional ethical committee approval and patient consent total of 60 patients were enrolled in this prospective randomized study and were randomly divided into two groups: US (Group US) and C (Group C). Both groups received 0.5% bupivacaine. The amount of local anesthetic injected calculated according to the body weight and was not crossing the toxic dosage (injection bupivacaine 2 mg/kg). The parameters compared between the two groups were lock execution time, time of onset of sensory and motor block, quality of sensory and motor block success rates were noted. The failed blocks were supplemented with general anesthesia. Results: Demographic data were comparable in both groups. The mean time taken for the procedure to administer a block by eliciting paresthesia is less compared to ultrasound, and it was statistically significant. The mean time of onset of motor block, sensory blockade, the duration of sensory and motor blockade was not statistically significant. The success rate of the block is more in ultrasound group than conventional group which was not clinically significant. The incidence of complications was seen more in conventional method. Conclusion: Ultrasound guidance is the safe and effective method for the supraclavicular brachial plexus block. Incidence of complications are less as ultrasound provides real-time visualization of underlying structures and the spread of local anaesthetic.

Keywords: Paresthesia, supraclavicular block, ultrasound

Introduction

Pain is “an unpleasant sensory or emotional experience associated with actual or potential tissue damage, or described in terms of such damage.” It is an unpleasant effect associated with significant psychological and physiological changes during surgery and postoperative period. This can be overcome by the use of suitable drugs and techniques. Regional anesthetic techniques have specific advantages both for standalone anesthesia or as analgesic supplements for intraoperative and postoperative care.

Brachial plexus blockade is a time-tested technique for the upper limb surgeries. The first supraclavicular brachial plexus block was performed by Kulenkampff in 1912. The classical approach using paresthesia technique is a blind technique and may be associated with a higher failure rate and injury to the nerves and surrounding structures. To avoid some of these problems, use of peripheral nerve stimulator was started which allowed better localization of the nerve/plexus. However, this technique may not be foolproof with persistent risk of injury to surrounding structures, especially vascular structures, nerves and pleura leading to pneumothorax.

The application of ultrasound technique for exact localization of nerves/plexus has revolutionized the regional anesthesia field where in ultrasound probes with suitable frequencies have been successfully tried.

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Ultrasound for supraclavicular brachial plexus block has improved the success rate of block with excellent localization as well as improved safety margin.\(^\text{[8]}\) Hence, a study was planned for comparing the efficacy of conventional supraclavicular brachial plexus block with ultrasound-guided technique.

**Subjects and Methods**

After approval by the Institutional Ethics Committee and written informed consent obtained from all patients, 60 patients who satisfied the inclusion and exclusion criteria, undergoing surgeries of the upper limb were selected for the study.

Patients of either sex, aged between 18 and 50 years, with the American Society of Anesthesiologists (ASA) physical Classes I and II posted for elective upper limb surgeries were included in the study.

A patient who refuses, age <18 years and >50 years of age, with significant coagulopathy, peripheral neuropathy, physical Classes III and IV patients; pregnant patients, allergy to local anesthetics (LAs), significant preexisting systemic diseases, emergency surgical procedures were excluded from the study.

All the patients were fasted adequately and were premedicated with tablet diazepam 10 mg and tablet ranitidine 150 mg in the night before surgery and in the morning of surgery. In the operation theater, patients were monitored with pulse oximetry (SpO2), noninvasive blood pressure, and electrocardiogram. No other sedation was given till the evaluation of the block was completed.

The patients were randomly allotted by closed envelope technique into either of the two groups, namely, US-guided (Group US) or C-guided (Group C). The respective equipment was kept ready, and the drugs were loaded maintaining sterility. The drug used was a 25 ml of 0.5% bupivacaine +0.25 ml sodium bicarbonate +5 cc normal saline. The amount of LA injected was calculated according to the body weight and was within the upper limit of not crossing the toxic dosage (injection bupivacaine 2 mg/kg). The patients were positioned supine with the arms by the side, and head turned to the opposite side by 45\(^\circ\). The proposed site of the block was aseptically prepared and draped.

In Group US, block is performed after real-time visualization of the vessels, nerve, and bone. In-plane approach, using 10 ml syringe-containing LA was injected, and the drug distribution was noted. This procedure was done using Sonosite HM\(^\circ\) ultrasound machine available with high frequency linear 38/6–13 MHz transducer and 38 mm linear array probe in-plane approach using 5 cm 22G block needle.

In Group C, conventional supraclavicular brachial plexus was performed by eliciting paresthesia in the forearm and hand and when paresthesia was obtained we withdrew the needle about 1–2 mm and then, the drug was injected.

The time taken for the procedure, the onset of sensory and motor blockade was noted. Intraoperatively, hemodynamics were monitored at regular intervals. Following completion of surgery, the patients were monitored to assess the quality and duration of postoperative analgesia. Thus, the patients were asked to classify analgesia as no pain, mild pain, moderate pain, or severe pain every hour for the first 6 h, and then, again at 8 and 10 h. At the time of each subsequent assessment, patients were observed and/or questioned about any subjective and/or objective side effects (sedation, nausea, vomiting or respiratory depression, and neurological injury).

The various parameters noted were:
- Time taken for the procedure
- Onset and duration of sensory neural blockade
- Onset and duration of motor blockade
- Overall effectiveness of the block/success rate
- Incidence of complications.

Grading of sensory blockade
- I = No difference
- II = Some difference but cold still sensed in blocked arm
- III = No cold sensation in blocked arm.

Grading of motor blockade
- I = Normal power
- II = Reduced power
- III = Complete loss of power.

Data will be collected every 3 min for the first 15 min, subsequently every 5 min for 15 min and later every 10 min for 30 min and every 15 min till the end of surgery and at least for 8 h postoperatively. Assessment of complete recovery of both sensory and motor blockade will be done for at least 8 h postoperatively. The assessment will be continued every 4th h for subsequent 24 h if blockade prolongs more than 8 h.

**Statistical analysis**

Results were statistically analyzed using Chi-square and Fisher’s exact tests. Nonparametric values were analyzed using Student’s \(t\)-test.

**Results**

There were no significant differences between both groups with respect to demographic data as shown in Table 1.

The mean time taken for the procedure to administer a block by eliciting paresthesia (Group C) was 5.33 min, whereas using ultrasound (Group US), it was 9.96 min. This was clinically and statistically significant Table 2.

**Table 1: Demographic data**

|             | Mean±SD | Group C | Group US | \(P\)   |
|-------------|---------|---------|----------|---------|
| Age (years) | 33.7±10.10343 | 33.53±9.004 | 0.946   |
| Weight (kg) | 60.53±10.9578   | 61.53±8.977  | 0.686   |
| Sex         | 23±7   | 19±11     | 0.3985   |

SD=Standard deviation
The onset of motor block was within 16.06 ± 4.49 min in Group C and 14.9 ± 3.62 min in Group US group. This was not clinically or statistically significant. Duration of motor blockade in Group US was more than Group C Table 3.

The block was successful in 66.6% of patients in Group C compared to 80% in Group US. Of the remaining patients, partial block requiring additional sedation/analgesia was 13.2% in Group C and 6.66% in Group US. Total failure of block occurred in 20% in Group C compared to 13% in Group US. These were comparable both clinically and statistically. Two patients in Group US and four patients in Group C required additional sedation/analgesia Table 5.

The incidence of vessel injury/haematoma was not noticed in Group US whereas it was 16.67% in Group C which was statistically significant. Incidence of nerve injury was 3.33% in Group C compared to nil in Group US. There was no incidence of pneumothorax in either groups [Table 6].

**DISCUSSION**

Peripheral nerve blocks are cost-effective anesthetic techniques used to provide good quality anesthesia and analgesia while avoiding airway instrumentation and hemodynamic consequences of general anesthesia. Patient satisfaction, a growing demand for cost-effective anesthesia and a favorable postoperative recovery profile have resulted in increased popularity for regional techniques. Brachial plexus block is an easy and relatively safe procedure for the upper limb surgeries.

Lanz et al.⁹ showed that blockade of the brachial plexus with a technique directed near the first rib (at the level of trunks and divisions of brachial plexus) provides the most reliable, uniform, and predictable anesthesia for the upper extremity. It can be given either after eliciting paresthesia or using nerve stimulator.

Frequently cited disadvantages of paresthesia technique include patient discomfort on eliciting paresthesia and that its success is highly dependent on the cooperation of the patient. The presence of phrenic or cervical sympathetic nerve blockade normally requires only reassurance. Although nerve damage can occur, it is uncommon and usually self-limited.¹⁰

This study was done in patients undergoing upper limb surgeries with the similar demographic profile. The study done by Morros et al. suggest that the use of ultrasound in regional anesthesia requires the acquisition of new knowledge and skills not only by anesthesiologists in training but also by anesthesiologists experienced in neurostimulation-guided peripheral nerve blocks.¹¹

**Table 2: Block execution time in both groups**

|                  | Mean±SD | P     |
|------------------|---------|-------|
|                  | Group C | Group US |    |
| Time taken for   | 5.36667±1.449931 | 9.96666±2.442205 | 0.0001 |
| the procedure (min) |        |        |    |

SD=Standard deviation

**Table 3: Onset and duration of sensory block**

|                  | Mean±SD | P     |
|------------------|---------|-------|
|                  | Group C | Group US |    |
| Onset of sensory | 11.26667±3.483 | 11±2.94 | 0.7500 |
| blockade         |        |        |    |
| Duration of      | 393.2±95.33 | 444.16±116.27 | 0.0994 |
| sensory blockade |        |        |    |

SD=Standard deviation

**Table 4: Onset and duration of motor blockade**

|                  | Mean±SD | P     |
|------------------|---------|-------|
|                  | Group C | Group US |    |
| Onset of motor   | 16.06±4.494 | 14.9±3.623201 | 0.272926 |
| blockade         |        |        |    |
| Duration of      | 409.16±86.49 | 409.16±94.03 | 0.6338 |
| motor blockade   |        |        |    |

SD=Standard deviation

**Table 5: Overall effectiveness of the blockade**

|                  | Group C | Group US | Test    | P    |
|------------------|---------|---------|---------|------|
| Totally effective| 20      | 24      | Chi-square test | 0.489118 |
| Partially effective| 4   | 2      |        |      |
| Failure           | 6       | 4       |        |      |
| Total             | 30      | 30      |        |      |

**Table 6: Complications**

|                  | Complications | Count (%) |
|------------------|----------------|-----------|
| Group C          | Nerve injuries | 1 (3.33)  |
|                  | Vessel puncture | 5 (16.67) |
|                  | Pneumothorax   | 0         |
|                  | Nil            | 24 (80.0) |
| Group US         | Nil            | 30 (100)  |

Williams et al.¹² found that the amount of practice necessary to master supraclavicular blockade remains an open question. One of the studies examining the number of brachial plexus blocks needed to attain a reasonable degree of proficiency with the technique estimated that at least 62 blocks should be performed to achieve a success rate of 87%. This number of blocks may not allow most residents to complete their nerve block learning curve before entering practice. The longer time for the block performance found in Group US can be explained by the moderate experience and skills in using the ultrasound.
The onset of sensory blockade in all the major nerve distributions was similar in the conventional and ultrasound groups in our study. Onset time of sensory block in our study was similar to the study done by Danelli et al. The times for sensory and motor blocks in the distribution of radial, axillary, and musculocutaneous nerves were assessed every 5 min until 30 min from the end of LA injection. They found that block onset times and success rate were similar whether nerve stimulation or US was used although US guidance allowed shorter procedural times, fewer needle punctures, and fewer vascular punctures.

In contrast, Marhofer et al. found that the onset time was significantly shorter in the US-guided group compared with both NS-guided Group A (US guidance with 20 mL 0.5% bupivacaine), Group B (received 20 mL 0.5% bupivacaine using NS guidance), Group C (received 30 mL 0.5% bupivacaine using nerve stimulator) (Group A: 13 ± 6 min; Group B: 27 ± 12 min; and Group C: 26 ± 13 min; P < 0.01 to Groups B and C). The quality of sensory block was significantly better in ultrasound group than nerve stimulator.[13]

Williams et al. compared ultrasound and nerve stimulator for the supraclavicular brachial plexus block. They have reported that in Group US, 85% of blocks could be successfully achieved (surgical anesthesia) without supplementation, compared with 78% in nerve stimulator group. General anesthesia was required in 0% and 8% of US and NS patients, respectively.[15] The present study showed that out of thirty patients in ultrasound group, 24 blocks (80%) were completely successful; two blocks (6.66%) were incomplete and needed supplementation; four blocks (13.3%) failed and required general anesthesia. Out of thirty patients in conventional group, twenty blocks (66.66%) were completely successful; four blocks (13.2%) were incomplete and needed supplementation; and 6 blocks (20%) failed and required general anesthesia.

From Williams et al. found that the onset of motor blockade paralleled that of sensory blockade. We found the similar outcome in our study.

Kapral et al. studied ultrasound-guided supraclavicular block. They found that there was no significant difference in the extent of the motor or sensory block of the ulnar, median, and radial nerve between the two groups 1 h after application of block. The onset of plexus block was similar in both groups between 10 and 20 min, with complete analgesia occurring in 40 min.[14] In the present study, the duration of sensory blockade was more in ultrasound group than the conventional group which was not statistically significant.

In contrast, Kapral et al. compared ultrasound and nerve stimulator-guided supraclavicular brachial plexus block in 160 patients and found that sensory, motor, and extent of blockade was significantly better in the ultrasound group when compared with the nerve stimulation group.[15]

Yuan et al. studied the complications of US and peripheral nerve stimulator guidance for upper extremity peripheral nerve blocks (brachial plexus) and found that US decreases the risks of complete hemi-diaphragmatic paresis or vascular puncture and improves the success rate of brachial plexus nerve block compared with techniques that utilize percutaneous nerve stimulation for nerve localization.[16] Larger studies are needed to determine whether or not the use of US can decrease the risk of neurologic complications.

Neurological complications following peripheral nerve blocks, i.e., postblock neuralgia[17] show an incidence of 1.7% up to 12.5%.[18]

Symptoms mostly are moderate and transitory with a tendency of spontaneous recovery within times related to nerve regeneration and repair mechanisms. Interestingly, Kaufman et al. reported a series of seven patients suffering from severe, debilitating chronic pain states after peripheral nerve blocks.[19]

In our study, one patient in the conventional group developed neuropraxia and weakness in radial nerve distribution of the blocked arm postoperatively. The patient was started on steroids. The patient was followed up for 1 month. The patient recovered well within 1 month.

Fear of pneumothorax limits the use of the supraclavicular technique. The incidence of pneumothorax with the classic supraclavicular technique ranges from 0.5% to 6%.[20] No patients in our study showed any clinical evidence of pneumothorax.

Kapral et al. observed no complications such as pneumothorax, puncture of a major blood vessel, paresis or irritation of the plexus, recurrent laryngeal nerve, or the phrenic nerve in his study of ultrasound-guided supraclavicular approach brachial plexus blockade.[15]

**Drawbacks of the study**

There was no blinding in data collection which was a possible source of bias in the present study. The moderate experience of the specialist may have contributed to more procedural times; however, this need not possibly affect the outcome with respect to major study parameters.

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**Conflicts of interest**

There are no conflicts of interest.

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