A Descriptive Study of Safety and Efficacy of Ultrasound-Guided Supraclavicular Brachial Plexus Blocks by Inexperienced Providers

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ABSTRACT

Ultrasound guidance has increased the popularity of using the supraclavicular approach to a brachial plexus block. This study retrospectively evaluated the safety and efficacy of ultrasound-guided supraclavicular block (USSB) conducted by anesthesia residents in patients undergoing upper extremity surgery. The outcomes of 300 consecutive patients who received USSB for upper extremity surgery were reviewed. USSB were performed by inexperienced anesthesia residents under the supervision of a senior anesthesiologist with the regional anesthesia experience. The patients' medical records were reviewed for major complications of USSB including local anesthetic toxicity, pneumothorax, hematoma, nerve injury, hemidiaphragmatic paresis, Horner's syndrome, unintended vascular puncture, seizures, and possible symptoms of these complications over a 1-month postoperative period. Adequate postoperative analgesia was defined as a Visual Analogue Scale (VAS) score of less than three, where 0 = no pain and 10 = unbearable pain, without any request for pain medication within 4 hours.

There were four reported complications for an overall incidence of 1.3%. These complications included one episode of shortness of breath. Three patients reported neuropathy of the blocked arm; all resolved within the thirty-day follow-up period. Ninety-four percent of patients reported VAS of 3 or less within ten minutes following recovery room arrival.

Data from this retrospective case series demonstrates that USSB is associated with a very low rate of complications or failed block in a teaching institution when the block is administered by inexperienced anesthesia registrars.
INTRODUCTION

The supraclavicular approach for brachial plexus blockade offers anesthesia and postoperative analgesia for upper arm surgery [1]. Pneumothorax and inadvertent intravascular administration are fearful complications and the major concern with the traditional landmark-based techniques [2, 3]. Ultrasound guidance for regional anesthesia provides advantages such as shorter procedure duration time, faster onset, lower drug volume, and decrease in the incidence of local anesthetic toxicity [4-8]. Despite evidence that ultrasound guidance increases the safety [9, 10], little data exists regarding the frequency of complications, especially with inexperienced providers.

Anesthesiology residency programs offer a specific regional anesthesia rotation; however, there is concern that residents do not have equal exposure to all types of peripheral nerve blocks. The supraclavicular approach for a brachial plexus block is the least often preformed procedure among available upper extremity blocks [11]. Although the use of ultrasound can ensure safe regional anesthesia practice, it may require sound anatomy knowledge and the skill sets such as visualization of needle tip, and real time injection of the local anesthetic solution [12, 13]. Sites et al. [12] have demonstrated that failure to maintain needle visualization during advancement occurs in up to 43% of cases where the block is being performed by the inexperienced persons.

The incidence of complications of ultrasound-guided supraclavicular block (USSB) in the hands of inexperienced providers is limited. We hypothesized that ultrasound guidance reduced complications associated with supraclavicular nerve block in the inexperienced providers. The primary aim of this retrospective case series was to determine incidence of complications associated with USSB conducted by anesthesiology residents in upper arm surgery cases.

MATERIALS AND METHODS

After Institutional Review Board approval, a retrospective examination of the electronic medical records was performed in 300 consecutive patients who received USSB for upper arm surgery between January 1 and December 31, 2012. The patient age, weight, height, body mass index, American Society of Anesthesiologists Classification, type of surgery, type of the local anesthetics, pain scores within ten minutes at Post-Anesthesia Care Unit (PACU), and analgesic request during hospital stay were collected.

Electronic medical records were also retrospectively reviewed for any major complications following USSB including local anesthetic toxicity, pneumothorax, hematoma, nerve injury, hemidiaphragmatic paresis, Horner’s syndrome, unintended vascular puncture, and seizures. Other symptoms of the complications such as shortness of breath (SOB), dyspnea, chest pain, and weakness of the arm, neurological symptoms including numbness, and altered sensation anywhere in the blocked extremity for a 1-month follow-up period were also noted. The presumed etiology of symptoms was evaluated together with pre-existing conditions.

Regional anesthesia notes, as well as intraoperative and postoperative notes, were reviewed to determine major complications of nerve block. Surgical reports, discharge summaries, and nursing progress notes and outpatient follow-up visits during a 1-month postoperative period were also reviewed. Patients with an incomplete medical record were excluded from the study.

During Acute Pain Service (APS) rotation, physician residents received lectures and hands-on experience with regional anesthesia. After discussing the risk and benefits of the procedure with the patient, USSB were performed by different levels (CA-2 and CA-3) of anesthesia residents under direct supervision by senior APS anesthesiologist in the preoperative holding area. Regional anesthesia documentation included the time and purpose of the nerve block, technique used, medication given, and any complications of the nerve block. Adequate postoperative pain
was defined as a Visual Analogue Scale (VAS) score of less than three, where 0 = no pain and 10 = unbearable pain, without any request for postoperative pain medication within 4 hours.

Categorical variables were presented as frequency and percentages. Continuous variables were presented as mean and standard deviation (SD) or median and interquartile range.

**Ultrasound-Guided Supraclavicular Nerve Block**

Brachial plexus blocks using a supraclavicular approach were performed under real time ultrasound guidance using a Sonosite M-Turbo Miramax Ultrasound System and a high frequency linear probe. The neurovascular structures were imaged on short axis, and the needle was inserted slowly using an in-plane technique. With standard monitoring and sedation with intravenous midazolam and fentanyl, the resident physician utilized ultrasound guidance to find the brachial plexus cephalad to the clavicle. The block proceeded with Stimuplex A insulated needle (B. Braun Medical, Melsungen, Germany), 100 mm or 50 mm length under direct ultrasound visualization to approximate the brachial plexus. The senior anesthesiologist assisted in aspirating and then injecting 5 ml aliquots of ropivacaine (0.5%) solution for a total volume of 25 ml. The injected local anesthetic was seen forming a “lake” surrounding the trunks of the brachial plexus in real time (Figure 1).

**Figure 1. Ultrasound image illustrating brachial plexus (white arrow) and subclavian artery (SCA).**
RESULTS

USSB were performed in 300 consecutive patients who underwent upper extremity surgery during 12 months. During the 12-month period, the lead author has provided anesthesiology resident education in APS. As seen in Table 1, among 300 cases, 143 (48 %) patients underwent renal access surgery, arteriovenous (AV) fistula/basilic vein transposition. These cases were completed under Monitored Anesthesia Care (MAC) and USSB were primarily used to provide surgical anesthesia and postoperative analgesia. Patients who underwent orthopedic surgery received general anesthesia. Characteristics of the patients are presented in Table 1. Ropivacaine was the primary local anesthetic solution used for the nerve block.

<table>
<thead>
<tr>
<th>Table 1. Descriptive data of 300 analyzed supraclavicular nerve block.</th>
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<tbody>
<tr>
<td>Overall (N=300)</td>
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<tr>
<td>Age, years</td>
</tr>
<tr>
<td>Female/Male, n</td>
</tr>
<tr>
<td>Height, cm</td>
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<tr>
<td>Weight, kg</td>
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<tr>
<td>BMI, kg/m²</td>
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<tr>
<td>ASA score, n (%)</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>Comorbidity</td>
</tr>
<tr>
<td>Congestive Heart Failure, n (%)</td>
</tr>
<tr>
<td>Pulmonary disease, n (%)</td>
</tr>
<tr>
<td>Diabetes Mellitus, n (%)</td>
</tr>
<tr>
<td>Chronic Kidney Disease, n (%)</td>
</tr>
<tr>
<td>Obesity (BMI≥30), n (%)</td>
</tr>
<tr>
<td>Morbid obesity (BMI≥40), n (%)</td>
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</tbody>
</table>

[Data are shown as mean ± standard deviation and categorical data as number (rounded %). BMI: body mass index; ASA: American Society of Anesthesiologists.]
There were a total of four cases with reported complications for an overall incidence of 1.3%. Three patients reported paresthesia as numbness in the blocked arm, which resolved within the 30-day follow-up period. One of the four complications consisted of SOB noted immediately after the block placement. The SOB was thought to be due to phrenic nerve blockade, which resolved within two minutes and did not require chest imaging. This occurred in a 58-year-old male who was scheduled for left upper arm basilica vein transposition under MAC. The patient had a history of hypertension, type II Diabetes Mellitus (DM) without complication, and Congestive Heart Failure (CHF). Preoperative block was performed with 150 mg ropivacaine for surgical anesthesia and, immediately after the nerve block, patient complained of SOB. After a comprehensive evaluation of internal medicine, the symptom was evaluated as phrenic nerve involvement.

There were no documented occurrences of pneumothorax, injection site hematoma, inadvertent intravascular injection, Horner’s syndrome, and local anesthetic toxicity.

As seen in Table 2, recovery room VAS < 3 was reported in 94% (282 of 300) of the patients. Eighteen patients failed to achieve adequate postoperative analgesia and required supplemental analgesic treatment with postoperative VAS between 4 and 10 (Table 2).

<table>
<thead>
<tr>
<th></th>
<th>Over all (N=300)</th>
<th>Renal access surgery (N=143)</th>
<th>Orthopedic surgery (N=157)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>VAS score at PACU, median (IQR).</strong></td>
<td>0 (0-0)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Cases with VAS less than 3, n (%)</strong></td>
<td>282 (94)</td>
<td>137 (96)</td>
<td>145 (92)</td>
</tr>
<tr>
<td><strong>Cases with VAS 4-7, n (%)</strong></td>
<td>13 (4)</td>
<td>6 (4)</td>
<td>7 (5)</td>
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<tr>
<td><strong>Cases with VAS 8-10, n (%)</strong></td>
<td>5 (2)</td>
<td>0 (0)</td>
<td>5 (3)</td>
</tr>
<tr>
<td><strong>Pain medication request, n (%)</strong></td>
<td>18 (6)</td>
<td>6 (4)</td>
<td>12 (8)</td>
</tr>
<tr>
<td><strong>Ropivacaine dose ≥150 mg</strong></td>
<td>174 (58)</td>
<td>89 (62)</td>
<td>85 (54)</td>
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</table>

[Data are expressed as median (IQR) or number (rounded %). IQR: interquartile range; VAS: Visual Analogue Scale.]

**DISCUSSION**

According to the current review, the ideal peripheral nerve block technique should be independent of the anesthesiologist’s skill with minimal chance of failed procedures [14]. This retrospective study provides evidence that the incidence of complication rate of USSB is low with the inexperienced people and also supports the view that the blocks performed by trainees, under ultrasound guidance, become safer and with a higher success rate.

Pneumothorax is a major concern for the supraclavicular approach due to the close proximity of the pleura [5]. An incidence rate of pneumothorax has been reported to be between 0.5 and 6.1% and the risk may decrease with experience of the operator [15]. In our study, no pneumothorax occurred even though all USSB were performed by residents with limited peripheral nerve block experience. Perlas et al. [16] reported 510 consecutive cases serious without any clinical signs of pneumothorax and the rate of the other reported complications were symptomatic hemidiaphragmatic paresis (1%) and transient sensory deficits (0.4%).

Koyyalamudi et al. [17] reviewed the interest of supraclavicular blocks for regional anesthesia and concluded that hemidiaphragmatic paralysis from phrenic nerve involvement is a very common complication and may cause
respiratory difficulty especially in patients with reduced functional residual capacity. Diaphragmatic paresis may be seen as SOB, a change in the breathing pattern and/or coughing difficulty. In our retrospective cases, one case had transient phrenic nerve involvement. This patient was undergoing renal access surgery and had multiple comorbidities.

Using ultrasound guidance, clinicians are able to visualize the needle tip with respect to target nerve, pleura, and vascular structure and also distribution of the local anesthetic solution [18]. USSB will not, however, have direct effects on patient specific risk factors such as age or obesity [19]. In a retrospective review, obesity was reported as a risk factor, which may decrease success rate but not block-related complications [20]. They utilized peripheral nerve stimulation and reported that 70% of supraclavicular nerve block was successfully completed by residents in morbidly obese patients. It is still an open question for the amount of practice necessary to be master for USSB. In a small sample size study, Barrington et al. [21] showed significant improvement in the proficiency of participants in capturing sonograms and identifying anatomical structures over 8 to 10 learning sessions. At our institution, anesthesiology residents’ exposure consists of 40 peripheral nerve block procedures during their entire residency program.

The quality of the ultrasound image, especially for deeper structures, may be a concern for morbidly obese patients especially for the inexperienced persons. In a previous study, the incidence of respiratory complication rate was reported to be 4.5% for AV graft formation [21]. Koscielniak-Nielsen et al. [22] reported suspected diaphragmatic paresis in 12% of patients who received USSB for upper extremity surgery. In a prospective study, the frequency of neurological complications was reported as 8.2% at day 10 [23]. In our series, incidence of paresthesia was 1%.

Our study confirms results of previously published studies that adequate postoperative pain control can be achieved with USSB. The success rate of sensory blockade as well as surgical anesthesia for ultrasound guidance is typically 90-100% [6].

Like many retrospective reviews, this study has a number of limitations. Our study is not limited to one type of the surgery. In renal access hemodialysis cases, intraoperative anesthesia was targeted while orthopedic surgery cases received preoperative nerve block for postoperative analgesia. Additionally, this study did not compare different levels of resident’s performance for the nerve block.

CONCLUSION

The data from this retrospective study shows that USSB is associated with a very low rate of complications with higher success rate even in a teaching institution. However, underlying respiratory disease, coagulopathy, and diabetic neuropathy may increase the risk of complications in unoptimized patients.

DECLARATION OF CONFLICTING INTEREST

The authors have no conflicts of interest (political, personal, religious, ideological, academic, intellectual, commercial or any other) to declare in relation to this manuscript.

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