Case Reports/Case Series

Case series: Septa can influence local anesthetic spread during infraclavicular brachial plexus blocks

[Les septa peuvent influencer la diffusion de l'anesthésique local durant les blocs infraclaviculaires du plexus brachial]

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Purpose: To ultrasonically identify the presence of septae within the neurovascular sheath and to assess their effect on local anesthetic spread when performing infraclavicular brachial plexus blocks.

Clinical features: Thirty ASA status I and II patients scheduled for minor hand surgeries were enrolled in the study. Ultrasound guided infraclavicular brachial plexus blocks were performed on 28 patients. The images of the local anesthetic spread and the effect of the septum within the neurovascular sheath were analyzed. Septae were present in four of six patients where unilateral local anesthetic spread was seen. Septae were not visualized in the 22 patients with unrestricted local anesthetic spread after the initial injection. All 28 patients underwent their planned operations successfully with adequate anesthesia.

Conclusions: Our study shows that the presence of septae within the neurovascular sheath may influence the pattern of local anesthetic spread associated with the infraclavicular approach to brachial plexus blocks.

et l'effet du septum dans la gaine neurovasculaire ont été analysés. Des septa étaient présents chez quatre des six patients chez qui on avait observé une diffusion unilatérale de l'anesthésique local. Aucun septum n'a été observé chez les 22 patients où la propagation de l'anesthésique local n'a pas été restreinte après l'injection initiale. Les chirurgies prévues chez les 28 patients se sont bien déroulées avec une anesthésie satisfaisante.

Conclusion : Notre étude montre que la présence de septa dans la gaine neurovasculaire peut influencer le mode de diffusion de l'anesthésique local associé à une approche infraclaviculaire pour les blocs du plexus brachial.

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Objectif : Identifier par échoguidage la présence de septa dans la gaine neurovasculaire et évaluer leur effet sur la diffusion de l'anesthésique local lors de blocs infraclaviculaires du plexus brachial.

Éléments cliniques : Trente patients ASA statut I et II devant subir des chirurgies mineures de la main ont participé à cette étude. Vingt-huit patients ont eu des blocs infraclaviculaires du plexus brachial échoguidés. Les images de la diffusion de l'anesthésique local

A previous cadaveric study revealed that a compartmentalized neurovascular sheath, and uneven distribution of local anesthetic around the nerve components of the plexus may be associated with failed and partial blocks.^{1,2} With the use of nerve stimulators, the success rate of the single injection technique was as low as 44%, especially when only the lateral cord was stimulated.³⁻⁶ We hypothesized that ultrasonographic identification of septae may be beneficial in performing infraclavicular brachial plexus blocks. The purpose of this study was to ultrasonically identify the presence of septae within the neurovascular sheath and to assess their possible effect on local anesthetic spread.

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FIGURE 1 Ultrasound guided infraclavicular block.

FIGURE 3 Ultrasound image of an infraclavicular brachial plexus after initial injection demonstrating unilateral local anesthetic spread. AA = axillary artery; AV = axillary vein; LA = local anesthetic.

FIGURE 2 Ultrasound image of an infraclavicular brachial plexus before injection. (Orientation = left - cephalad, right - caudad). AA = axillary artery; AV = axillary vein.

FIGURE 4 Ultrasound image of an infraclavicular brachial plexus after the completion of injection. The septum is visualized.

Methods

After obtaining the Institutional Review Board approval, 30 consecutive and consenting ASA physical status I and II adult patients who were scheduled to undergo ultrasound guided infraclavicular brachial plexus blocks, were enrolled in the study. Patients were excluded if they had a history of pre-existing neuropathy or bleeding disorder, or required a block technique other than the one described by our protocol. Only one anesthesiologist was assigned as the regional anesthesia provider in this study to reduce the operator variability in techniques.

At our institution, the preferred technique for ultrasound guided infraclavicular brachial plexus block is similar to that described by Sandhu *et al.*⁷ and Klaastad *et al.*⁸ Patients were placed supine with the arm abducted at 90°. Standard monitors were applied, and after the placement of an intravenous catheter, midazolam 2 mg *iv* and fentanyl 50 ug *iv* were administered. At the location slightly caudad and medial to the coracoid process, the ultrasound probe was positioned sagittally to obtain the cross-sectional view of the axillary vessels and nerves (Figure 1); (Sonosite Titan and C11 curved

array 4–7 MHz transducer, Sonosite Inc., Bothel, WA, USA). The brachial plexus cords were typically seen in a circumferential manner within the neurovascular sheath at medial, lateral, and posterior locations around the artery.⁹ After local anesthetic infiltration to the skin at a cranial location, a block needle (22G 30° short bevel 80 mm Chiba type needle, Havel's Inc., Cincinnati, OH, USA) was introduced along the long axis of the ultrasound probe at a 45° angle. Upon the needle tip reaching the lateral aspect of the neurovascular sheath, a dose of approximately 10 mL of local anesthetic was injected slowly under direct visualization. It was observed as an expansion of hypoechoic area around the axillary artery. In our study, the pattern of the local anesthetic spread around the artery after the initial injection was described as either circumferential or unilateral. If the pattern of spread was unilateral, the needle was then redirected to the posterior aspect of the axillary artery to complete the injection (Figures 2, 3). This was done to ensure circumferential local anesthetic spread, which has been thought to increase the success rate.¹⁰ Furthermore, if a septum, which is connective tissue and thus ultrasonically hyperechoic, was visualized during the procedure, it was noted and the location was marked. In our study, septum was differentiated from other hyperechoic connective tissue in the neurovascular sheath by its linear appearance and outward extension to the sheath. All patients in this study received 20 mL of lidocaine 2% with epinephrine 1:200,000, 10 mL of bupivacaine 0.25%, and 3 mL of 8.4% sodium bicarbonate.

Ten minutes after the deposition of the local anesthetic, the effectiveness of anesthesia was assessed by examining the distribution areas of the musculocutaneous, radial, median, and ulnar nerves at the arm and forearm. Pin pricks were used to assess the sensory anesthesia, and the responses were recorded as complete, partial, or no block. Motor blockade was not assessed for the purpose of this study. Additional local anesthetic infiltration and/or conversion to general anesthesia were offered to patients with inadequate blocks.

Results

The study population consisted of 30 consecutive patients. Two patients were excluded from the study because their infraclavicular regions were not accessible. Different approaches to the brachial plexus were employed for those patients. Of the 28 patients who received blocks under the protocol, all underwent their planned operations successfully. Six patients required injections on both lateral and posterior aspects after noting unilateral local anesthetic spread around the axillary artery. Of the patients who received two injec-

TABLE

<i>(n</i> = 28)	
Pattern of the spread (<i>n</i> = 28):	
Circumferential	22
Unilateral	6
Of the 22 patients with circumferential spread:	
Septum visualized	0
Septum not visualized	22
Of the six patients with unilateral spread:	
Septum visualized	4
Septum not visualized	2

tions, septae were present in four patients, delaying the local anesthetic spread onto the posterior and medial sides after the initial lateral injection (Table). The locations of the septae were in postero-lateral aspect of the axillary artery within the neurovascular sheath in all four patients (Figure 4). The septae were not observed at any other location. The remaining two patients with unilateral spread demonstrated no visible septum under the ultrasound examination. The septae were not visualized in the 22 patients with circumferential local anesthetic spread after the initial injections. All 28 patients in the study had complete sensory blocks when assessed ten minutes after the injections. Complications such as inadvertent vessel puncture, pneumothorax, and persistent paresthesiae were not observed in any patient.

Discussion

Our findings indicate that the presence of septae within the neurovascular sheath influence the pattern of local anesthetic spread of the infraclavicular approach to brachial plexus blocks. The ultrasound technology was helpful in visualizing the spread pattern of the local anesthetic. This study provides a correlation of the functional anatomy of the brachial plexus and its effect on the local anesthetic spread with the infraclavicular approach to brachial plexus anesthesia.

Previous cadaveric dissections reveal that the neurovascular sheath of the brachial plexus is a multi-compartmented structure.^{1,2} The brachial plexus originates from the nerve roots of C5 to T1. Once they emerge from the paravertebral foramina, the nerves travel in the interscalene groove formed between the anterior and middle scalene muscles as the connective tissue begins to encircle the nerve plexus. The neurovascular bundle is formed as the structures approach the clavicle. In the infraclavicular region, the plexus sheath often becomes more loosely organized, and the con-

nective tissue often extends inward, forming longitudinal septae between the cords.¹

The lateral aspect of the brachial plexus was chosen as the initial injection site for two reasons. First, because the ultrasound guided block needle was introduced from a cephalad location and directed inferiorly to the neurovascular bundle, the approach to the lateral cord was shorter and more direct when compared to the approach involving the posterior and medial aspects. Secondly, because failed and partial blocks occurred more frequently when the injection was made after stimulating only the lateral cord, we thought that this location would provide us with better opportunity to examine the relationship between the septae and the distribution of local anesthetic.^{3-6,11}

Klaastad *et al.*¹² reported uneven local anesthetic spread on magnetic resonance imaging examination after single injection axillary brachial plexus blocks. In our study, approximately 20% (six of 28) of patients had unilateral spread of the local anesthetic after one injection when the infraclavicular brachial plexus was approached from the lateral direction. Of those patients, septae were visible in approximately 67% (four of six patients) of the time. Patients in our study with circumferential spread did not have identifiable septa. We found that the presence of a septum is associated with unilateral spread of local anesthetic. Because all observed septae were located in posterolateral aspect of the axillary artery, local anesthetic was not seen to reach the posterior cord in cases of suspected septal presence, as has been shown to provide the most effective anesthesia.³⁻⁶ This may explain the high failure rate of the single lateral injection technique. This finding also agrees with a recent study that examined the relationship between the local anesthetic spread and the infraclavicular block success.¹¹

It is generally accepted that multiple injections improve the success of infraclavicular brachial plexus blocks.^{4,5} However, one of the criticisms of the multiple injection technique is its potential to increase complications.⁵ By selectively performing multiple injections only when the local anesthetic spread is unilateral, our blocks were 100% successful without any complication. The use of ultrasound effectively determined the adequacy of a single injection by visualizing the circumferential spread of the local anesthetic in the infraclavicular region. This claim, however, has yet to be verified.

This study has several limitations. Since the initial unilateral spread prompted subsequent injection to ensure circumferential spread around the axillary artery, the resulting block after untreated unilateral spread was not assessed. We can only hypothesize that

the presence of septae resulted in incomplete blocks. Interestingly, if the infraclavicular brachial plexus anatomy is similar to that of the axillary region as described by Partridge *et al.*,² there should be unrestricted fluid movement between the compartments. Although this does not fully support the observed lower success rates with single injection techniques, further study is warranted to examine the outcome of unilateral local anesthetic spread.³⁻⁵ Furthermore, because we used only 33 mL instead of the traditional 40 to 50 mL of local anesthetic in performing the infraclavicular brachial plexus blocks, it is unclear if the smaller volume may have contributed to the observed unilateral spread of local anesthetic in our study. According to Sandhu *et al.*,¹³ however, a volume as low as 14 mL of carefully injected local anesthetic under ultrasound guidance is sufficient to produce adequate nerve blocks. Another factor to consider is the possibility that the ultrasound machine lacked sufficient sensitivity, or the operator failed to recognize finer anatomical features such as thin septae that may have been present in patients who experienced unilateral spread. Conversely, a thin septum may have been present in patients with circumferential spread that did not retard local anesthetic migration. Ultrasound equipment with higher resolution, a dedicated ultrasonographer, or concurrent computed tomography or magnetic resonance imaging could possibly address these issues. It is recognized that ultrasound provides an indirect visualization of anatomic structures and is highly dependent on operator experience in interpreting artifactual images resulting from tissue shadowing and scanning techniques, including transducer angle. Future investigations with larger cohorts appear to be warranted to examine the implications and complications of ultrasonography for detecting septae within the targeted sheath, and thus determining the need for multiple injections in performing infraclavicular brachial plexus blocks.

In conclusion, this study shows that septae within the neurovascular sheath may alter the distribution of local anesthetic spread associated with the infraclavicular approach to brachial plexus blocks.

References

- 1 Thompson GE, Rorie DK. Functional anatomy of the brachial plexus sheaths. *Anesthesiology* 1983; 59: 117-22.
- 2 Partridge BL, Katz J, Benirschke K. Functional anatomy of the brachial plexus sheath: implications for anesthesia. *Anesthesiology* 1987; 66: 743-7.
- 3 Lecamwasam H, Mayfield J, Rosow L, Chang Y, Carter C, Rosow C. Stimulation of the posterior cord predicts

- successful infraclavicular block. *Anesth Analg* 2006; 102: 1564–8.
- 4 *Rodriguez J, Barcena M, Taboada-Muniz M, Lagunilla J, Alvarez J.* A comparison of single versus multiple injections on the extent of anesthesia with coracoid infraclavicular brachial plexus block. *Anesth Analg* 2004; 99: 1225–30.
 - 5 *Gaertner E, Estebe JP, Zamfir A, Cuby C, Macaire P.* Infraclavicular plexus block: multiple injection versus single injection. *Reg Anesth Pain Med* 2002; 27: 590–4.
 - 6 *Porter JM, McCartney CJ, Chan VW.* Needle placement and injection posterior to the axillary artery may predict successful infraclavicular brachial plexus block: a report of three cases. *Can J Anesth* 2005; 52: 69–73.
 - 7 *Sandhu NS, Capan LM.* Ultrasound-guided infraclavicular brachial plexus block. *Br J Anaesth* 2002; 89: 254–9.
 - 8 *Klaastad O, Smith HJ, Smedby O, et al.* A novel infraclavicular brachial plexus block: the lateral and sagittal technique, developed by magnetic resonance imaging studies. *Anesth Analg* 2004; 98: 252–6.
 - 9 *Sauter AR, Smith HJ, Stubhaug A, Dodgson MS, Klaastad O.* Use of magnetic resonance imaging to define the anatomical location closest to all three cords of the infraclavicular brachial plexus. *Anesth Analg* 2006; 103: 1574–6.
 - 10 *Chan VW, Perlas A, Rawson R, Odukoya O.* Ultrasound-guided supraclavicular brachial plexus block. *Anesth Analg* 2003; 97: 1514–7.
 - 11 *Bloc S, Garnier T, Komly B, et al.* Spread of injectate associated with radial or median nerve-type motor response during infraclavicular brachial-plexus block: an ultrasound evaluation. *Reg Anesth Pain Med* 2007; 32: 130–5.
 - 12 *Klaastad O, Smedby O, Thompson GE, et al.* Distribution of local anesthetic in axillary brachial plexus block: a clinical and magnetic resonance imaging study. *Anesthesiology* 2002; 96: 1315–24.
 - 13 *Sandhu NS, Bahniwal CS, Capan LM.* Feasibility of an infraclavicular block with a reduced volume of lidocaine with sonographic guidance. *J Ultrasound Med* 2006; 25: 51–6.