BRIEF TECHNICAL REPORT

A Cadaver Study Investigating Structures Encountered by the Needle During a Retroclavicular Approach to Infraclavicular Brachial Plexus Block

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Background and Objectives: Retroclavicular block is designed to overcome the negative aspects of the commonly utilized ultrasound-guided parasagittal approach to the infraclavicular block. However, this approach necessitates the needle traversing an area posterior to the clavicle inaccessible to ultrasound wave conduction. This study sought to document the structures vulnerable to needle injury during a retroclavicular block.

Methods: A Tuohy needle was inserted using a retroclavicular approach to the infraclavicular block in 3 lightly embalmed cadavers followed by a catheter insertion 4 cm beyond the needle tip. The process was repeated on the contralateral side. With the needle and catheter in position, the cadavers were dissected and photographed.

Results: In 4 of the 6 dissections, the needle was directly touching the suprascapular nerve deep to the clavicle. In the remaining 2 dissections, the suprascapular nerve was within 2 cm of the needle. In 1 dissection, the suprascapular vein was indented, behind the clavicle. The trapezius was the only muscle layer traversed by the needle in all dissections. In 3 of the 6 dissections, the catheter penetrated the posterior cord. In the remaining 3, the catheter threaded along the neurovascular bundle.

Conclusions: The suprascapular nerve is consistently in the path of the block needle posterior to the clavicle. This raises the possibility of risk of injury to the suprascapular nerve when using this approach to the brachial plexus. Vascular injury is also possible deep to the clavicle, and because of the noncompressible location, caution is advised in patients with disordered coagulation.

(*Reg Anesth Pain Med* 2018;43: 752–755)

Infraclavicular brachial plexus block is useful approach to provide anesthesia and analgesia for the elbow, forearm, and hand surgery.[1] The commonly utilized ultrasound-guided parasagittal method has several disadvantages: needle visualization can be difficult because of its steep insertion angle, the lateral cord is vulnerable to injury, and the acromial branch of the thoracoacromial artery is prone to puncture.[2,3] In 2007, Hebbard and Royse[4] published an ultrasound-guided posterior approach to the infraclavicular brachial plexus designed to overcome these limitations. With this approach, the needle is inserted posterior to the clavicle and passes underneath it in a cephalad-to-caudad direction. This allows excellent needle visualization as the ultrasound beam is perpendicular to the shaft of the needle. Further, the needle trajectory is posterior to the lateral cord and acromial artery and therefore might reduce the chance of direct needle trauma to these structures during the procedure.[3] Charbonneau and colleagues[5] showed the technique is quick and reliable. Subsequently, Ozturk and Kavakli[6] replicated these findings and found this "retroclavicular approach" is associated with better needle tip and shaft visibility, reduced performance time, and fewer paresthesias than with the conventional approach.

However, there is one significant disadvantage to the retroclavicular approach: the bony clavicle causes acoustic impedance, creating a "blind spot" that the needle must traverse before appearing on the ultrasound image. Structures behind the clavicle cannot be visualized and therefore are at risk of damage. Preexisting anatomical descriptions of the area indicate that the subclavius muscle, supraspinatus muscle, and subscapularis muscle may be encountered during needle insertion, and the suprascapular nerve and its attendant artery and vein may be vulnerable to injury.[4] To our knowledge, there is no published cadaver dissection describing the structures that lie in the needle's path while using the retroclavicular approach. The purpose of this study was to facilitate reflection that hopefully will improve safety and quality, considering lack of knowledge in this area. The primary objective of this cadaver study was to describe structures encountered by the needle during a retroclavicular block. Our secondary goal was to investigate the course of the catheter beyond the needle tip.

METHODS

After approval by the Nova Scotia Health Authority Research Ethics Board, 3 lightly embalmed cadavers were independently chosen by the manager of the Human Body Donation Program at Dalhousie University. The details of the embalming procedure have been described in a previous publication.[7] Exclusion criteria included deformity or injury to the shoulder region.

Cadaver Preparation

Following surface disinfection, cadavers were embalmed (950 mL/min at 18 psi) using a commercial embalming machine (Dodge Co, Mississauga, Ontario, Canada) and a 2-stage process. The primary solution (3 L) contained 5% potassium acetate (Univar, Dartmouth, Nova Scotia, Canada) and 17% glycerol (Univar) in warm water. The secondary solution (3.74 L) contained 6.5%

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Accepted for publication March 10, 2018.
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No external funds were obtained for the study. Internal departmental funds were used.
V.U. has been a principal investigator for a Recro Pharma (Devault, PA)–funded clinical trial involving intravenous meloxicam in Halifax, Nova Scotia, Canada. This conflict does not directly or indirectly affect the conduct or reporting of this study. The authors declare no conflict of interest.
Author contributions: Study design/planning: all authors; study conduct: S.F.S., V.U., R.S.; writing of the paper: S.F.S., V.U; revision of the manuscript: all authors.
Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's Web site (www.rapm.org).

ISSN: 1098-7339
DOI: 10.1097/AAP.0000000000000826

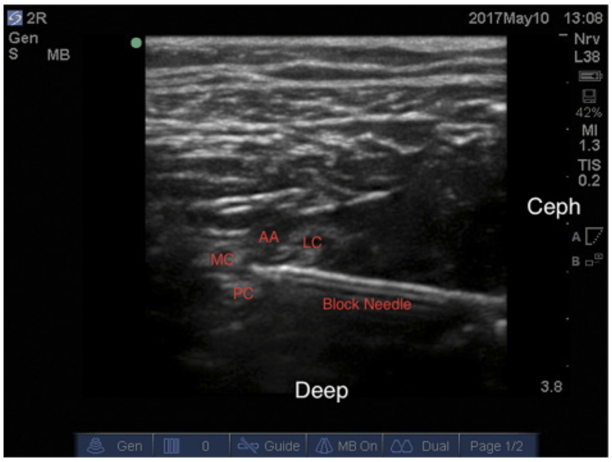

FIGURE 1. Needle tip deep to the axillary artery. AA indicates axillary artery; LC, lateral cord; MC, medial cord; PC, posterior cord.

commercial arterial embalming chemical (B4; Hydrol Chemical Co, Yeadon, Pennsylvania) in warm water. After embalming, the cadavers were washed thoroughly, catalogued, and wrapped in flannel sheets moistened with a solution of 1.5% phenol (VWR, Mississauga, Ontario, Canada), 9.5% ethanol (Commercial Alcohols, Toronto, Ontario, Canada), and 11% glycerol in water to prevent mold growth and to slow dehydration. The cadaver was placed in a sealed pouch and kept at 4°C until use.

Block Procedure

A SonoSite M-turbo (FUJIFILM SonoSite, Inc, Bothell, Washington) ultrasound machine and linear array probe (7–13 MHz) were used by an experienced regional anesthesiologist (S.F.S.) who performed bilateral retroclavicular needle/catheter insertions on each cadaver using an 18-gauge Arrow Tuohy Needle (Arrow International, Reading, Pennsylvania) and Arrow Stimulating Catheter (Arrow International).

The retroclavicular block was performed as described by Charbonneau and colleagues.[5] Each cadaver was positioned supine with arms fully adducted and head turned away from the block side. The ultrasound probe was placed in a parasagittal orientation in the deltopectoral groove just medial to the coracoid process. Here the axillary artery and its surrounding cords are visualized. The probe was then moved medially to a point where the pleural lining becomes visible, then moved back laterally to ensure at least 1.5 cm from the axillary artery to the pleura.

The needle insertion site was chosen using the triangulation technique described by our group previously.[8] The distance from the anterior chest wall to the posterior cord (6 o'clock to axillary artery) was measured on the ultrasound image. This depth was used as a needle insertion point posterior to the clavicle with the goal of achieving a horizontal angle of needle insertion relative to the anterior chest wall (Figure, Supplemental Digital Content 1, http://links.lww.com/AAP/A253). The needle was inserted posterior to the clavicle and advanced 3 to 4 cm until its tip became visible on the ultrasound screen. Once the needle was visualized, the needle tip was guided in-plane to the posterior aspect of the axillary artery (Fig. 1), and the catheter was inserted 4 cm past the needle tip. Ultrasound still images and videos were recorded throughout each procedure onto the hard drive of the ultrasound machine. The needle and catheter were left in place during the dissection process.

Dissection Procedure

Dissections were performed by an experienced anatomist (R.S.). Initially, the skin cephalad to the clavicle was removed to reveal the trapezius (Figure, Supplemental Digital Content 2, http://links.lww.com/AAP/A254), deltoid, and clavicle. As the subcutaneous fat was resected, the superior trunk could be easily visualized running over the middle scalene muscle and giving off the suprascapular nerve. Next, the suprascapular nerve was stripped of investing tissue to reveal its course posterior to the clavicle. After this, the dissection caudad to the clavicle was performed, starting with the removal of the skin and subcutaneous fat to reveal the pectoralis major. The pectoralis major muscle was reflected to allow resection of pectoralis minor. Beneath this, the axillary artery, brachial plexus, Tuohy needle, and catheter were visible. Excess subcutaneous tissue was resected to allow good visualization of the relationship between the needle, the catheter, the brachial plexus, and the axillary artery. In the final phase, a bone saw was used to resect the portion of clavicle lying above the needle. It was difficult to completely immobilize the needle during clavicle resection with a saw. However, the presence of the catheter maintained needle stability and some information about structures that had been penetrated (if the catheter was within a structure, most likely it had been initially penetrated by the needle itself). Resecting the clavicle revealed the relationship

TABLE 1. Structures Penetrated by the Needle During Dissection

Cadaver	Cephalad to Clavicle	Deep to Clavicle	Caudad to Clavicle	Comments
1: Left side (55 y, female)	Skin, subcutaneous tissues, trapezius	Adipose/connective tissue, suprascapular nerve (touching only)	Adipose/connective tissue, posterior cord	Permanent pacemaker and wires clear of needle
1: Right side (55 y, female)	Skin, subcutaneous tissues, trapezius	Adipose/connective tissue, suprascapular vein (touching only)	Adipose/connective tissue	
2: Left side (59 y, male)	Skin, subcutaneous tissues, trapezius	Adipose/connective tissue, suprascapular nerve (touching only)	Adipose/connective tissue, posterior cord	Likely had radiation to left chest wall, difficult dissection
2: Right side (59 y, male)	Skin, subcutaneous tissues, trapezius	Adipose/connective tissue, suprascapular nerve (touching only)	Adipose/connective tissue, radial nerve, axillary nerve	
3: Left side (83 y, male)	Skin, subcutaneous tissues, trapezius	Adipose/connective tissue	Nil	
3: Right side (83 y, male)	Skin, subcutaneous tissues, trapezius	Adipose/connective tissue, suprascapular nerve (touching only)	Nil	

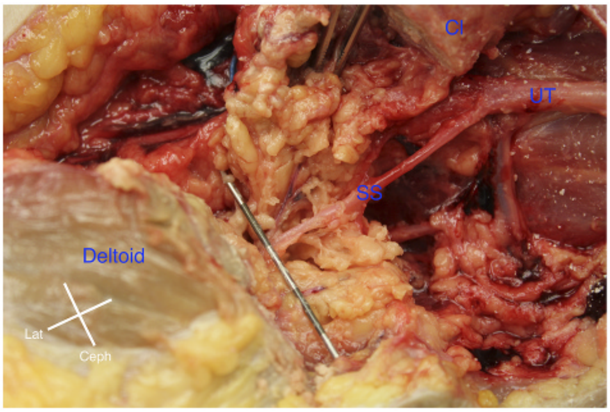

FIGURE 2. Clavicle has been resected, and the suprascapular nerve is seen just deep to the needle. Ceph indicates cephalad; Cl, cut end of the clavicle; Lat, lateral; SS, suprascapular nerve; UT, upper trunk.

between the needle and such elements as the suprascapular nerve and suprascapular vein posterior to the clavicle.

RESULTS

Three cadavers each had bilateral block procedures and dissections, giving a total of 6 dissections. The individual dissection results are presented in Table 1. In 4 instances, the needle shaft was touching the suprascapular nerve (Fig. 2) and within 2 cm in the other 2 cases. It did not penetrate the nerve in any instance. One dissection revealed the needle shaft was touching the suprascapular vein under the clavicle (Fig. 3). The only muscle layer traversed in all dissections was the trapezius (Figure, Supplemental Digital Content 2, http://links.lww.com/AAP/A254), subclavius being consistently medial to the needle (Fig. 3). In 3 instances, the catheter had penetrated the posterior cord or its components (radial and axillary nerves) (Fig. 4 and Figure, Supplemental Digital Content 3, http://links.lww.com/AAP/A255). In the other 3 dissections, the catheter coursed along the neurovascular bundle (Fig. 5 and Figure, Supplemental Digital Content 4, http://links.lww.com/AAP/A256). The catheter tip was coiled and remained near the plexus in all cases.

None of the cadavers had scarring to indicate previous shoulder surgery. Cadaver 1 had an implanted pacemaker on the left side. Our block needle did not come close to the unit or the leads.

FIGURE 3. Posterior aspect of the resected clavicle. The needle passes between the suprascapular vein and the clavicle. Subclavius ends medial to the needle. AT, adipose tissue; Ceph, cephalad; Lat, lateral; PC, posterior surface of the clavicle.

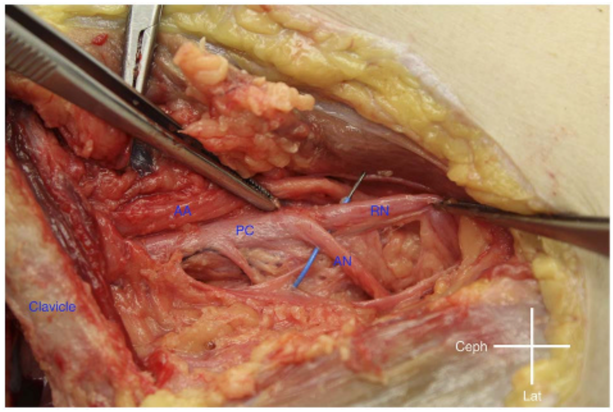

FIGURE 4. Catheter transecting axillary and radial nerves close to where the posterior cord divides. Tuohy needle has been withdrawn for clarity. AA indicates axillary artery; AN, axillary nerve; Ceph, cephalad; Lat, lateral; PC, posterior cord; RN, radial nerve.

Cadaver 2 appeared to have had radiation to the left chest wall, and cause of death was breast cancer. This made dissection difficult but did not appear to affect the block procedure.

DISCUSSION

The cadaver dissections during this study showed that there are some vulnerable structures in the needle path posterior to the clavicle. The suprascapular nerve is consistently present in the needle path during the performance of a retroclavicular block, and the needle was touching the suprascapular vein in 1 out of 6 dissections. The only muscle layer traversed was trapezius. In 3 of the 6 dissections, there was penetration of the posterior cord or its components.

To our knowledge, this is the only reported cadaveric dissection investigating the anatomy deep to the clavicle in the setting of the retroclavicular block. Our dissections showed that the suprascapular nerve was directly touching the needle posterior to the clavicle in half of the dissections and in close proximity in the other cases. Ultrasound is not helpful in avoiding this nerve because of the acoustic shadow of the clavicle, which suggests the possibility of needle injury to the suprascapular nerve. The incidence of suprascapular nerve injury after retroclavicular block

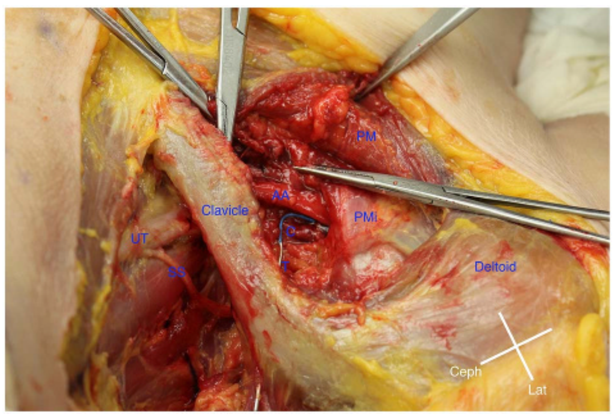

FIGURE 5. Catheter traveling along neurovascular bundle (posterior to artery). AA indicates axillary artery; C, catheter; Ceph, cephalad; Lat, lateral; PM, pectoralis major (reflected); PMi, pectoralis minor; SS, suprascapular nerve; T, Tuohy needle; UT, upper trunk.

has not been reported in the literature. Considering that the technique is relatively new, the incidence of injury may become apparent as the technique gains popularity. Suprascapular nerve injury may manifest as a weakness with external rotation indicating denervation of the infraspinatus and supraspinatus muscles.[9] Potential safety measures could include an awake patient instructed to report paresthesia and the use of nerve stimulator during needle advancement to warn of the close proximity of the needle tip to the suprascapular nerve.[10] Other nerves could also be at risk such as the supraclavicular nerves, but we did not find any of its branches near the block needle.[11]

This study demonstrated that vascular structures such as the suprascapular vein travel just deep to the clavicle and could be vulnerable to injury. Considering these vessels are hidden from ultrasound by the clavicle and are in a noncompressible location, caution should be exercised with this approach in patients with disordered coagulation.

The dissections revealed several penetrations of the posterior cord, which may be linked to the cadaver model used. We noted that after the needle emerged caudad to the clavicle we had to angle it anteriorly toward the anterior chest wall on several occasions. Perhaps the deflated lungs in the cadaver model resulted in a loss of intrathoracic volume, thereby altering the approach angle to the posterior cord. Furthermore, the loss of elasticity of the cords in cadavers might make them more susceptible to needle penetration. There is no previous published literature with which to compare these findings. Future clinical studies should closely monitor if the incidence of neurological injury is more likely with the retroclavicular approach when compared with conventional infraclavicular techniques.

Limitations of this study include a small sample size with 6 dissections. This raises the possibility that individual anatomical variations may unduly influence the results. Nevertheless, it is enough to emphasize the potential risks involved and should be of interest to the anesthesia community. All cadavers had a normal body mass index, so the results may not apply to very large or very thin patients. The collapse of the axillary artery and lung in the cadaver model limits its ability to represent conditions in living patients once the needle tip is caudad to the clavicle. Further, injury to small branches of the supraclavicular nerve would also be challenging to discover. Finally, the clinical safety of the technique regarding neurological and vascular injury cannot be determined using cadaver models.

CONCLUSIONS

The needle passes close to the suprascapular nerve during the performance of a retroclavicular block. Further study is required to determine if this results in a clinically significant risk of suprascapular nerve injury. Reasonable safety precautions may include an awake patient instructed to report paresthesia and the use of nerve stimulator during needle advancement. The presence of vulnerable vascular structures deep to the clavicle should prompt caution when considering this block in patients with disordered coagulation.

ACKNOWLEDGMENTS

The authors thank the individuals and families of those that donate their bodies to science.

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