



Brief Report

Ultrasound-guided retroclavicular approach infraclavicular brachial plexus block for upper extremity emergency procedures



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ABSTRACT

The American Society of Anesthesiology guidelines recommend multimodal analgesia that combines regional anesthetic techniques with pharmacotherapy to improve peri-procedural pain management and reduce opioid related complications. Commonly performed emergency procedures of the upper extremity such as fracture and dislocation reduction, wound debridement, and abscess incision and drainage are ideal candidates for ultrasound-guided (USG) regional anesthesia of the brachial plexus. However, adoption of regional anesthesia by emergency practitioners has been limited by concerns for potential complications and perceived technical difficulty. The Retroclavicular Approach to The Infraclavicular Region (RAPTIR) is a newly described USG brachial plexus block technique that optimizes sonographic needle visualization as a means of making regional anesthesia of the upper extremity safer and easier to perform. With RAPTIR a single well-visualized injection distant from key anatomic neck and thorax structures provides extensive upper extremity anesthesia, likely reducing the risk of complications such as diaphragm paralysis, central block, nerve injury, vascular puncture, and pneumothorax. Additionally, patient positioning for RAPTIR is well suited for the awake, acutely injured ED patient as the upper extremity remains adducted in a position of comfort at the patient's side. Thus, RAPTIR is a potentially ideal combination of infraclavicular targeting, excellent needle visualization, single injection, safety, comprehensive upper extremity analgesia, rapid performance, and comfortable patient positioning. Herein we present the first description of the RAPTIR utilized in the ED. Our initial experience suggests this is a promising new technique for brachial plexus regional anesthesia in the ED setting.

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1. Introduction

Emergency practitioners (EPs) routinely manage patients with painful upper extremity injuries, fractures, dislocations, large wounds or abscesses. Reliance on procedural sedation and opioids for peri-procedural pain control often results in inadequate analgesia while risking the complications of unintended sedation, hypotension, nausea, vomiting, and respiratory depression [1]. Procedural sedation involves assembling a team of additional staff and equipment, often impeding ED patient throughput, and potentially exposing the patient to rare but serious complications including apnea and hypotension. Hence, the surgical-grade anesthesia of the arm provided by ultrasound guided (USG) regional anesthesia of the brachial plexus is an appealing alternative in this patient population [2]. Despite the many benefits of brachial plexus anesthesia for appropriately selected ED patients, concerns for technical difficulty and potential complications have slowed its adoption within

emergency medicine. The recently described retroclavicular approach infraclavicular brachial plexus block also known as the Retroclavicular Approach to The Infraclavicular Region (RAPTIR) [3] may provide a safer and easier technique well suited to emergency practice.

2. RAPTIR brachial plexus block background and anatomic basis

The upper extremity is almost entirely innervated by an interconnected network of nerves that arise primarily from the anterior rami of the C5–T1 spinal nerves to form the brachial plexus. These nerve roots combine into 3 trunks, divide into 6 divisions, recombine into 3 cords, and finally split to the 5 terminal branches of the musculocutaneous, axillary, median, radial, and ulnar nerves. As the plexus emerges from the neck it is enveloped in an extension of the prevertebral fascia that forms the axillary sheath. This sheath, which also contains the axillary artery, surrounds the plexus as it courses away from the neck under the clavicle, through the axilla, and into the proximal arm [4–7]. The familiar (in order from proximal to distal) interscalene (ISB), supraclavicular (SCB), infraclavicular (ICB) and axillary (AXB) blocks all deposit local anesthetic (LA) in this fascial sheath at different locations along its course from neck to arm [4–7].

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For extensive upper extremity anesthesia in the ED setting, ICB has several advantages over ISB and SCB including more reliable blockade of the ulnar nerve, and fewer adverse events such as diaphragm paralysis, central block, pneumothorax, or Horner's syndrome [6–11]. This makes ICB a better choice for ED patients with pulmonary comorbidities or respiratory depression secondary to opiates administered pre-hospital and in the ED, who may not tolerate the potentially significant compromise of respiratory function from phrenic nerve blockade and resulting diaphragm paralysis.

Like the ICB, the AXB targets the brachial plexus a safe distance from the neck and pleural dome. However, for an AXB the arm must be abducted, which is poorly tolerated by ED patients with an acutely injured upper extremity [7,8]. Furthermore, early branching of the medial cutaneous nerve of the forearm, musculocutaneous nerve, and axillary nerves requires multiple needle passes and redirections for an AXB to achieve the extensive arm anesthesia that can be achieved by a single injection ICB [6–8]. Each needle pass and redirection adds time to the

procedure and increases risk of needle to nerve contact or vascular puncture.

Another advantage of the ICB over other brachial plexus blocks is the simplified sonoanatomy of the infraclavicular space. The primary landmarks, the axillary artery and second rib, are easily identified and avoided. Even the individual cords of the plexus need not be identified sonographically, as a larger volume of LA can be injected within the sheath at the infraclavicular location with minimal risk of adverse effect. This permits reliable blockade of all the cords with a single injection, eliminating the need to target them individually [12–17].

Despite all these advantages, wider adoption of the ICB has likely been hindered by the poor needle visualization associated with the ICB. Passing a block needle from the traditional insertion site just below the clavicle to the brachial plexus requires a steep trajectory. This places the needle and the ultrasound beam at an acute angle to one another, resulting in the ultrasound beam reflecting off the needle and away from the transducer, greatly reducing needle visibility [18,

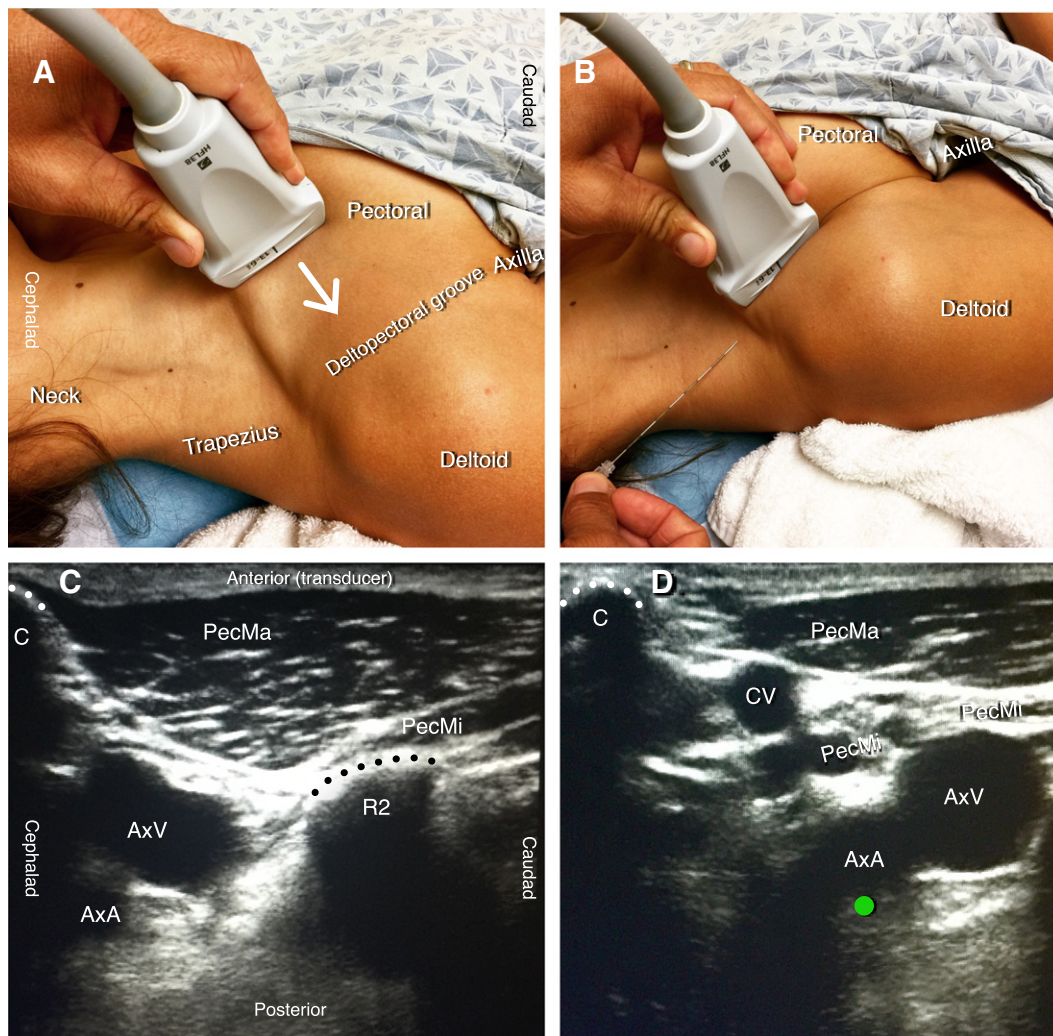


Fig. 1. Ultrasound technique for finding the injection target. A. Position A: With the transducer marker cephalad, the transducer is placed on the medial clavicle in the parasagittal orientation with the clavicle and infraclavicular region in view. B. Position B: Maintaining the same orientation and keeping the clavicle at the cephalad edge of the view, the transducer is moved laterally to the deltopectoral groove, placing the transducer lateral to the thoracic cage and medial to the coracoid process. While moving the transducer, the axillary artery is sonographically observed emerging from beneath the clavicle, traversing the 2nd rib, then coursing away from the thoracic cage. When the second 2nd rib drops out of view the injection target is identified. The transducer is then rotated slightly so that the caudad portion aims towards the axilla. C. Ultrasound image at Position A. Axillary artery visible emerging from under the clavicle. The 2nd rib is also visible. D. Ultrasound image at Position B. Axillary artery and clavicle still in view, but the 2nd rib is no longer visible as the transducer has moved lateral to the thoracic cage. The injection target posterior to the axillary artery is now in view. *With experience an alternative position can be used between position A and position B, in a location where the axillary artery has emerged far enough from the clavicle to have a sufficient view of the approaching needle, but where the 2nd rib is still in view and used to shield the pleura from the needle. This can be helpful in patients with a "full" supraclavicular fossa, but is not advised for novice practitioners.* Dotted line = clavicle, C = acoustic shadow of the clavicle, PecMa = pectoralis major, PecMi = pectoralis minor, AxA = axillary artery, AxV = axillary vein, R2 = 2nd rib, CV = cephalic vein, green dot = injection target location. (AxV and CV may not be visible on ultrasound due to compression from transducer pressure on the chest wall).

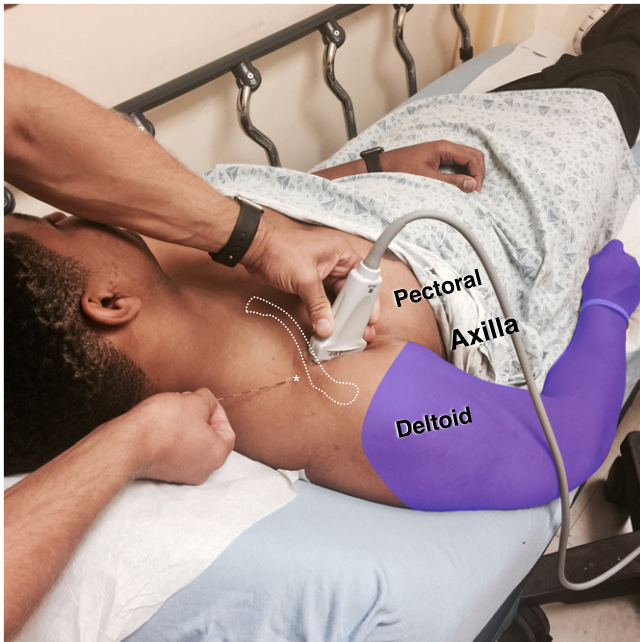


Fig. 2. Needle, transducer, and axilla alignment; angle of approach; and area of anesthesia. The transducer is in the deltopectoral groove with the injection target in view on ultrasound and rotated slightly to aim at the axilla. The needle insertion point is approximately 2 cm cephalad to the clavicle and aligned with the ultrasound beam. The angle of approach is parallel with both the gurney bed and the transducer surface. Dotted line = clavicle, asterisk = insertion point, Pec = pectoral, purple shading = area of anesthesia with the RAPTIR.

perpendicularly and reflects directly back to the transducer, greatly enhancing needle visibility. Thus, the operator can maneuver the needle to the injection target assured that the needle tip is avoiding adjacent neurovascular and thoracic structures [20–22].

Since the ultrasound beam cannot penetrate the clavicle, the RAPTIR block needle initially passes through an approximately 3 cm “blind zone” before emerging from the clavicle’s acoustic shadow and becoming visible on ultrasound in the infraclavicular space. This presents the novel experience of passing a needle behind a bone while performing a regional block. To safely transverse this “blind zone,” the transducer is positioned lateral to the thoracic cage and aimed towards the axilla, then the advancing needle is simply aligned with the long axis of the ultrasound beam. By staying close to the underside of the clavicle and advancing at an angle parallel to the surface of the gurney bed, the block needle passes safely through muscle and loose connective tissue [20–25].

3. Cases

Patient 1: A 16-year-old male needed reduction and splinting of a closed distal radius fracture and ulnar dislocation (Galeazzi fracture) after his gloved hand was caught in a drill press.

Patient 2: A 56-year-old male required reduction and splinting of a closed posterior elbow dislocation after a fall.

Patient 3: A 62-year-old female needed I&D of a large deltoid abscess after injection drug use.

In all patients, a RAPTIR was performed using 30 mL of 1%–1.5% lidocaine with epinephrine. All patients had complete upper extremity anesthesia within 30 min permitting comfortable, awake completion of needed procedures.

4. Description of technique

4.1. Pre-assessment

Inspect the patient’s pectoral region, clavicle, supraclavicular fossa, and neck length. Patients with a thick pectoral region, deformed clavicle

19]. For the non-specialist, navigating a poorly visualized needle to a peri-vascular injection target can be a formidable task.

The RAPTIR was developed to overcome this limitation by approaching the brachial plexus “retroclavicularly,” i.e. from behind the clavicle, placing the block needle at an angle parallel to the ultrasound transducer. At this angle, the ultrasound beam strikes the needle

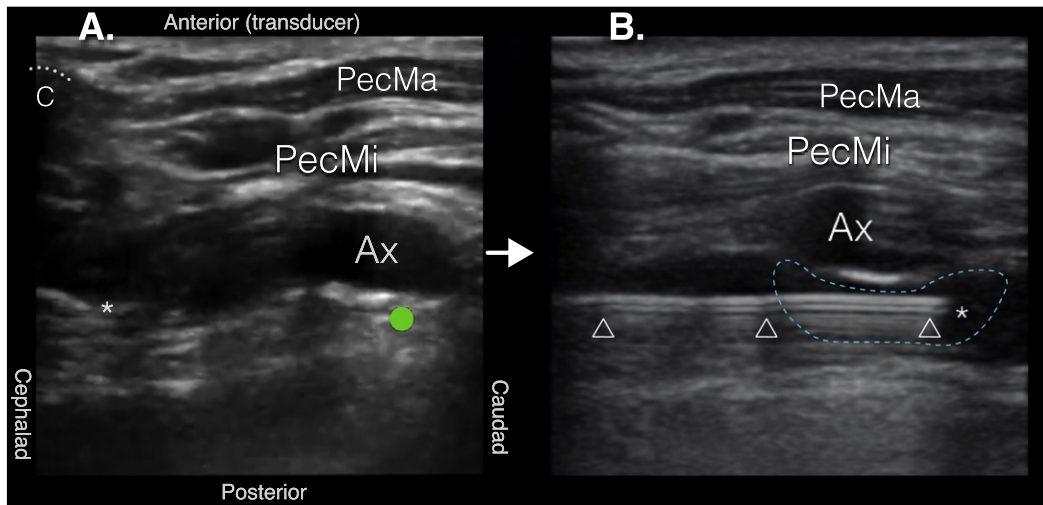


Fig. 3. Ultrasound guidance of block needle. A. After traversing the approximately 3 cm “blind zone” further needle advance is stopped and slight transducer and needle adjustments are made until the needle tip is visible emerging from the clavicle’s acoustic shadow. B. The block needle is then advance with in-plan ultrasound guidance to the target location just posterior to the axillary artery. Fine adjustments in needle position are made until small test injections of normal saline or local anesthetic (LA) are seen spreading within the axillary sheath just posterior to the artery. The axillary artery often appears to float away (anteriorly towards the transducer) from the needle tip with injection, and anechoic anesthetic fluid collects just posterior to the artery (forming the “double bubble sign”, with the first “bubble” being the axillary artery and the second “bubble” being the injected fluid) as additional confirmation of injectate deposition within the axillary sheath [12,13]. Once satisfied with the needle position, LA is gradually injected in small aliquots following negative aspiration, until a total of 20–35 mL is deposited within the sheath. White dotted line = clavicle, C = acoustic shadow of the clavicle, PecMa = pectoralis major, PecMi = pectoralis minor, Ax = axillary artery, asterisk = needle tip, triangles = needle shaft, green dot = injection target location, blue dashed line = LA.

(such as from prior fracture), “full” supraclavicular fossa, or a short neck are poor candidates for the RAPTIR and another technique should be considered.

4.2. Positioning

Place the patient in a semi-recumbent supine position with the affected extremity adducted at their side in a position of comfort. Rotate the patients head away from the injured limb, and place a folded towel under the ipsilateral shoulder. Stand at the head of the bed with the ultrasound system in direct line-of-sight on the side of injury.

4.3. Scanning

Place a high-frequency linear transducer in parasagittal orientation over the medial portion of the clavicle with the transducer marker facing cephalad (Fig. 1A). Slide the transducer laterally along the clavicle to the deltopectoral groove, then rotate the transducer slightly so that it aims towards the axilla (Fig. 1B). While sliding laterally, sonographically visualize the axillary artery in cross section as it

emerges from under the clavicle (Fig. 1C), traverses the 2nd rib, then courses away from the thoracic cage (Fig. 1D). The extrathoracic portion of the axillary artery will be apparent on ultrasound when the 2nd rib drops out of view. At this location, identify the injection target which lies just posterior to the axillary artery.

4.4. Injection

Keeping the transducer fixed over the injection target and aimed at the axilla, identify a block needle insertion site aligned with the long axis of the ultrasound beam and approximately 2 cm cephalad to the clavicle (Fig. 2). This will ensure a safe needle path and allow adequate room for the needle to clear the posterior surface of the clavicle without angling posteriorly.

Place a LA skin wheal at the insertion site using a 25–27 g needle, then insert a block needle (e.g. Tuohy 20 g 90 mm epidural needle) through the skin wheal and advance the needle beneath the clavicle towards the ultrasound beam at angle parallel to the gurney bed. When passing through the “blind zone” created by the clavicle, the needle should never be angled posteriorly as this increases the risk of

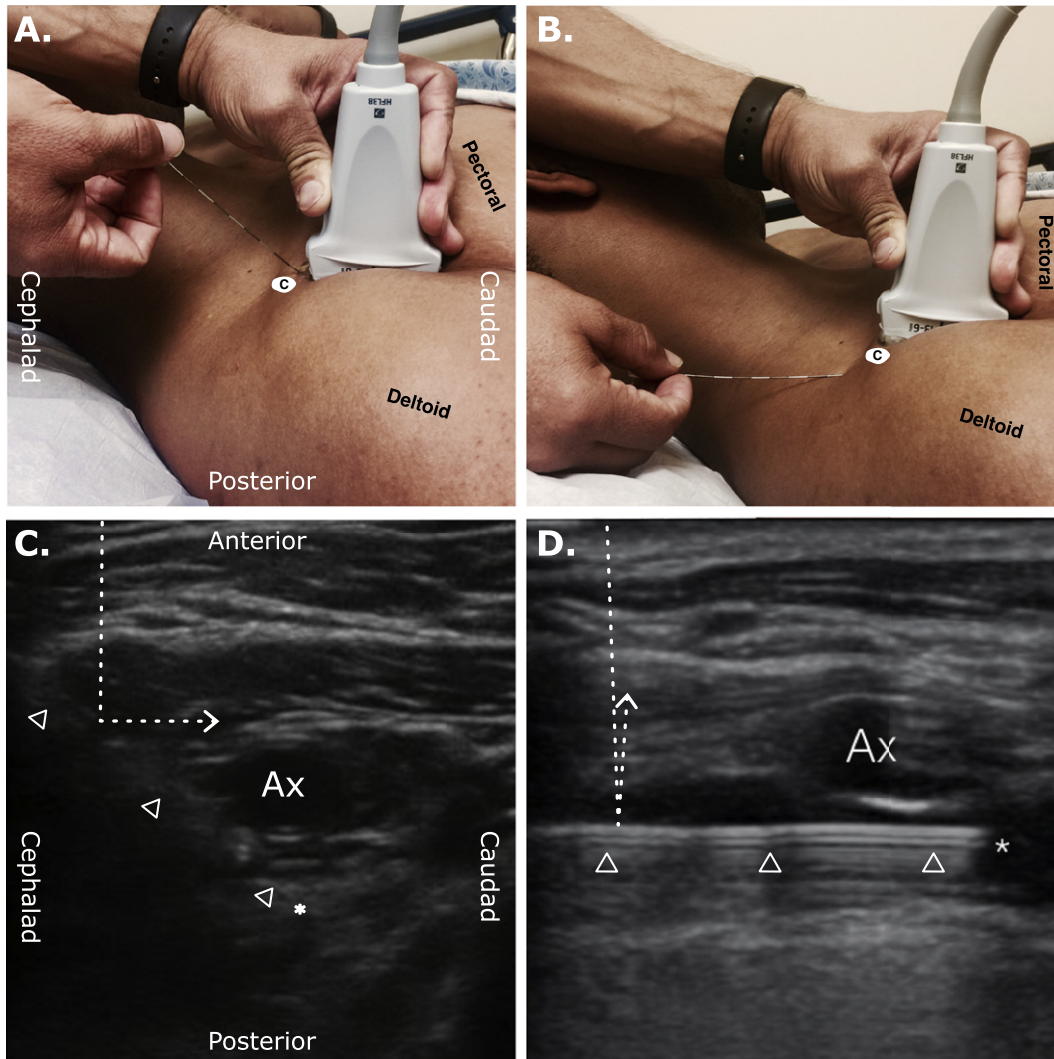


Fig. 4. Needle visibility in the traditional approach ICB (TICB) vs the RAPTIR. Most tissues in the human body have irregular surfaces and act as radiating reflectors reflecting ultrasound beams in many directions. In contrast, needles have machined smooth and straight surfaces that act as specular (mirror-like) reflectors reflecting nearly the entire ultrasound beam at an angle directly opposite its angle of incidence upon the needle. A. Needle and transducer positions for the TICB. B. Needle and transducer positions for the RAPTIR. C. Ultrasound view of the needle in the TICB. At this needle trajectory, the ultrasound beam is reflected off the mirror-like surface of the needle away from the transducer making the needle shaft and tip nearly invisible. D. A similar ultrasound view of the needle in the RAPTIR. The needle trajectory is now parallel to the transducer and the beam reflects straight back to the transducer resulting in an intensely hyperechoic needle shaft and tip. A Tuohy 20 g 90 mm epidural needle is used as the block needle in both images. Dashed arrow = ultrasound beam, triangles = needle shaft, asterisk = needle tip, C = clavicle cross section at insertion point, Ax = axillary artery.

pneumothorax. After insertion through the approximately 3 cm “blind zone” stop further needle advance and make slight transducer and needle adjustments until the needle tip is seen emerging from beneath the clavicle (Fig. 3A). Continue advancing with in-plane ultrasound guidance towards the target location just posterior to the axillary artery. Here, the operator may feel a slight “fascial click” theorized to correspond with penetration of a fascial septum within the axillary sheath [12,15]. Aspirate to check for inadvertent vascular puncture, and then inject small aliquots of LA. Anechoic anesthetic fluid should be seen spreading just posterior to the axillary artery, confirming needle tip location within the sheath (Fig. 3B) [12–17]. Once satisfied with the needle position, gradually inject LA until a total of 20–35 mL is deposited within the sheath. In our experience, total needling time is usually less than 5 min and dense arm anesthesia develops within 30 min.

5. Discussion

Brachial plexus regional anesthesia is an effective alternative to procedural sedation for painful emergency procedures [2]. Despite its efficacy, brachial plexus regional anesthesia remains relatively uncommon in the ED due to perceptions that it is technically difficult, time consuming, and associated with complications. The RAPTIR may provide an easily mastered, safe, and practical technique for brachial plexus regional anesthesia. Advantages of the RAPTIR include: infraclavicular injection point (comprehensive anesthesia of the upper extremity, greater distance from the neural axis, reduced risk of phrenic nerve blockade or pneumothorax); “one and done” injection (single injection blocks the entire plexus without multiple needle passes decreasing needling time and minimizing risk of needle to nerve contact or vascular puncture); and comfortable patient positioning (requires no special manipulation of injured extremity).

The traditional approach to the ICB (TICB) with the insertion point caudal to the clavicle shares many of these advantages with the RAPTIR. However, the physical barrier of the clavicle forces the TICB needle into a steep trajectory, resulting in poor needle visualization (Fig. 4A & C) [18–22]. By moving the insertion site cephalad and passing the needle underneath the clavicle in the RAPTIR, the needle emerges from beneath the clavicle nearly parallel to the ultrasound transducer surface [20–22]. Because the smooth, straight surface of the needle acts as a specular (mirror-like) reflector, when the needle and transducer are thus aligned the beam reflects directly back to the transducer, markedly improving needle visualization (Fig. 4B & D) [18–22]. The nearly horizontal needle trajectory of the RAPTIR also minimizes the risk of puncturing deep into the thoracic cavity and pleura and avoids the thoracoacromial artery, cephalic vein, and lateral cord, all of which lie near the TICB needle path [3]. Additionally, the retroclavicular approach does not require the patient to move or abduct their arm, in contrast to the TICB where both visualization of anatomy and ease of needle trajectory are improved with arm abduction [26].

6. Conclusion

Single-injection USG regional anesthesia of the brachial plexus can be an ideal method of analgesia for painful upper extremity ED procedures including fracture and dislocation reduction, wound debridement, complex laceration repairs, and I&D. The flat needle angle, distance from critical neck and thoracic structures, comprehensive upper extremity anesthesia, and minimal manipulation of the injured upper extremity are clear benefits of the RAPTIR, making it an appealing technique for EPs to rapidly integrate into the clinical care of the acutely injured patient. Our initial experience suggests that the RAPTIR is technically feasible and highly effective in providing arm anesthesia, eliminating the need for procedural sedation or excessive opiates in these patients. Further study in a larger patient population is needed to evaluate if utilizing the RAPTIR results in improved efficacy, increased safety, and more rapid acquisition of skill for novice providers.

Prior presentations

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References

- [1] American Society of Anesthesiologists Task Force on Acute Pain Management. Practice guidelines for acute pain management in the perioperative setting: an updated report by the American Society of Anesthesiologists Task Force on Acute Pain Management. *Anesthesiology* Feb 2012;116(2):248.
- [2] Stone MB, Wang R, Price DD. Ultrasound-guided supraclavicular brachial plexus nerve block vs procedural sedation for the treatment of upper extremity emergencies. *Am J Emerg Med* Jul 31 2008;26(6):706–10.
- [3] Sutton EM, Bullock WM, Gadsden J. The retroclavicular brachial plexus block: additional advantages. *Reg Anesth Pain Med* Nov 1 2015;40(6):733–4.
- [4] Winnie AP, Collins VJ. The subclavian perivascular technique of brachial plexus anesthesia. *J Am Soc Anesthesiol* May 1 1964;25(3):353–63.
- [5] Partridge BL, Katz J, Benirschke K. Functional anatomy of the brachial plexus sheath: implications for anesthesia. *Anesthesiology* Jun 1987;66(6):743–7.
- [6] Neal JM, Hebl JR, Gerancher JC, Hogan QH. Brachial plexus anesthesia: essentials of our current understanding. *Reg Anesth Pain Med* Jul 31 2002;27(4):402–28.
- [7] Chin KJ, Alakkad H, Adhikary SD, et al. Infraclavicular brachial plexus block for regional anesthesia of the lower arm. *Cochrane Database Syst Rev* Aug 28 2013; 8:CD005487.
- [8] Cousins MJ, Bridenbaugh PO, editors. *Neural Blockade in Clinical Anesthesia and Management of Pain*. Lippincott Williams & Wilkins; 1998.
- [9] Koscielniak-Nielsen ZJ, Frederiksen BS, Rasmussen H, Hesselbjerg L. A comparison of ultrasound-guided supraclavicular and infraclavicular blocks for upper extremity surgery. *Acta Anaesthesiol Scand* May 1 2009;53(5):620–6.
- [10] Yazer MS, Finlayson RJ, Tran DQ. A randomized comparison between infraclavicular block and targeted intracubital injection supraclavicular block. *Reg Anesth Pain Med* Jan 1 2015;40(1):11–5.
- [11] Fredrickson MJ, Wolstencroft P. Evidence-based medicine supports ultrasound-guided infraclavicular block over the corner pocket supraclavicular technique. *Reg Anesth Pain Med* Dec 2010;36(5):525–6.
- [12] Lévesque S, Dion N, Desgagné MC, Morimoto M, Popovic J, Kim JT, et al. Endpoint for successful, ultrasound-guided infraclavicular brachial plexus block. *Can J Anesth* May 1 2008;55(5):308–9.
- [13] Tran de QH, Charghi R, Finlayson RJ. The ‘double bubble’ sign for successful infraclavicular brachial plexus blockade. *Anesth Analg* 2006;103:1048–9.
- [14] Fredrickson MJ, Wolstencroft P, Kejrival R, Yoon A, Boland MR, Chinchawal S. Single versus triple injection ultrasound-guided infraclavicular block: confirmation of the effectiveness of the single injection technique. *Anesth Analg* Nov 1 2010; 111(5):1325–7.
- [15] Desgagnés MC, Lévesque S, Dion N, Nadeau MJ, Coté D, Brassard J, et al. A comparison of a single or triple injection technique for ultrasound-guided infraclavicular block: a prospective randomized controlled study. *Anesth Analg* Aug 1 2009; 109(2):668–72.
- [16] Bloc S, Garnier T, Komly B, Asfazadourian H, Leclerc P, Mercadal L, 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* Mar 31 2007;32(2):130–5.
- [17] Dingemans E, Williams SR, Arcand G, Chouinard P, Harris P, Ruel M, et al. Neurostimulation in ultrasound-guided infraclavicular block: a prospective randomized trial. *Anesth Analg* May 1 2007;104(5):1275–80.
- [18] Chin KJ, Perlas A, Chan VW, Brull R. Needle visualization in ultrasound-guided regional anesthesia: challenges and solutions. *Reg Anesth Pain Med* Dec 31 2008; 33(6):532–44.
- [19] Sites BD, Brull R, Chan VW, Spence BC, Gallagher J, Beach ML, et al. Artifacts and pitfall errors associated with ultrasound-guided regional anesthesia. Part I: understanding the basic principles of ultrasound physics and machine operations. *Reg Anesth Pain Med* Sep 1 2007;32(5):412–8.
- [20] Hubbard P, Roysse C. Ultrasound guided posterior approach to the infraclavicular brachial plexus. *Anesthesia* 2007;62:539.
- [21] Beh ZY, Hasan MS, Lai HY, Kassim NM, Zin SR, Chin KF. Posterior parasagittal in-plane ultrasound-guided infraclavicular brachial plexus block—a case series. *BMC Anesthesiol* Jul 21 2015;15(1):105.
- [22] Charbonneau J, Fréchette Y, Sansoucy Y, et al. The ultrasound-guided retroclavicular block. A prospective feasibility study. *Reg Anesth Pain Med* 2015;40(5):605–9.
- [23] Vlasakov KV, Janfaza DR. Ultrasound-guided retroclavicular approach to the brachial plexus cords. Poster session presented at the *ASRA Annual Spring Meeting and Workshops Playa del Carmen, Mexico*; May 2008.
- [24] Echave P, Charbonneau J, Fréchette Y, Sansoucy Y. Reply to Dr Price. *Reg Anesth Pain Med* Sep 1 2016;41(5):657–8.
- [25] Standing S, editor. *Gray’s Anatomy: The Anatomical Basis of Clinical Practice*. Elsevier Health Sciences; Aug 7 2015.
- [26] Auyong DB, Gonzales J, Benonis JG. The Houdini clavicle: arm abduction and needle insertion site adjustment improves needle visibility for the infraclavicular nerve block. *Reg Anesth Pain Med* Jul 1 2010;35(4):403–4.