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# Determining anatomic accuracy of shoulder field injection: triangular injection technique does adequately reach pain transmitters

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**Background:** Controlling pain after shoulder surgery is a critical component of postsurgical care. Several recent studies have described the use of periarticular, local infiltration anesthesia, and field blocks (FBs) with clinical efficacy after shoulder surgery. The anatomic accuracy and safety of these FBs have not been well described. The purpose of this study was to determine the accuracy of a surgeon performed shoulder field injection. We hypothesized that our field injection would adequately reach the pain transmitters responsible for postsurgical shoulder pain.

**Methods:** A total of 10 cadaveric specimens were used in the study. A mixture of liposomal bupivacaine, normal saline, and methylene blue totaling 60 cc was prepared. After injection, the specimens were left for 4 hours to allow medication diffusion. The dissection of specimens was performed to identify 4 areas: axillary nerve, suprascapular nerve, supraclavicular nerves, and joint capsule. On dissection, accuracy rates were determined for each area.

**Results:** All 10 cadaveric specimens were injected and dissected to completion. The dissection of the axillary nerve showed methylene blue dye surrounding the nerve in 10 of 10 (100%) specimens, the suprascapular nerve in 9 of 10 (90%), and the supraclavicular nerves in 10 of 10 (100%). Zero of 10 (0%) specimens had any dye penetrate into the glenohumeral joint or capsule.

**Conclusion:** The accuracy rates of the injection of the mixture into the shoulder specimens suggest potential to reproduce an FB to the tissues that are responsible for postoperative pain after shoulder surgery. This may represent an option when interscalene nerve block is not desired or contraindicated.



Controlling pain after shoulder surgery is a critical component of postsurgical care. Approximately 45% of adult patients report severe pain in their shoulder during the immediate postoperative period.[1] Current postoperative pain management protocols are under greater scrutiny in the setting of minimizing opiate consumption.

Approximately 82% of patients undergoing arthroscopic shoulder surgery and total shoulder arthroplasty (TSA) receive an interscalene block (ISB).[10–12] Although ISB continues to be a favored anesthesia technique, the rising interest in ISB alternatives is driven by several factors. Abdallah et al[1] reported that the duration of analgesia provided by the ISB, as measured by pain relief and opioid consumption, is limited to 8 and 12 hours after operation, respectively. Unfortunately, ISB is also associated with rebound pain and a high incidence of undesirable adverse events including respiratory complications, undesirable diaphragmatic blockade, and block-related neurologic complications and paresthesia.[16] In addition, cost, time required for blocks, and availability of trained clinicians can negatively impact the use of nerve blocks. Given the aforementioned, the question then arises: can a field block (FB) be a possible alternative when ISB is not readily available or is contraindicated?

Several authors have reported on periarticular injection, local infiltration anesthesia (LIA), and local FBs. Sicard et al,[19] in a prospective randomized controlled study, evaluated the efficacy of LIA when compared with ISB in patients undergoing TSA. The LIA group had less severe pain and lower opioid consumption.[19] Further studies have compared multimodal therapies of combining LIA and ISB. Boddu et al[3] evaluated the efficacy of the multimodal analgesic protocol associating ISB and LIA in patients who underwent TSA. These reports include local blocks with and without ISB with clinical efficacy and equivalent (and in some cases enhanced) efficacy.[3,18,19] In 2019, Sethi et al[18] reported a decrease in the consumption of opioids with the use of a liposomal bupivacaine FB in addition to an ISB. These adjuvant blocks are a useful alternative or

Institutional review board approval was not required for this basic science study.

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additive to ISB, but there are no reports on the anatomic accuracy or safety of these techniques.

The purpose of this study was to determine whether a triangular field injection used in shoulder surgery will adequately reach the relevant peripheral nerves and not the articular cartilage. Our hypothesis was that this field injection would adequately reach the pain transmitters needed to alleviate postsurgical shoulder pain and may be an alternative to traditional nerve blocks.

## Methods

A total of 10 intact cadaveric human shoulder specimens were identified. All specimens included both 6 males and 4 females without any age restriction or prior shoulder surgery. Specimens were removed from the freezer for 24 hours to allow thawing before the start of the procedure. Shoulders were positioned in a simulated beach chair position with a clamp on the scapula in order to simulate patient position in the operating room. When the shoulder was adequately thawed and positioned, the triangular field injection mixture was applied by a board-certified sports orthopedic surgeon.

### *Injection technique*

In accordance with previous studies examining the efficacy of a nerve block,[14,15] a solution consisting of 20 mL of liposomal bupivacaine, 40 mL of normal saline, and 5 drops of methylene blue was prepared. Landmarks of the triangular field were determined and marked based on an infiltration technique as shown in Figure 1. First, 15 mL of mixture was injected with a 22-gauge needle at the suprascapular notch (2.0 cm medial to the medial border of the acromioclavicular joint) at the superior apex of the triangle. The needle was inserted to the bone on the floor of the scapular notch, aspiration performed, and then the mixture was injected. Subsequently, 3.0 mL was injected at intervals of 1.5 cm along the perimeter of the triangle. The inferior margin of the triangle was just proximal to the posterior axillary fold. The injections were then carried out transversely across the shoulder to the level of the bicipital groove and then superiorly along the third line of the triangle back toward the suprascapular notch (Supplementary Video 1).

### *Macroscopic evaluation*

On completion of injection into the shoulder, the specimens were left for 4 hours to ensure the diffusion of the mixture. The shoulders were then carefully dissected to assess methylene blue staining of the suprascapular, axillary, and supraclavicular nerves. First, the deltoid was dissected posteriorly to identify the axillary nerve. The second nerve identified was the suprascapular nerve, and afterward, the branches of the supraclavicular nerve were identified. All 3 nerves were delicately dissected to determine its interaction with the mixture. Once all nerves were identified, the shoulder joint capsule was examined to determine if any anesthesia/methylene blue mixture had entered. Pictures for all 3 nerves and joint capsule were obtained for every shoulder specimen; examples can be seen in Figures 2-4.

## Results

All 10 specimens were injected and dissected to completion.

Injection into tissues surrounding the axillary nerve, suprascapular nerve, supraclavicular nerve(s), and glenohumeral joint was identified and recorded. Ten of 10 (100%) axillary nerves had methylene blue staining from the injection, 9 of 10 (90%) suprascapular nerves were dyed, and 10 of 10 (100%) supraclavicular nerves were dyed. In addition, 0 of 10 (0%) specimens had any leakage of dye into the glenohumeral joint or joint capsule (Table I). Two specimens had native rotator cuff tears with no glenohumeral joint penetration as well. There were no intraneural injections, which would have been evidenced by a concentration of dye in the actual nerve.

## Discussion

Several recent studies have described the clinical efficacy of pain control using periarticular, LIA, and FBs in open and arthroscopic shoulder surgery.[3,18,19] These injections represent methods for pain control, opiate minimization, and in some cases an alternative to

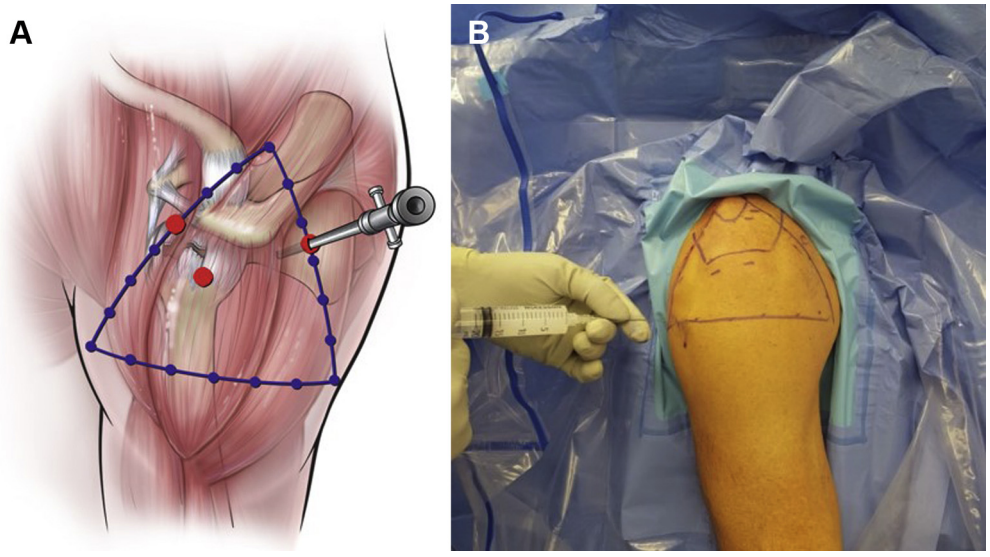


**Figure 1** A schematic and a clinical image of the triangular technique, which was used to create landmarks, which were used for injection of the mixture. These images depict (**A**) a drawing and (**B**) a clinical image of the triangular injection field for the intraoperative introduction of liposomal bupivacaine into the surgical site during arthroscopic surgery. After surgical preparation and before repair of the rotator cuff, 20 mL of liposomal bupivacaine is diluted with an additional 40 mL of saline and injected into the triangular field using a 22-gauge spinal needle at intervals of 1.5 cm along the perimeter of the triangle. A bolus of 15 mL is injected at the suprascapular notch, and then every 1.5 cm another 3.0 mL is injected as the needle is slowly withdrawn.

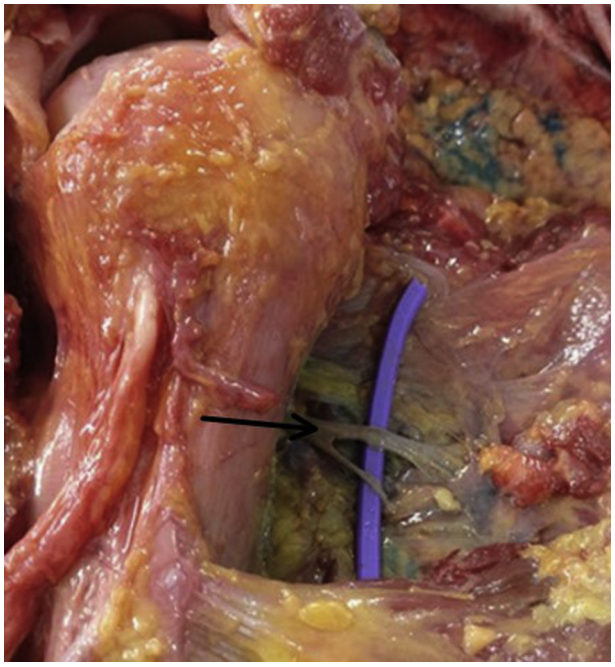

**Figure 2** The anterior image of the shoulder; the anesthetic/methylene blue stained axillary nerve (→) and surrounding area. There were no incidences of intraneural injection. Supraclavicular infiltration is observed in the top right of the photograph.

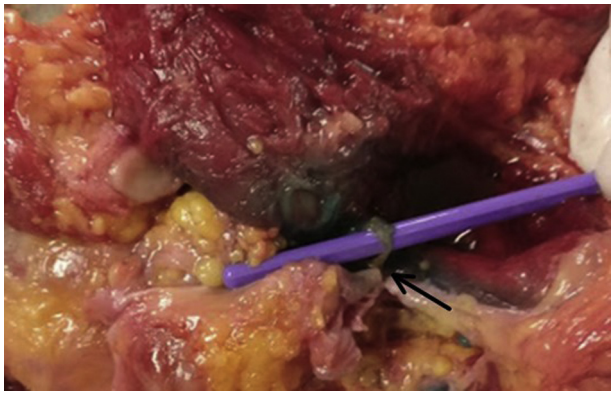

**Figure 3** Anesthetic/methylene blue stained suprascapular nerve (under the purple rod) and surrounding area. The suprascapular ligament has been ligated (just inferior).

ISB. Although there are many studies that report favorable clinical outcomes, there are very limited data that evaluate the anatomic accuracy and safety of these injections.[14] This study demonstrates that a surgeon performed field injection accurately reaches the desired tissues and nerves that are responsible for postoperative pain after shoulder surgery without risk for intraarticular joint injection. Although methylene blue staining seems to be relatively simple methodology, it remains the gold standard in assessing accuracy after injection.[14,15] This may be a useful alternative for local-regional anesthesia when ISB is undesirable or not available.

Postoperative pain after surgery is mediated by the suprascapular, axillary, and supraclavicular nerves.[4] Current estimates suggest that 82% of patients undergoing any type of shoulder surgery undergo ISB to manage perioperative pain.[10–12] ISB is associated with respiratory complications, undesirable blockades, and block-related complications.[16,17] Other adverse effects include undesirable blockade of the cervical plexus, recurrent laryngeal nerve, and weakness in the forearm and hand. In addition, ISB is further

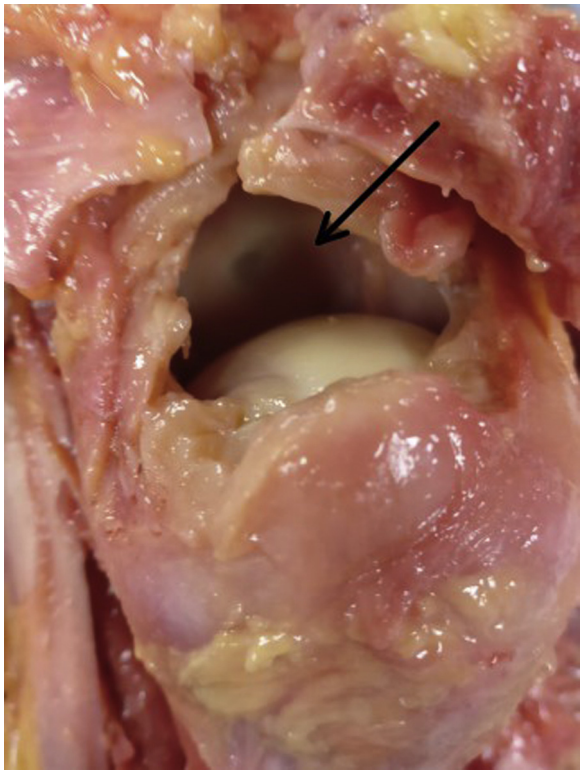

**Figure 4** A representative specimen capsule of the glenohumeral joint with a large rotator cuff tear. The injected fluid did not leak into the joint or capsule in any specimen alleviating concern about local anesthesia and chondrotoxicity from this technique.

associated with rebound pain; this spike of pain results in increased utilization of health care resources, phone calls, and itinerant visits to costly emergency rooms.[1] All of this does not even account for the cost, high-resolution ultrasound, staffing, time required for blocks, and availability of trained clinicians outside of academic centers.

The use of intraoperative local and regional anesthesia (LRA) or FBs, in contrast to ISB, in conjunction with multimodal pharmacological strategies, is a widely accepted approach for managing surgical pain and reducing opiate use. FBs have the advantage of avoidance of injury to the phrenic nerve, which when blocked may create tremendous patient anxiety or represent a serious health threat in the patient with chronic obstructive pulmonary disease. The triangular field injection in this study is based on previously described techniques, first in 1941 by Wertheim and Rovenstine.[20] This block anesthetizes branches of the suprascapular nerve, which provides 70% of the sensory input to the glenohumeral joint, and also innervates the infraspinatus and supraspinatus muscles.[8] On this anatomic basis, the suprascapular nerve block alone, in contrast to the entire triangular block, has been proposed to produce sufficient analgesia for shoulder surgery.[2,9,13] The additional posterior arm of the triangular FB is useful for branches of the axillary nerve, and the anterior arm addresses the supraclavicular branches that address the residual neurologic innervation of the shoulder.[18] Clinical studies suggest that LRA, inclusive of the suprascapular and axillary nerve block, have potential for postoperative analgesia when compared with ISB.[5,6]

Our concerns about LRA, and specifically this triangular FB, revolved around accuracy, risk for intraneural injection, and risk for chondrotoxicity, especially without the use of adjuvant ultrasound imaging. In cadaveric setting, we were able to demonstrate a >90%

**Table I**
Frequency and percentage rates of injection

| Axillary nerve | | Suprascapular nerve | | Supraclavicular nerve | | Glenohumeral joint | |
|---|---|---|---|---|---|---|---|
| Frequency | Percentage | Frequency | Percentage | Frequency | Percentage | Frequency | Percentage |
| 10/10 | 100 | 9/10 | 90 | 10/10 | 100 | 0/10 | 0 |

accuracy for dye penetration for the suprascapular, axillary, and supraclavicular nerves without the use of ultrasound guidance. In addition, there were no intraneural injections, and the dye did not leak into the glenohumeral joint or stain the joint capsule in any cases, alleviating the concern for chondrotoxicity.

This local block avoids anesthesia of the distal extremity, which is not uniformly tolerated well.[2,9,13] The technique may eliminate the risk of transient and persistent hand paresthesia.

This study does have limitations. This is a nonclinical study performed on cadaveric specimens, and as such, limited commentary can be made about the clinical efficacy of this block technique. Our goal was to assess the anatomic safety and accuracy of this technique. Furthermore, the clinical efficacy and safety of this FB have been reported.[18] A second concern is that the staining of tissues with methylene blue may appear simplistic. Nonetheless, this methodology remains the gold standard in the reported literature, highlighted by Laumonerie et al's 2019 study[14] on the accuracy of the ultrasound-guided injection of the suprascapular nerve. We state that no intraneural injection occurred, in theory injection is best evaluated with histologic section of the nerves; nonetheless, we are not aware of any studies in which this was performed. In fact, we describe a methodology consistent with published research on the safety of nerve blocks.[7] Normally, a sample size of 10 would be considered a limitation, but this number is considered normal for cadaveric studies. This procedure is harder on cadaveric shoulders as the absence of the head and neck makes many anatomic landmarks harder to identify. Finally, because arthroscopy portals were not created, it is possible that some dye may leak into the joint in vivo, but this is not likely significant.

Our clinical experience with this technique (in over 100 subjects) mirrors the published literature with excellent clinical analgesia and without complication.[18] We have not observed distal blockade, sensory deficits, or hemidiaphragm blockage with the triangular FB. Although ISB is an effective strategy for many patients, this technique represents an option for patients when regional trained anesthesia is not available (on call/weekends), when time for block is not available, when distal nerve blockage is not desired (previous nerve injury), and in the setting when phrenic nerve compromise is unacceptable (chronic obstructive pulmonary disease or CVA).

## Conclusion

The accuracy rates of the injection for the triangular method of anesthesia and methylene blue accurately and reproducibly provide an FB to the tissues that are responsible for postoperative pain after shoulder surgery. Although ISB remains an effective pain management strategy, this technique represents an option when ISB is unavailable, contraindicated, or not desired.

## Disclaimer

The authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

## Supplementary Data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jseint.2020.04.017.

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