We wanted to determine whether 1 of 3 brachial plexus blocks was best for one of our most common surgeries, the cubital tunnel release with or without transposition of the ulnar nerve. Brachial plexus blocks can provide excellent results for upper extremity surgery, but we noticed inexplicable block failure for cubital tunnel releases with an incision in the proximal arm. In this case series, we initially reviewed 90 patients receiving axillary, infraclavicular, or supraclavicular blocks to determine if one block performed better for a surgical procedure that proceeds up the inner aspect of the arm. The theory that infraclavicular and supraclavicular blocks were superior for this surgery was not demonstrated in these patients. Success was not determined by the block chosen; however, the intercostobrachial nerve may be inconsistently blocked because it is difficult to visualize on ultrasound. We subsequently reviewed 30 more patients, but this time the volume of the intercostobrachial block was doubled. By increasing the volume, there appeared to be less need for surgeons to “touch up” blocks in the operating room. We suggest that increasing the volume of the intercostobrachial nerve block may improve success. Further studies to identify the intercostobrachial nerve by ultrasound are needed.

Keywords: Brachial plexus block, cubital tunnel release, ultrasound.

The benefits of regional anesthesia for ambulatory wrist and hand surgeries are well established. McCartney et al described the benefits of improved analgesia, reduced nausea, and faster discharge in the immediate postoperative period. Regional anesthesia decreases time to discharge from the surgery center, by improving recovery times, as well as improves analgesia and patient satisfaction. In particular, the brachial plexus block has a long history of success for upper extremity surgery. A retrospective analysis of 1,146 cases reported a block success rate of 99.3%. The elbow often serves as a transitional point for the most common block approaches. Generally, a more distal block such as the axillary block is favored more for the distal portions of the hand and forearm, whereas a more proximal block such as the interscalene approach is more useful for surgery on the shoulder and proximal arm.

Cubital tunnel syndrome is the second most common compression neuropathy of the arm following carpal tunnel syndrome and often requires surgical treatment (Figure 1). Local anesthesia has long been described as effective, and the 2 common approaches of axillary and infraclavicular blocks have been successful; however, we have noticed the need for occasional local anesthetic “touch-up” at the most proximal portion of cubital tunnel releases and transpositions at our facility. One study suggested that there is an arborization of several cutaneous branches that originate from the medial cord of the brachial plexus. This occurs approximately 7 cm proximal to the medial condyle. Because this nerve originates at the cord level, a well-placed infraclavicular or supraclavicular block may perform better than the more distal axillary block.

To our knowledge, no studies have examined which is the most effective block for the specific elbow surgery of cubital tunnel release. In this case series, we compared ultrasound-guided axillary, infraclavicular, and supraclavicular block techniques to determine whether there are any advantages of one over another in this type of surgery, and specifically to determine whether patient response to surgical stimulus at the proximal cubital tunnel is different among the 3 techniques.

Figure 1. Cubital Tunnel Release
Methods

- **Initial Cases.** After obtaining institutional review board (IRB) approval (University of Louisville, Louisville, Kentucky), 90 patients undergoing cubital tunnel release procedures were observed. Inclusion criteria were as follows: age of at least 18 years, ASA physical status 1 to 3, and patient consent to monitored anesthesia care with axillary, infraclavicular, or supraclavicular block guided by ultrasound imaging.

After patients arrived in the presurgical bay and the preanesthesia workup was completed, an intravenous line was started in a nonoperative extremity. One of 3 standard brachial plexus blocks was used based on provider preference. Two of the anesthesia providers administered axillary blocks only, whereas 1 provider was experienced and comfortable with all 3 types of blocks. Data were collected for 30 patients of each block type. Before block placement, standard monitors were applied, and oxygen (2 L/min) was administered by nasal cannula. For anxiolysis, patients were sedated with up to 5 mg of midazolam and up to 100 μg of fentanyl. All blocks were ultrasound guided using an ultrasound machine (General Electric Venue 40, GE Healthcare) equipped with a transducer (GE 12L-SC) capable of 7.5 ± 20% MHz frequency (according to the Venue 40 Basic Service Manual). A nurse assisted the block placement by helping to sedate and monitor the patient, and to inject the local anesthetic as requested. The local anesthetic chosen for all cases was a mixture of 0.5% ropivacaine (APP Pharmaceuticals) and 0.5% bupivacaine with epinephrine at a concentration of 1:200,000 (Hospira Inc). Equal volumes of these solutions were mixed. Needles chosen for injection were 22-gauge, 7.5-cm (3-in), noninsulated, Quincke-style block needles (BD Medical).

The nerves were identified as circular, hypoechoic bundles surrounded by hyperechoic areas in the perineural space further contained within the epineurium. For the axillary block, the 4 nerves of the brachial plexus were identified in the axilla. Injection volumes were as follows: 5 mL for the musculocutaneous, 10 mL for the median, 10 mL for the ulnar, and 15 mL for the radial nerve, resulting in a 40-mL total volume. These volumes were divided based on relative nerve size. On ultrasound examination, the musculocutaneous nerve often appears small and outside the brachial plexus sheath. It innervates the biceps and coracobrachial muscles but is sensory only to the lateral aspect of the forearm. The radial nerve often appears large but is somewhat obscured in posteromedial fashion to the axillary artery in the sheath. It innervates nearly all the extensor muscles in the arm and forearm as well as being sensory to the posterior arm; as such, it received a larger volume of anesthetic (Figure 2).

In the case of the infraclavicular block, the axillary artery, vein, and 3 cords of the brachial plexus were identified at the appropriate depth, and anesthetic volumes were administrated.
were 10 mL for the lateral cord, 10 mL for the medial cord, and 20 mL for the posterior cord, for a total volume of 40 mL (see Figure 2). If the ultrasound machine was unavailable, the preferred method of brachial plexus block was the infraclavicular approach using a nerve stimulator and insulated needles. After experience with hundreds of blocks, the success rate at this institution increased by electrolocating the posterior cord (demonstrated by triceps and/or metacarpal extension with the stimulator) and depositing most, if not all, of the local anesthetic here. De Tran et al\textsuperscript{12} showed no difference in single vs double injection for infraclavicular blocks, but a closer review of that study shows that the highest volumes were injected dorsal to the artery in both samples, which is the position of the posterior cord in this region.

If a supraclavicular block was chosen, care was taken to identify the upper, middle, and lower trunks or divisions lateral to the subclavian artery. These nerves are compact in this area, but they do change angle and directional course with respect to each other as they progress between the clavicle and first rib. The trunks and divisions of the brachial plexus block can be identified with experience by toggling the ultrasound probe. There can be 3 or 4 distinct nerve bundles depending on the ultrasonic angle because the supraclavicular block is, in essence, a distal interscalene block. Because these nerves can be difficult to see on ultrasound images, the general intent was to inject 10 mL into the area of the upper trunk, 10 mL for the middle trunk area, and 10 mL for the lower trunk area, which added to a total volume of 30 mL (see Figure 2). Whenever possible, attempts were made to position the needle outside the nerve and to surround it with local anesthetic to avoid intraneural injection and its associated complication profile. For this reason, patients were mildly sedated so that paresthesias could be ascertained. Special attention was given to inject a portion of the lower trunk at the lateral border of the subclavian artery and the first rib, to help prevent ulnar sparing of the inferior trunk.\textsuperscript{13} In all cases, the needle was positioned in-plane with observation of the needle tip during advancement and injection. Careful aspiration was performed because vessels may be obscure even with ultrasonic Doppler imaging.

The intercostobrachial nerve was standardly blocked along the axillary crease as described by Neal.\textsuperscript{14} In all 90 patients, the intercostobrachial nerve was blocked by injecting the subcutaneous tissue with 5 mL of local anesthetic from the midaxillary line at the proximal arm to the inferior border of the triceps (Figure 3).

The surgical failure rate remained unacceptably high in all 3 types of blocks in this first case series. Because the initial incision created most of the problems, as opposed to deeper dissection, we suspected the intercostobrachial (cutaneous) nerve was the culprit.

\textbf{Added Cases.} For testing of this theory, another 30 patients were subsequently added—10 patients to each block type—again with IRB exemption. With this set of observations, the intercostobrachial block volume was doubled from 5 to 10 mL.

All blocks were observed for timing, including time necessary to complete the injections and time required for the block to be “ready” for the operating room (OR). This was assessed by the common “push-pull-pinching” test, which tests the radial nerve (triceps extension), musculocutaneous nerve (biceps flexion), median nerve (comparative pinch in the hypothenar region), and the ulnar nerve (comparative pinch at the medial border of the hand). Each of the providers performed this test by clock or wristwatch observation. In some cases, the preoperative nurse was delegated to record this in the event that the anesthesia provider was needed elsewhere. This pull-pinching test was conducted every 5 minutes for up to 30 minutes until the block was deemed ready for surgery in the fashion just described. The readiness for surgery was determined as follows. Each time the block was assessed, it was assigned a number on a 3-point scale. Normal strength or sensation was assigned a “2,” whereas a weakened strength or sensation was assigned a “1,” and an insensate or paralyzed nerve was assigned a “0.” In the OR, standard monitors and oxygen were applied as in the preoperative area. Although patients had received midazolam and fentanyl for block placement, they were able to answer questions in the OR. Once the

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{Figure3.png}
\caption{Intercostobrachial Injection}
\end{figure}
skin preparation was complete and the tourniquet was inflated, the surgeon was asked to test the proximal incision site by either pinching the area with the bipolar Bovie-tip or proceeding with proximal incision while the patient was verbal. If the patient indicated no pain at the site, this was recorded, and monitored anesthesia care sedation was given with propofol to maintain spontaneous respirations and adequate hemodynamic parameters. A sedation scale was not used, but the patients were no longer verbal. Patients were observed for movement or retraction to surgical dissection. Any sedation requiring additional drugs such as opioids, ketamine, or general anesthesia was recorded as a “failed” block. When a patient verbalized pain, the surgeon injected 5 to 10 mL of 0.5% bupivacaine at the proximal incision, and this also was recorded as a “failed” block.

Results
Table 1 shows demographics of the original 90 patients, including gender, age, side of surgery, weight, height, and body mass index (BMI). The axillary group had a higher mean BMI in our series. This did not appear to contribute to axillary block failure compared with the other groups (data not shown).

Table 2 shows the mean time of block onset. Block failure or success by patient weight and height is shown in Table 3.

All 90 original blocks set up adequately for surgery as determined by the “push-pull-pinch-pinch” test. In the OR, failed blocks initially totaled 20%, 20%, and 33% in the axillary, infraclavicular, and supraclavicular groups, respectively, with 23% of all blocks requiring cutaneous anesthetic touch-ups by the surgeons. Once this was accomplished, deeper dissection was possible in all but 3 (3.3%) of the 90 original patients, requiring very deep sedation or general anesthesia.

The block failure rate improved somewhat when the intercostobrachial block volume was doubled to 10 mL in our second series of cases (Figure 4).

Discussion
Cubital tunnel syndrome is a compression of the ulnar nerve at the elbow. This can lead to chronic neuropathy resulting in muscle weakness that does not respond to conservative measures, and surgery may be advised. All these surgeries are performed with the patient under regional anesthesia at our institution. All block approaches need to work well for the 10 surgeons performing cubital tunnel release. In this review, the anesthesia providers could administer their preferred block approaches, and efforts were taken to standardize the equipment, local anesthetic volumes, and block approach.

Careful analysis of our observations revealed there were more physical characteristics associated with failed blocks,
rather than the choice of block itself. For example, the average weight of patients in the failed block category was 92.1 kg (204.7 lb) vs 80.6 kg (179 lb) in the successful blocks, whereas heights were nearly identical in the 2 categories (see Table 3). Furthermore, failed block percentages increased from 13% in normal-weight patients to 21% and 33% in the overweight and obese categories, respectively, when the 5-mL intercostobrachial block was used (see Figure 3). To us, this suggested a problem with intercostobrachial volume or placement, particularly because the pain was superficial and proximal. This nerve is a well-described branch of the second thoracic nerve (T2) outside the brachial plexus. Identification of this small and somewhat tortuous nerve with ultrasound imaging has not been well established, so blocking it is a blind procedure.

Because this was a case review, and the original idea that the axillary block would be least effective was disproved, it was decided to add another 30 patients to the study. Ten patients in each block category (axillary, infraclavicular, and supraclavicular) were added. This time, the intercostobrachial block volume was doubled, from 5 to 10 mL. Interestingly, the percentage of failures dropped to 0%, 18%, and 13% in the normal-weight, overweight, and obese categories, respectively (see Figure 4). The failure rate in the 10-mL group improved but was still unsatisfactory. We surmise that the intercostobrachial nerve is too often dismissed as “easily blocked” when, in fact, it is not being adequately assessed.

Clearly, the additional volume of local anesthetic that we subsequently added to our case series provided us with an important step toward performance improvement. We believe that ensuring adequate block of this nerve is more important than the type of brachial plexus block chosen. This may be especially important in obese patients. Using ultrasound to identify and block this nerve had shown mixed success, but we are attempting to use this more. Just one change in technique has decreased time and effort required for anesthetic touch-ups. This has reduced the need to place local anesthetic directly into the incision, which produces suboptimal conditions for some surgeons.

This observational series was particularly helpful in assessing and solving a performance issue, but clearly a randomized, controlled trial would be more conclusive and useful. In particular, a study designed to identify the intercostobrachial nerve using ultrasound guidance would be helpful.

In conclusion, we strongly recommend assessment of the intercostobrachial nerve specifically to achieve adequate anesthesia for numbness from the inner aspect of the axilla to the elbow. In our experience, innervation of this nerve may proceed more distally than many reference sources suggest, leading to risk of block failure.

Table 3. Respective Weight, BMI, and Height in (mean ± SD) for Failed vs Successful Block
Abbreviation: BMI, body mass index.

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Weight, kg (lb)/BMI</th>
<th>Height, cm (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failed block</td>
<td>92.1 (204.7) / 32 ± 47.0</td>
<td>171.7 ± 9.1 (67.6 ± 3.6)</td>
</tr>
<tr>
<td>Successful block</td>
<td>80.6 (179.0) / 29 ± 39.9</td>
<td>169.2 ± 10.7 (66.6 ± 4.2)</td>
</tr>
</tbody>
</table>

Figure 4. Percentage of Block Failures for Each BMI Category After Change of Intercostobrachial Block Volume from 5 mL to 10 mL
Abbreviations: BMI, body mass index; ICB, intercostobrachial block. BMI classification: Normal weight, < 24.9 kg/m²; overweight, 24.9 to 29.9 kg/m²; and obese, > 29.9 kg/m². Adapted from National Institutes of Health. Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults: The Evidence Report

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