Background: Ultrasound guidance improves the localization of anesthetic placement during regional anesthesia, but a decreased rate of adverse events has not been demonstrated in the current literature. In this large prospective study, we evaluated the safety, efficacy, and patient satisfaction associated with ultrasound-guided interscalene block.

Methods: A cohort of 1319 patients undergoing arthroscopic shoulder surgery at an outpatient surgery center was prospectively evaluated. Interscalene blocks were performed by experienced anesthesiologists and trainees with use of ultrasound guidance. Patients were queried by a physician twenty-four hours postoperatively regarding their satisfaction with the interscalene block and were screened for a comprehensive register of minor and major adverse events. Individuals with adverse events were followed until symptoms resolved.

Results: Interscalene block was ultimately successful in 99.6% of the cases. A total of thirty-eight adverse events (prevalence, 2.88%) were noted. At the time of the latest follow-up, permanent sequelae were present in three patients (0.23%), all of whom had relevant comorbidities. With regard to patient satisfaction, 99.06% of the respondents were “satisfied” or “very satisfied” with the interscalene block, whereas 0.94% of respondents were unsatisfied. In addition, 97.8% of the patients stated that they would elect to have an interscalene block again in the future.

Conclusions: The present study supports the use of ultrasound-guided interscalene block by trained anesthesiologists for well-screened patients undergoing shoulder arthroscopy, given the high rate of patient satisfaction and the low rate of adverse events.

Level of Evidence: Therapeutic Level IV. See Instructions for Authors for a complete description of levels of evidence.
intraoperative anesthesia and muscle relaxation without the need for high-dose intravenous opiates and paralytics. Paralytics require airway protection and reversal, which potentially extends operative time if not tightly managed. High-dose intravenous opiates may cause nausea, vomiting, and/or sedation, which may prolong the time to discharge. The benefits of interscalene block extend to excellent postoperative analgesia that obviates or reduces the need for oral and intravenous pain medication in the hours after surgery. Interscalene block can allow patients to bypass acute (phase-1) postoperative anesthesia care for earlier discharge. Patients who have undergone sequential general anesthesia followed by interscalene block on the contralateral shoulder strongly prefer interscalene block when queried the day after surgery.

The apprehension of some orthopaedic surgeons to recommend or endorse regional anesthesia is likely due to trepidation about adverse events. Earlier orthopaedic literature demonstrated high rates of neurological, cardiac, and respiratory complications, some of which were permanent. Recent studies of interscalene block performed with nerve stimulation have demonstrated lower rates of permanent complications, although a meta-analysis by Brull et al demonstrated that transient neuropathy after interscalene block still occurs about 3% of the time. Interscalene block had the highest rate of transient neuropathy among the peripheral blocks examined in that meta-analysis.

Ultrasound guidance clearly demonstrates the brachial plexus anatomy for block localization. In vivo studies have demonstrated that even with direct nerve-to-needle contact on ultrasound, there is a 13.5% false-negative rate with nerve stimulation. This means that, in more than one in seven cases, no stimulation is elicited even when the tip of the needle is in the nerve, potentially increasing the risk of nerve injury via intraneural injection.

The available data suggest that ultrasound guidance may be superior to previous methods of administering regional anesthesia in terms of a reduction in the number of needle sticks, more rapid block onset times, higher block success rates, prolongation of both surgical anesthesia and postoperative analgesia, reduction in block procedure times and procedure-related discomfort, lower effective doses of local anesthetic, and less time for trainees to learn the technique. However, a lower complication rate has not been proven.

The purpose of the present study was to prospectively analyze the use of ultrasound-guided interscalene block at a hybrid academic-private outpatient surgery center in terms of efficacy, complications, readmissions, and patient satisfaction. Our hypothesis is that interscalene block is efficacious and safe and is associated with a high level of patient satisfaction.

**Materials and Methods**

A collaborative perioperative protocol was established by the anesthesia, nursing, and orthopaedic departments at the inception of an outpatient surgery center in 2005. Anesthesia and analgesia were optimized by using both ultrasound-guided interscalene block and supplemental laryngeal mask airway anesthesia. Institutional review board approval was obtained, and prospective data collection for all cases began in September 2005.

<table>
<thead>
<tr>
<th>TABLE I</th>
<th>Shoulder Arthroscopy Primary Procedures (N = 1319)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary Procedure</strong></td>
<td><strong>Number of Patients</strong></td>
</tr>
<tr>
<td>Rotator cuff repair</td>
<td>512</td>
</tr>
<tr>
<td>Subacromial decompression</td>
<td>289</td>
</tr>
<tr>
<td>Labral repair</td>
<td>135</td>
</tr>
<tr>
<td>Stabilization/Latarjet/plication</td>
<td>94</td>
</tr>
<tr>
<td>Acromioclavicular joint resection</td>
<td>90</td>
</tr>
<tr>
<td>Biceps tenodesis</td>
<td>67</td>
</tr>
<tr>
<td>Diagnostic arthroscopy</td>
<td>41</td>
</tr>
<tr>
<td>Debridement/other</td>
<td>91</td>
</tr>
</tbody>
</table>

Individuals were included if they were classified as American Society of Anesthesiologists grade 1 or 2 (ASA 1 or 2) and had shoulder arthroscopy between September 2005 and October 2008. Patients gave informed consent for interscalene block and subsequent data collection. Unlike in other studies, patients with diabetes and patients undergoing neurologically high-risk procedures such as manipulation or capsular releases were included in this cohort. The surgical diagnoses of this cohort are presented in Table I.

Patients were excluded if there was any evidence of neurological compromise that might constitute the first insult of a "double crush" syndrome to the brachial plexus. Such insults included thoracic outlet syndrome, multiple sclerosis, cervical disc disease with ipsilateral radiculopathy, or any preexisting neuropathy or brachial plexopathy. Active infection at the block site or coagulopathy (hemophilia, von Willebrand disease, or an international normalized ratio [INR] of >2) that might increase risk of hematoma or bleeding complications were cause for cancellation of interscalene block. Given that temporary ipsilateral phrenic nerve paralysis is commonly associated with interscalene block, patients with evidence of chronic obstructive pulmonary disease (COPD) were denied interscalene block. Finally, patients who refused interscalene block after informed consent, and those who were managed by surgeons who declined use of interscalene block, were excluded.

All blocks were performed preoperatively by either attending anesthesiologists or senior anesthesia residents under direct attending supervision. All attending anesthesiologists had performed more than fifty ultrasound-guided interscalene blocks prior to commencement of the study. Routine electrocardiography (EKG), noninvasive blood-pressure monitoring, and pulse oximetry were applied. The patient was placed in the supine position with the head turned to the contralateral (nonoperative) side. A procedural "time out" was performed. Midazolam (1 to 4 mg) and remifentanil, titrated in 10 to 20-µg increments, were administered intravenously. The skin was prepared with 2% chlorhexidine in 70% alcohol. Two different ultrasound machines were utilized (Envisor [Philips, Andover, Massachusetts] or Sonix CEP [Ultrasonix, Burnaby, British Columbia, Canada]). A linear high-frequency probe (L12-3 MHz [Philips] or L14-5 MHz [Ultrasonix]) covered with a sterile dressing (Tegeaderm; 3M, St. Paul, Minnesota) was used. A "trace back" method was used to identify the brachial plexus. The ultrasonic scanning began in the supraclavicular fossa, with identification of the subclavian artery and then the adjacent brachial plexus. The brachial plexus was then followed in a cephalad direction to the level of the root-trunk divisions. Once the optimum level was located, the skin posterior to the probe was anesthetized with a skin wheal of 2% lidocaine. With use of a posterior "in-plane" approach, the 23-gauge needle was pushed through the middle scalene and then was advanced under direct ultrasonic guidance through the prevertebral fascia adjacent to the C5-C6 nerve roots or the upper trunk of the brachial plexus. We directly visualized the entire needle parallel with the ultrasound beam. After negative aspiration, 30 to 40 mL of 0.5% mevipacaine with 1:400,000 epinephrine was injected with low resistance. If there was paresthesia, pain, increased pressure, or difficulty with the injection, the needle was repositioned and the block was resumed.
The patient was examined by the anesthesiologist after block placement and was observed in the block area by nursing staff until transport to the operating room. Block failure was defined as an inadequate sensory blockade after thirty minutes of block placement. Desaturation, seizure, ear numbness, or other complications were noted. Patients with block failure were offered the option of a second interscalene block. In nearly every case, interscalene block was used as an adjuvant, and laryngeal mask airway general anesthesia was induced in the usual fashion. If the block was used as the primary anesthetic, the patient was positioned and sedated to the desired level with use of midazolam, fentanyl, and propofol.

Arthroscopy was performed at the discretion of the orthopaedic surgeon. If subpectoral biceps tenodesis was performed, the incision site was infiltrated with 10 mL of 0.5% bupivacaine as the axilla is not consistently covered by the interscalene plexus block.

Postoperatively, the patient was monitored in the postanesthesia recovery room. Discharge was allowed when the patient was awake, able to walk, and hemodynamically stable and after the surgeon had spoken to the patient and/or family. The time between arrival in the recovery room and discharge was recorded.

The patient was contacted by a physician twenty-four hours after discharge. As many as three telephone calls were made if necessary. Set data points were prospectively collected, including the onset of pain and the severity of pain on a 10-point scale. The efficacy of interscalene block was defined as the number of hours of sensory blockade as reported by the patient. The patient was queried with regard to a comprehensive registry of complications, including admission to the emergency department, ear numbness, difficulty voiding, shortness of breath, neuropaxia, and incomplete block. The patient was asked whether he or she would have the block again if another shoulder arthroscopy was needed. Finally, patient satisfaction with interscalene block was rated as very satisfied, satisfied, or dissatisfied. Patients who reoperated with successful sensory blockade, leaving three interscalene blocks (0.23%) that were ultimately unsuccessful in terms of providing analgesia. The ultimate success rate was thus 99.77%.

There were four immediate block failures in the preoperatively arranged cases. Two patients were ultimately managed with a repeat block preoperatively with successful sensory blockade, leaving three interscalene blocks (0.23%) that were ultimately unsuccessful in terms of providing analgesia. The ultimate success rate was thus 99.77%.

The mean amount of time from the end of the procedure to discharge to home was ninety-two minutes. The average duration of pain relief was $14.3 \pm 4.1$ hours with 1:400,000 epinephrine.

Perioperative Complications

A total of thirty-eight major and minor perioperative complications occurred, for a rate of 2.88%. This rate includes all cancellations, emergency department visits, and hospital admissions that may have been even peripherally attributable to interscalene block complications.

The majority of complications were transient neurological events. Fourteen patients experienced ear numbness; this complication was likely due to the placement of the patients in the beach-chair position as eight of these cases involved the contralateral ear. Eight individuals reported digital numbness. One patient reported distal ulnar mononeuropathy. All of the aforementioned conditions resolved over a period of days to four months. There were three cases of postoperative brachial plexitis. One individual was managed with immunoglobulin G (IgG) and had complete resolution of symptoms. The other two patients, as reported in the section on “Permanent Sequelae” below, did not have resolution of symptoms but had substantial underlying comorbidities.

Four procedures were canceled as a result of events before or during the initiation of anesthesia. One patient had chest pain, and another experienced flank pain during block placement. Both patients with pain had a negative cardiac workup. Two patients had oropharyngeal anatomy that precluded laryngeal mask airway placement. These patients were rescheduled for awake intubations in the hospital setting, which proceeded without complication.

Hospital/Emergency Department Admissions

Medical complications, while unrelated to interscalene block, are included to better understand the complications associated with shoulder arthroscopy and to demonstrate the rigor with which adverse events were vetted. Three patients presented to the emergency department. All three were discharged after a few hours of observation. Two of these three patients had emesis that required resuscitation with intravenous crystalloids. The third patient had an allergic reaction to the oral opiate medication that had been given for postoperative pain control. These adverse events are summarized in Table II.

Finally, six patients required overnight admission to the hospital for workup of conditions encountered during the perioperative period. Three of these patients had cardiac issues that were likely not related to the interscalene block. One of

<table>
<thead>
<tr>
<th>TABLE II Miscellaneous Adverse Events*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presentation</td>
</tr>
<tr>
<td>Flank pain after block (1 case)</td>
</tr>
<tr>
<td>Unable to secure airway (2 cases)</td>
</tr>
<tr>
<td>Nausea and vomiting (2 cases)</td>
</tr>
<tr>
<td>Allergy to pain medication (1 case)</td>
</tr>
</tbody>
</table>

*Six cases (prevalence, 0.46%).
these three patients had a myocardial infarction. The second patient had postoperative chest pain and a negative workup. The third patient experienced intraoperative bradycardia that necessitated the halting of the procedure and admission; telemetry and laboratory workup were negative. Hospital admissions are summarized in Table III.

Noncardiac complications varied in this large study group. One patient had substantial pain in the recovery room and was admitted for twenty-three hours for pain control. A young male patient aspirated during the procedure, resulting in mild hypoxemia and bilateral lung consolidation. The patient was discharged after twenty-three hours of observation. Finally, a sixth patient required admission to the hospital because of an apparent seizure in the recovery room. Full neurological workup was negative. A neurologist later made the diagnosis of factitious seizure.

**Permanent Sequelae**

Although the majority of adverse events proved to be transient, three patients (0.23%) had persistent sequelae at the time of the latest follow-up. Each of these individuals had comorbidities that explained part or all of the pathology. The first patient presented with perioperative myocardial infarction. Concomitant emboli in the left and anterior descending arteries necessitated cardiac catheterization despite the placement of sequential compression devices during surgery. The second individual initially was believed to have persistent brachial plexitis but subsequently was diagnosed with transverse myelitis with substantial involvement of all four extremities. The third patient, also with persistent brachial plexopathy, was subsequently diagnosed with multiple sclerosis, which was later identified as a potential risk factor for brachial plexopathy after interscalene block. Multiple sclerosis is a relative contraindication for interscalene block. Neurological complications are summarized in Table IV.

**Patient Satisfaction**

Of the 1319 patients who were managed with the aforementioned protocol, seventeen could not be contacted the next day despite a series of three calls initiated by the anesthesiologist. Thirty-one...
patients had partially incomplete data sheets. Thus, complete next-day follow-up was available for 1271 patients (96.4%).

One thousand one hundred and sixty-one patients (91.35%) were "very satisfied" with the interscalene block, ninety-eight (7.71%) were "satisfied," and twelve (0.94%) were "unsatisfied." Of the twelve unsatisfied patients, four reported pain earlier than expected, three felt uncomfortable with the sensation of numbness/paresthesia, two reported pain at the subpectoral biceps tenodesis site, and three gave no reason for their dissatisfaction. The percentage of "satisfied" and "very-satisfied" respondents was 99.06%. These data are summarized in Table V.

Finally, 97.8% of individuals reported that they would elect to have another ultrasound-guided interscalene block if they required shoulder arthroscopy in the future.

**Discussion**

To our knowledge, this is the largest prospective study of interscalene block anesthesia for shoulder arthroscopy and it is one of the few to employ modern ultrasound guidance or to evaluate patient satisfaction. This study is unique in several respects. We included only shoulder arthroscopy cases. No adjunctive local anesthesia (suprascapular or axillary nerve block) was performed. Set data points were collected prospectively with great sensitivity for both major and minor adverse events. Patient satisfaction has been largely ignored in the literature but was included in the present study. The greatest strength of the present study is the large study cohort. The large cohort was essential in order to screen for the rare major complications that dissuade orthopaedic surgeons from recommending interscalene block.

Bishop et al. retrospectively reviewed 568 blocks that had been performed with nerve stimulator guidance. Both open and arthroscopic shoulder procedures were included in that study. The authors reported a 97% success rate, a 2.3% minor complication rate, and no major complications. Only neurologic complications were reported; events such as readmissions, emergency department visits, and medical events were not included in the 2.3% complication rate. Patient satisfaction was not reported. In our cohort of 1319 cases, we found a 99.6% rate of successful blockade on the first attempt, representing a reduction in the failure rate from 3% (as reported by Bishop et al.) to 0.4%. Ultrasound guidance resulted in approximately one failure in 300 patients, as compared with one failure in forty patients managed with nerve stimulation.

A similar study in the anesthesia literature was a well-designed prospective study by Borget et al., who followed 520 patients who were managed with interscalene block for shoulder surgery performed with nerve stimulation. Those authors reported more early symptoms than we found in the current study, but they reported a nearly identical rate of catastrophic permanent sequelae. Patient satisfaction was not evaluated.

In another recent prospective study, Liu et al. compared ultrasound-guided interscalene block (n = 515) with supraclavicular block (n = 654) for shoulder arthroscopy procedures. They reported no permanent neurological injuries, a 0.9% rate of transient neurological symptoms with interscalene block, no need for conversion to general anesthesia, and high patient satisfaction.

Understandably, some orthopaedic surgeons remain guarded when recommending interscalene block to their patients, given earlier case reports documenting catastrophic events such as signs of toxicity, seizure, pneumothorax, arrhythmia, peripheral neurological complications, and death. These severe adverse outcomes, highlighted in a retrospective review by Lenters et al., led some surgeons to abandon the use of interscalene blocks for fear of adding a potential source of morbidity to shoulder arthroscopy. Those early studies, however, were retrospective in nature. More importantly, they only included blocks performed with paresthesia or nerve stimulator techniques.

Nerve stimulation and paresthesia-guided interscalene blocks require more time, require more needle sticks, have a shorter effective duration, require more training, and are less efficacious than interscalene blocks performed with ultrasound guidance. One recent study demonstrated that with direct needle-to-nerve contact on ultrasound, nerve stimulation elicited a positive response in only 75% of cases, whereas the paresthesia technique was even less accurate. Superior localization of the needle in relation to the brachial plexus should result in increased quality and success of interscalene block, as demonstrated in the studies by Kapral et al. and Soeding et al. Given these data, it is reasonable to assume that blind techniques would lead to more direct trauma to nerves or would result in a hazardous bolus of local anesthetic being injected intraneurally, causing transient or permanent nerve injury. Decreased neurologic complications with ultrasound guidance, however, have not been scientifically proven.

In a study of 218 patients, Weber and Jain reported a high (13%) rate of interscalene block failure, a 3.7% rate of major complications, and higher cost as compared with general anesthesia. They concluded that the benefits and risks of the procedure were equivocal. The current study differs from that study in several important respects. First, Weber and Jain used the imprecise awake blunt needle nerve stimulation technique, leading to an unacceptably high rate of block failure, complications, and a high rate of utilization of narcotic medications postoperatively. The use of postoperative narcotics significantly added to the overall expense of the procedure in that study. Narcotic use is minimal after well-placed interscalene block, and the narcotic use in the study by Weber and Jain points to the imprecision of block placement. Second, we performed

### TABLE V Patient Satisfaction (N = 1271)*

<table>
<thead>
<tr>
<th>Satisfaction Level</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very satisfied</td>
<td>1161</td>
<td>91.35%</td>
</tr>
<tr>
<td>Satisfied</td>
<td>98</td>
<td>7.71%</td>
</tr>
<tr>
<td>Unsatisfied</td>
<td>12</td>
<td>0.94%</td>
</tr>
</tbody>
</table>

*The values are given as the number of patients. Overall, 99.06% of the patients were satisfied and 0.94% were unsatisfied.
Interscalene block in the preoperative area, decreasing the use of expensive operating room time and increasing efficiency. Our turnover time averaged less than fourteen minutes. Multiple authors have subsequently challenged the findings of the study by Weber and Jain.

Neurological complications of regional anesthesia have been the subject of multiple recent studies. Fredrickson and Kilfoyle prospectively examined such complications following 1000 peripheral blocks that were placed under ultrasound guidance, including 659 indwelling interscalene catheters. These resulted in neurological symptoms in 8.2% of patients at ten days and in 3.7% at one month. The increased prevalence of nerve injury in that study was possibly due to the longer exposure to anesthetic and out-of-plane technique.

The levels of training and experience of the anesthesiologist are directly proportional to success and safety of regional anesthesia. The data collected in the present study are all from a single outpatient surgery center where both academic and community orthopaedists practice. The nursing and anesthesia groups are run in a private practice model and are experienced with outpatient procedures and ultrasound-guided interscalene block, respectively. Resident anesthesiologists rotate through the center and are closely supervised during block placement by an experienced attending anesthesiologist. We believe that these factors, and thus our results, are reproducible in most practice settings.

While most of the reported complications in the present study were not related to the interscalene block but rather were related to patient comorbidities or to perioperative, anesthetic, or orthopaedic causes, they were included for the sake of transparency and because we were unable to directly assign a cause-and-effect relationship.

One limitation of the present study is that we did not review narcotic administration in the recovery room. There were two reasons for this. First, it has been well documented that narcotic use is very low after interscalene block. Second, unlike complication rates and patient satisfaction, which were the primary outcomes evaluated in this study, narcotic utilization is not a barrier to surgeon adoption of interscalene anesthesia.

Another limitation of the present study is the lack of a nerve stimulator-guided control group. Given the growing body of evidence regarding improved block placement efficiency, effect duration, patient tolerance, and reduced failure rates with ultrasound guidance, we believed that it would have been regressive to utilize a nerve stimulator when ultrasound is readily available at our institution. Given this factor, we cannot draw direct conclusions between the safety of ultrasound-guided and nerve stimulator-guided interscalene block.

A third limitation of the present study is the extensive use of patient-reported metrics. Patients were screened over the telephone by a physician who assessed a broad set of issues, but only individuals who reported any adverse events were followed by the surgeon and anesthesiologist until resolution. After the initial assessment, there was no regular reporting of a broad set of data but rather a more focused approach to the problem. This approach could be seen as a disadvantage that may have allowed late complications to be missed or as an advantage that allowed us to obtain data on what actually matters to patients in such a large cohort.

Our study strongly supports the use of interscalene block for operative anesthesia and postoperative analgesia in patients undergoing shoulder arthroscopy. The rate of successful sensory blockade was 99.77%, including the few individuals who had a repeat block. Patients were “very satisfied” or “satisfied” 99% of the time. The major and minor complication rate was an acceptable 2.88%, with the majority of complications being unrelated to the interscalene block. Permanent sequelae were present in only three patients (0.23%), each of whom proved to have comorbidities that help to explain the complications.

References


