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Efficacy of surgeon-directed suprascapular and axillary nerve blocks in shoulder arthroscopy: a 3-arm prospective randomized controlled trial

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Background: The use of regional anesthesia in shoulder arthroscopy improves perioperative pain control, thereby reducing the need for opioids and their recognized side effects. Occasionally one type of block is not suitable for a patient's anatomy or comorbidities or requires a specially trained anesthetist to safely perform. The primary aim of this study is to compare the efficacy of 3 different nerve blocks for pain management in patients undergoing shoulder arthroscopy.

Methods: A 3-arm, blinded, randomized controlled trial in patients undergoing elective, unilateral shoulder arthroscopic procedures between August 2018 and November 2020 was conducted at a single center. One hundred and thirty participants were randomized into 1 of 3 regional anesthesia techniques. The first group received an ultrasound-guided interscalene block performed by an anesthetist (US + ISB). The second group received an ultrasound-guided suprascapular nerve block and an axillary nerve block by an anesthetist (US + SSANB). The final group received a suprascapular nerve block without ultrasound and an axillary nerve block under arthroscopic guidance by an orthopedic surgeon (A + SSANB). Intraoperative pain response, analgesia requirements, and side effects were recorded. Visual analogue pain scores and opioid doses were recorded in the Post Anaesthesia Care Unit (PACU) and daily for 8 days following the procedure.

Results: Twelve patients withdrew from the study after randomization, leaving 39 participants in US + ISB, 40 in US + SSANB, and 39 in A + SSANB. The US + ISB group required significantly lower intraoperative opioid doses than US + SSANB and A + SSANB ($P < .001$) and postoperatively in PACU ($P < .001$). After discharge from hospital, there were no differences between all groups in daily analgesia requirements ($P = .063$). There was significantly more nerve complications with 6 patient-reported complications in the US + ISB group ($P = .02$). There were no reported differences in satisfaction rates between groups ($P = .41$); however, the A + SSANB group was more likely to report a wish to not have a regional anesthetic again ($P = .04$).

Conclusion: The US + ISB group required lower opioid doses perioperatively; however, there was no difference between groups after discharge from PACU. The analgesia requirements between the US + SSANB and A + SSANB were similar intraoperatively and postoperatively. A surgeon-administered SSANB may be a viable alternative when an experienced regional anesthetist is not available.

Mater Hospital & Health Services North Queensland Ethics Committee approved this study: MHS20171114-01.
Clinical Trial Registration: ACTRN12617001546347.

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The use of regional anesthesia in shoulder arthroscopic procedures improves perioperative pain control, thereby reducing the need for opioids and their recognized side effects.[3] Techniques for managing pain during and after surgery have been modified over time and now regional anesthesia is almost universally employed.[16]

The interscalene block (ISB) provides excellent analgesia to the entire shoulder and providing intraoperative muscle relaxation.[3] It is recognized as one of the most effective regional blocks for shoulder surgery.[3,4] The addition of ultrasonic imaging to visualize the anatomy and needle-tip has minimized inadvertent neurological injury which was previously a concern when using a landmark-based "blind" technique.[9] However, the ISB continued to have unwanted side effects and potentially serious complications including phrenic nerve palsy, pneumothorax, spinal cord injury, brachial plexus injury, transient Horner's syndrome, and persistent paresthesias.[9,15,24,25] Some patients also find the motor blockade of the hand and wrist following ISB concerning and troublesome.[7] The most common serious side effect is transient ipsilateral phrenic nerve palsy,[10] previously reported as occurring in up to 100% of patients and leading to a 25% reduction in pulmonary function.[20,28,29] Although tolerable and asymptomatic in healthy subjects, patients with chronic respiratory disease or contralateral phrenic nerve paralysis may not tolerate this loss of pulmonary vital capacity and an ISB is therefore considered a relative contraindication.[3,29]

Therefore, an anesthetist requires specific training to perform an advanced peripheral nerve block like ISB. Some centers may not have access to anesthetists with this type of subspecialty training.[16]

The potential of serious side effects from the ISB and potential lack of access to anesthestists with advanced training in the technique has led to research into more selective blockades. The suprascapular nerve is responsible for 70% of the innervation of the shoulder joint, supplying the bulk of the subacrominal, posterior glenohumeral capsule, and fascia of the proximal humerus.[6,26] The remaining 30% of inferior, lateral, and anterior structures are primarily innervated by the axillary nerve.[14,21] Price[22] and Checcucci[3] et al independently described the combined suprascapular and axillary nerve block (SSANB) as an alternative for when the ISB may not be well tolerated clinically or where the ISB had failed postoperatively. Subsequent authors have published variations of this block with the assistance of ultrasound or arthroscopic guidance.[2,14,21] The arthroscopic-assisted axillary block technique combined with a landmarks-based suprascapular nerve block is useful and straightforward for a surgeon to perform intraoperatively in the event that an anesthetist is not trained in the ultrasound-assisted block techniques such as an axillary block or ISB.[16] The addition of the axillary block to the suprascapular nerve block is a relatively new technique, with promising early prospective study results.[6] To our knowledge, there has been no study directly comparing an ultrasound-guided SSANB with arthroscopically-guided SSANB.

Table I
Inclusion and exclusion criteria.

Inclusion criteria	Exclusion criteria
Male and female	Preexisting nerve injury
Age 18-90	Adverse drug reaction to study medications
Patients with BMI < 40	Contraindications to interscalene block (eg, severe COPD)
Condition requiring arthroscopic shoulder surgery	Patients unable to comply with assessment requirements

BMI, body mass index; *COPD*, chronic obstructive pulmonary disease.

Our study aims to compare the efficacy of an ultrasound guided, anesthetist-administered interscalene block (US + ISB), an ultrasound guided, anesthetist-administered suprascapular and axillary nerve block (US + SSANB) with a surgeon-administered suprascapular nerve block and arthroscopically guided axillary nerve block (A + SSANB). These techniques were assessed in regards to pain scores, analgesic requirements, and patient satisfaction. To our knowledge, this is the first study to compare the clinical efficacy *in vivo* of these techniques.

Methods

Study design

We conducted a 3-arm, single-blinded, randomized clinical trial in patients undergoing elective, unilateral shoulder arthroscopic surgery between August 2018 and November 2020 at a single center. All patients provided a written consent prior to randomization. The trial was approved by the Mater Hospital & Health Services North Queensland Ethics Committee (MHS20171114-01) and a clinical trial registration was completed (ACTRN1261700 1546347).

Study patients

All patients who were scheduled to undergo shoulder arthroscopic surgery who met the inclusion criteria (Table I) were offered participation in the study. One hundred thirty participants were randomized into 1 of 3 interventions (Fig. 1). Randomization was performed with a computer random sequence generator by a nonclinical research co-ordinator (A.G.). The surgeon, anesthetist, and scrub nurses were made aware of the group arm prior to surgery. The patients remained blinded to the intervention.

Anesthetic and surgical technique

All patients received a general anesthetic and underwent standard anesthetic monitoring throughout the procedure. Induction agents consisted of fentanyl, propofol, and midazolam, based on patient's weight and titrated to effect. All patients in the US + SSANB and A + SSANB groups received a standardized baseline dose of parenteral opioids by patient weight. The type and volume of local anesthetic (LA) and the intraoperative and postoperative analgesia regimens were chosen by peer discussion among anesthetic colleagues (B.S., A.K., and A.F.) with experience in regional anesthesia. These were standardized throughout the study (Table II). Analgesia doses administered intraoperatively were recorded and a standardized regime was used (Table III).

The procedures were performed based on the pathology seen on preoperative magnetic resonance imaging and confirmed during arthroscopy. They were performed in the beachchair position (n = 107) or lateral decubitus position (n = 23), based on surgeon preference.

At the end of the procedure, LA was injected subcutaneously around port sites and additional skin incisions (5 mL saline + 5 mL Ropivacaine 1% + 0.1 mL 1:1000 adrenaline).

Peripheral nerve block technique

US + ISB

A US + ISB was performed by anesthstetists with specialized training in regional anesthesia. Skin was prepped with chlorhexidine and then an ultrasound transducer was placed over the

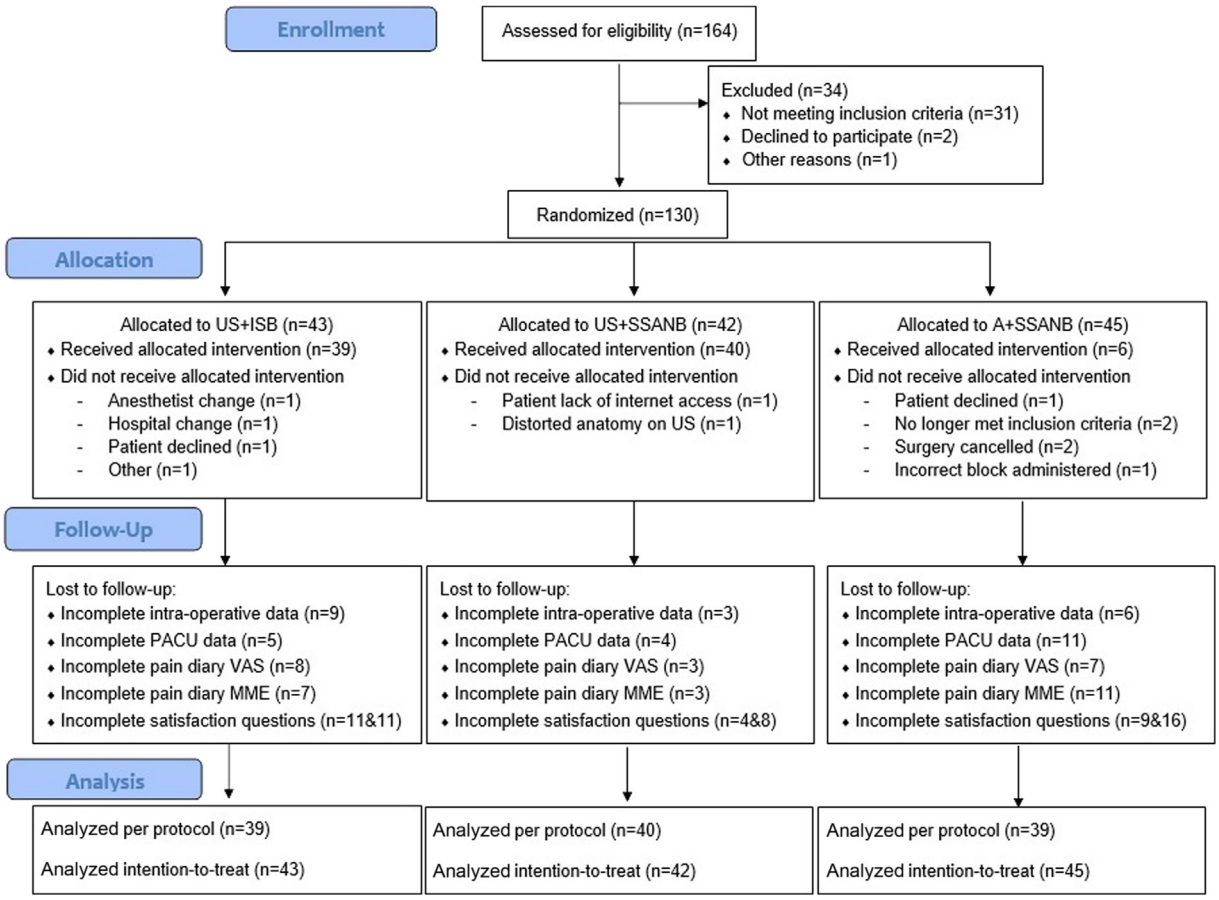

Figure 1 CONSORT flow diagram of recruitment. *US + ISB*, ultrasound-guided interscalene block; *US + SSANB*, ultrasound guided suprascapular and axillary nerve block; *A + SSANB*, arthroscopic-assisted suprascapular and axillary nerve block; *PACU*, post anesthesia care unit; *VAS*, visual analog scale; *MME*, morphine milligram equivalents. CONSORT diagram template accessed from http://www.consort-statement.org/.

Table II
Standardized intraoperative analgesia dosing regimen.

Group	Dose regime
US + ISB	- Ropivacaine 0.75% (150 mg) + Clonidine, (1 mcg/kg) made up to 20 mL with 0.9% saline - Single dose, prior to incision - All 20 mL given at once into ISB - No adjunct analgesia given as baseline (eg, parecoxib, paracetamol, or oxycodone).
US + SSANB	- Ropivacaine 0.75% (150 mg) + Clonidine, (1 mcg/kg) made up to 20 mL with 0.9% saline - Prior to incision - 13 mL into SSNB, 7 mL into ANB - Parecoxib and paracetamol given as baseline - Oycodone (0.1 mg/kg) given at baseline and then titrated based on heart rate, blood pressure, and respiratory rate
A + SSANB	- Ropivacaine 0.75% (150 mg) + Clonidine, (1 mcg/kg) made up to 20 mL with 0.9% saline - 13 mL into SSNB prior to incision, 7 mL into ANB with arthroscopic guidance - Parecoxib and paracetamol given as baseline - Oycodone (0.1 mg/kg) given at baseline and then titrated based on heart rate, blood pressure, and respiratory rate

US + ISB, ultrasound-guided interscalene block; *US + SSANB*, ultrasound-guided suprascapular and axillary nerve block; *A + SSANB*, arthroscopic-assisted suprascapular and axillary nerve block.

interscalene region to visualize the brachial plexus at the level of C5-C7. Once anatomy had been confirmed, a 22G Ultraplex needle was introduced through the skin using an in-line technique. Under continuous ultrasound guidance, with the needle remaining in view, 20 ml of the LA solution was infiltrated adjacent to the brachial plexus nerve roots and/or trunks.

US + SSANB

The 20 ml of the LA solution was divided into 13 ml for the SSNB and 7 ml for the ANB. The technique used was similar to that described by Price.[22] The US probe was used to visualize the suprascapular nerve as it courses along the most lateral part of the floor of the supraspinous fossa. The 22G Ultraplex needle was

Table III
Standardized breakthrough analgesia dosing regimen.

Time point	Dose regime
Intraoperative breakthrough pain	- Oxycodone IV 0.1 mg/kg OR morphine IV (if sensitivity to oxycodone) OR fentanyl IV (if sensitivity to oxycodone or morphine documented previously) - Titrate to heart rate, blood pressure, and respiratory rate
PACU breakthrough pain	- Oxycodone IV 0.1 mg/kg (titrate to respiratory rate) If no response: - Ketamine IV 0.3 mg/kg stat dose AND - Paracetamol 1 g QID for 48 h, then PRN - Ibuprofen 400 mg TDS for 24 h, then PRN
Discharge pain medication	- Paracetamol PO 1 g QID for 48 h, then PRN - Celecoxib PO 200 mg TDS for 24 h, then PRN - Oxycodone PO 5-10 mg Q4H PRN - Temazepam PO 10 mg nocte PRN (for RCRs only) - Tapentadol SR PO 50-100 mg BD PRN - Patient preferred adjuncts where appropriate (eg, paracetamol/codeine combinations, oxycodone with naloxone slow-release tablets)

IV, intravenous; *PACU*, post anaesthesia care unit; *PRN*, as required; *PO*, orally; *RCR*, rotator cuff repair; *SR*, slow release.

directed in plane into the lateral part of the fossa and 13 mL of LA was injected close to the nerve and deep to the fibres of supraspinatus and the superior transverse scapular ligament. For the ANB, US probe was positioned along the lateral aspect of the humerus to image the posterior surface of the humerus. The deltoid muscle fibers were identified and then the circumflex artery and axillary nerve. A 22G Ultraplex was introduced in plane and 7 ml of the LA solution was injected adjacent to the axillary nerve, between the circumflex artery and posterior surface of the humerus.

A + SSANB

The technique used for SSNB using surface landmarks was described by Meier[17] and described in English by Price.[22] A 22G spinal needle was inserted at a point 2-cm cranial and 2-cm medial to bisection of the scapula spine (Fig. 2). The needle was directed caudally, anteriorly and laterally, and walked along bone until the suprascapular notch was reached and a total of 13 ml of LA was injected. For the ANB, the arthroscope was placed into the glenohumeral joint via a posterior portal. The inferior recess of the glenohumeral joint was inspected and a 23-gauge spinal needle, with an introducer, was advanced from a posterior direction parallel to the arthroscope and beneath the inferior capsule, as the axillary nerve passes only a few millimeters beneath the capsule here. Distention of this space was easily visualized as the 7 mL of LA was injected (Fig. 3).

The user's perception of the difficulty of administering the block was then recorded as "Easy," "Moderate," or "Difficult". This was to assess for potential confounding factors such as difficult cervical nerve root anatomy with the ISB and to try and identify any learning curve associated with the A + SSANB or US + SSANB.

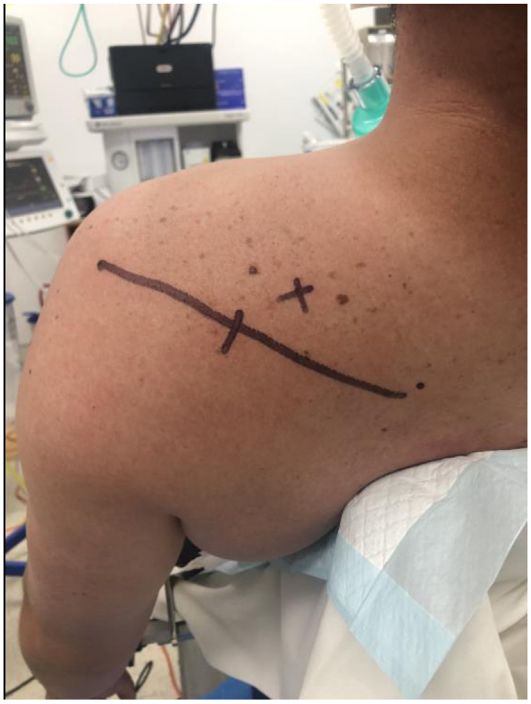

Figure 2 Landmark technique for suprascapular nerve block. The scapular spine is marked by the transverse line, with the middle bisected by a perpendicular line. The insertion point for the local anesthetic needle is denoted by "X".

Postoperative management

Pain scores were assessed from patients using a Visual Analog Scale (VAS) and analgesia doses during time in the Post Anesthesia Care Unit (PACU) were recorded. The extent of motor blockade was measured by PACU nurses after the patient had fully recovered from their general anesthesia. This was measured as "nil" (full active movement of operative limb), "partial" (some active movements of arm possible), or "complete" (no active movement of blocked arm possible). This was recorded, as patients can be troubled by motor blockade of the hand and wrist, associated with some ISB.[7]

A shoulder-immobilizing sling was given to all patients. Postoperative rehabilitation was individualized as per the procedure. Each patient was asked to record VAS scores and all medication administered over the course of the day for 8 days following the operation. All patients were discharged with prescriptions following a standard medication regimen (Table III). At the 1-week postoperative mark, patients were asked to complete a satisfaction questionnaire and report on neurological complications.

Morphine milligram equivalent dose calculations

The primary outcome was the efficacy of pain management—intraoperatively, in PACU, and in the 8 days postoperatively—as assessed by pain scores and conversion of analgesia doses to morphine milligram equivalent (MME) doses. MME doses were calculated using the Australian and New Zealand College of Anaesthetists Calculator.[31]

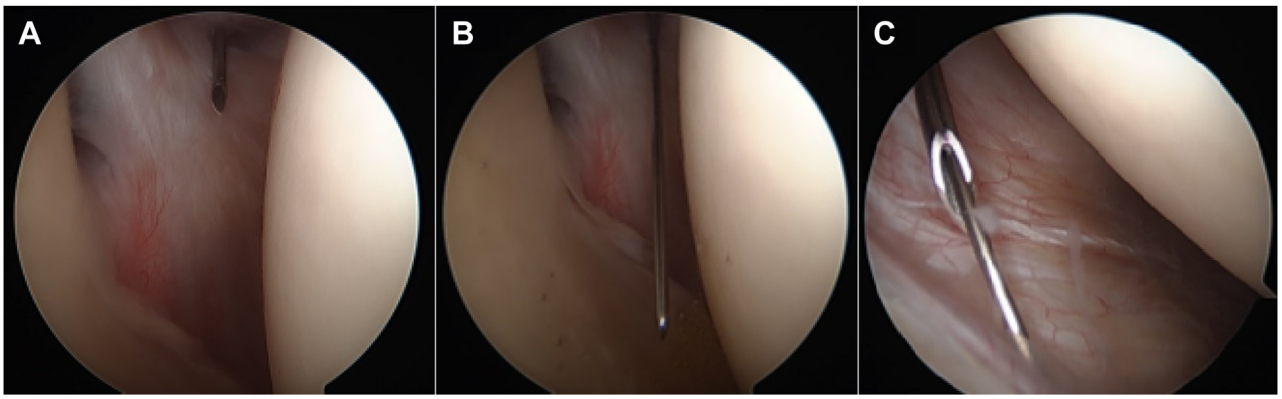

Figure 3 Intraoperative photos of the axillary nerve block. (**a**) The introducing cannula for a 23-G spinal needle is inserted in to the shoulder joint under arthroscopic visualization; (**b**) The spinal needle is advanced; (**c**) The inferior capsule is pierced and local anesthetic is administered to the area just deep to the inferior capsule.

Sample size

Assuming Type I error (alpha) to 5% ($P = .05$) and Type II error (beta) to 0.2% (power equal to 80%), the sample size calculated was 35 participants per study group. To compensate for expected loss to follow-up, 130 patients were recruited. This proposed study size is greater than other studies that compared US + ISB with SSANB.[5,13,19,23,30]

Statistical analysis

All data were analyzed using the statistical software (SPSS v28; IBM Corp., Armonk, NY, USA). The Shapiro-Wilk's test indicated that the continuous parameters were departed from the norm, and thus nonparametric tests were conducted. The measure of central tendency and dispersion of continuous parameters were reported as median and interquartile range (25%-75%) (IQR), while categorical variables were reported as frequencies. A one-way analysis of variance (ANOVA) test was used to assess the significance of the dropout between groups and intention-to-treat analysis (with worst case scenario assumption) was used to account for dropout and missing data points. The Kruskal-Wallis test was used to compare the nonparametric continuous parameters between groups. The Mann-Whitney U test was employed to determine the location of differences if a main effect of group was identified. The Mann-Whitney U test was also conducted for subgroup analysis, using the observed standardized effect size, with values of less than 0.3 considered small, between 0.3 and 0.5 as moderate, and more than 0.5 as a large effect. The chi-squared test was used to examine the association between the categorical variables, with a Cramer *V* test used to determine effect size. The alpha level was set to 0.05 for all analyses.

Results

The demographic characteristics for each group are reported in Table IV, with no significant intergroup differences. Twelve patients withdrew from the study after randomization, leaving 39 participants in US + ISB, 40 in US + SSANB, and 39 in A + SSANB. A one-way ANOVA test showed no significant difference in dropout rates between groups ($P = .392$). Reasons for withdrawal included participant reconsideration prior to day of surgery and inability to complete online data collection forms postoperatively (eg, the pain diary).

Operative characteristics are presented in Table V. No significant differences were identified between the 3 groups for the type of operation performed ($\chi^2 = 6.58$; $P = .62$), including whether or not a biceps tenodesis was performed ($\chi^2 = 5.92$; $P = .051$). There were no significant intergroup differences in the perceived "difficulty" of block administration at time of block preoperatively ($P = .07$; $\chi^2 = 8.72$).

Block failures

One patient in the US + ISB group, 1 patient in the US + SSANB, and 2 patients in A + SSANB received an additional interscalene block due to inadequate pain relief achieved from the standardized PACU protocol (Table III). A chi-squared test of independence was performed to examine the relation between rescue blocks between groups. The relation of the complication rate between these groups was not significant χ^2 (2, n = 118) = 0.5378, $P = .7642$.

Patient #23 (US + ISB group) underwent an arthroscopic rotator cuff repair, subacromial decompression, and open subpectoral biceps tenodesis. They received 18 MME doses intraoperatively for hypertension and tachycardia, and a further 30 MME doses in PACU for a VAS of 8. The anesthetist gave the patient a rescue ISB block, as they were concerned that the initial block was not administered correctly.

Patient # 63 (US + SSANB group) underwent an arthroscopic rotator cuff repair, subacromial decompression, and open subpectoral biceps tenodesis. They received 40 MME doses intraoperatively, 60 MME doses in PACU, and subsequently received a rescue ISB block in PACU. The VAS data and intraoperative data referencing signs of pain relief were incomplete for this patient.

Patient #77 (A + SSANB group) underwent an arthroscopic rotator cuff repair, subacromial decompression, acromioclavicular (AC) joint excision, and open subpectoral biceps tenodesis. This block was recorded as "difficult" due to body habitus. Intraoperatively, this patient required 50 MME doses and clonidine, droperidol, nitrous oxide, and ketamine and a further 80 MME doses in PACU. Despite this, he still had a VAS of 10, hypertension and tachycardia, so a rescue ISB was administered in PACU.

Patient #95 (A + SSANB group) underwent an arthroscopic subacromial decompression, AC joint excision, and open subpectoral biceps tenodesis. They received 50 MME doses intraoperatively and 60 MME doses in PACU. Despite this, he still had a VAS of 9, so a rescue ISB was administered in PACU. The VAS data and intraoperative data referencing signs of pain were incomplete for this patient.

Intention to treat analysis

To account for missing results data (eg, VAS, MME doses, satisfaction, pain diary, etc.) and minimize bias, intention-to-treat

Table IV
Demographic data.

Parameters	US + ISB	US + SSANB	A + SSANB	Difference
Age	56 (48-62)	51 (34-61)	51 (36-58)	$P = .18$
BMI	29.0 (27.0-35.0)	30.0 (26.0-34.8)	28.0 (26.0-31.5)	$P = .18$
Sex (male)	29/39 (74.4%)	28/40 (70.0%)	27/39 (69.2%)	$P = .86$

US + ISB, ultrasound-guided interscalene block; *US + SSANB*, ultrasound guided suprascapular and axillary nerve block; *A + SSANB*, arthroscopic-assisted suprascapular and axillary nerve block; *BMI*, body mass index.
Quantitative variables are summarized by median (interquartile range).

analysis was performed, using the "worst case scenario" assumption. The results for Patient #77 were viewed as the "worst case scenario" for the perioperative period, as they received the highest MME doses (50 MME doses intraoperatively and 80 MME doses in PACU) and received a rescue ISB in PACU. A "complete" motor blockade was deemed the "worst case scenario" for the extent of the motor block in PACU. The results for Patient #76 were viewed as the "worst case scenario" for postdischarge MME doses (722 MME doses over 8 days) and a VAS of 10 as the "worst case scenario" for the postdischarge pain diary. Satisfaction questions required a "yes" or "no" answer, with "no" being assigned the "worst case scenario".

Intraoperative MME

Regarding the intraoperative MME data, there were missing data in the US + ISB group (n = 9), US + SSANB group (n = 3), and the A + SSANB group (n = 6). A 1-way ANOVA test showed that the difference in the missing data was not significant ($P = .186$).

On intention-to-treat analysis, a Kruskal-Wallis test showed the type of block significantly affected the MME doses required intraoperatively, H (2, n = 130) = 28.10, $P < .001$, where US + ISB group required significantly less MME doses (median MME 20, IQR 15), compared to the US + SSANB group (median MME 40, IQR 20) and A + SSANB group (median MME 40, IQR 20).

PACU MME

Regarding the PACU MME data, there were missing data from all groups: US + ISB group (n = 5), US + SSANB (n = 4), and A + SSANB (n = 11). A 1-way ANOVA test showed no significant difference in missing data between the 3 groups ($P = .112$).

On intention-to-treat analysis, a Kruskal-Wallis test showed the type of block significantly affected the MME doses required in PACU, H (2, n = 130) = 21.66, $P < .001$, where the US + ISB group required significantly less MME doses (median MME 15, IQR 18), compared to the US + SSANB group (median MME 30, IQR 36) and A + SSANB (median MME 30, IQR 63.5).

Motor blockade in PACU

Regarding the extent of the motor blockade of the arm in PACU, there were missing data as follows: US + ISB group (n = 12), US + SSANB (n = 5), and A + SSANB (n = 11). A 1-way ANOVA test showed no significant difference in missing data between the 3 groups ($P = .171$).

On intention-to-treat analysis, a chi-squared test of independence was performed to examine the relation of extent of motor blockade ("nil", "partial", and "complete") between the groups (Table Motor Block). The relation between those groups was not significant χ^2 (4, n = 130) = 7.048, $P = .133$, with small effect size ($V = 0.165$). Given the small magnitude of difference between the 2 groups, this sample size is likely not large enough to detect a difference.

Table V
Operative characteristics.

Procedure type	US + ISB	US + SSANB	A + SSANB
SAD/acromioplasty	29/39 (74.4%)	30/40 (75%)	29/39 (74.4%)
Rotator cuff repair	22/39 (56.4%)	17/40 (42.5%)	16/39 (41%)
Biceps tenodesis	31/39 (79.5%)	22/40 (55%)	23/39 (59.0%)
Biceps tenotomy	1/39 (2.6%)	2/40 (5%)	1/39 (2.6%)
Remplissage	0/39 (0%)	0/40 (0%)	2/39 (5.1%)
Excision of calcium deposit	1/39 (2.6%)	0/40 (0%)	1/39 (2.6%)
ACJ excision	7/39 (17.9%)	10/40 (25%)	10/39 (25.6%)
Stabilization	5/39 (12.8%)	7/40 (17.5%)	10/39 (25.6)

US + ISB, ultrasound-guided interscalene block; *US + SSANB*, ultrasound guided suprascapular and axillary nerve block; *A + SSANB*, arthroscopic-assisted suprascapular and axillary nerve block; *SAD*, subacromial decompression; *ACJ*, acromioclavicular joint.
Quantitative variables are summarized by median (interquartile range).

Postdischarge MME

Regarding the postdischarge MME doses, patients listed their total analgesia doses per day, over 8 days postoperatively. There were missing data: US + ISB group (n = 7), US + SSANB (n = 3), and A + SSANB (n = 11). A 1-way ANOVA test showed no significant difference in missing data between the 3 groups ($P = .092$).

On intention-to-treat analysis, a Kruskal-Wallis test showed no overall significant difference in the median recorded 8-day MME doses between the 3 groups ($P = .063$), with US + ISB group 8-day MME doses (median 130, IQR 473), the US + SSANB group 8-day MME doses (median 113.5, IQR 123.5), and A + SSANB 8-day MME doses (median 123, IQR 509).

Postoperative pain diary VAS

Regarding the postoperative pain diary, patients listed their average VAS per day, over 8 days postoperatively. There were missing data: US + ISB group (n = 8), US + SSANB (n = 3), and A + SSANB (n = 7). A 1-way ANOVA test showed that there were no significant differences between the 3 groups ($P = .290$).

On intention-to-treat analysis, a Kruskal-Wallis test showed no overall significant difference in the total recorded 8-day pain scores between the 3 groups ($P = .945$): US + ISB group VAS (median 4.62 of 10, IQR 4.25) over the 8 postoperative days, US + SSANB group VAS (median 4.5 of 10, IQR 2.64), and A + SSANB group VAS (median 4.25, IQR 3.69).

Satisfaction scores

Regarding satisfaction reporting, there was incomplete documentation. However, the loss of data showed no significance between groups (Table VI).

A chi-squared test of independence was performed to examine patient-reported satisfaction questions using intention-to-treat analysis and per protocol analysis (Table VI).

For Satisfaction Q1: "Were you satisfied with the anesthetic you received?", there was no significant difference in responses

Table VI
Satisfaction questionnaire.

Questions	US + ISB	US + SSANB	A + SSANB	Significance
Satisfaction Q1: "Were you satisfied with the anesthetic you received?"				
No response submitted	11	4	9	$P = .417$
Yes	31	35	33	PP $P = .492$
No	1	3	3	ITT $P = .410$
Satisfaction Q2: "If you were to have the same operation again, would you have a regional anesthetic?"				
No response submitted	11	8	16	$P = .219$
Yes	29	33	24	PP $P = .019$*
No	14	9	21	ITT $P = .04$*

US + ISB, ultrasound-guided interscalene block; *US + SSANB*, ultrasound guided suprascapular and axillary nerve block; *A + SSANB*, arthroscopic-assisted suprascapular and axillary nerve block; *Q*, question; *PP*, per protocol analysis; *ITT*, intention to treat analysis.
*denotes statistical significance.

Table VII
Biceps tenodesis subgroup analysis.

Block group	Biceps Tenodesis MME	No Tenodesis MME	*P* value	Effect size
Intra-operative MME doses				
US + ISB	25.21 (14.10)	25.37 (14.19)	1	0
US + SSANB	41.57 (17.06)	41.07 (12.99)	.86	0.027
A + SSANB	43.72 (19.62)	41.69 (16.93)	.87	0.025
PACU MME doses				
US + ISB	15.08 (30.35)	15.58 (27.11)	.51	0.1
US + SSANB	34.57 (26.54)	29 (24.88)	.39	0.13
A + SSANB	35.51 (0.37)	50.94 (26.08)	.09	0.25

MME, morphine milligram equivalents; *US + ISB*, ultrasound-guided interscalene block; *US + SSANB*, ultrasound guided suprascapular and axillary nerve block; *A + SSANB*, arthroscopic-assisted suprascapular and axillary nerve block; *PACU*, post anaesthesia care unit.
MME, doses are reported as mean (standard deviation).

between groups, with patients reporting satisfaction in the US + ISB group (n = 31), US + SSANB group (n = 35), and A + SSANB group (n = 33); χ^2 (2, n = 130) = 0.178, $P = .41$.

For Satisfaction Q2: "If you were to have the same operation again, would you have a regional anesthetic?", there was a significant relationship between the A + SSANB group and patients reporting that they would not choose to have a regional anesthetic again (n = 21), compared to US + ISB (n = 14) or US + SSANB (n = 9); χ^2 (2, n = 130) = 6.23, $P = .04$.

Complications

Patients reported their complications of the regional anesthetic in response to a question "Have you developed new trouble with your nerves since the operation, at the site of the operation?", and were asked to describe if there was "trouble with sensation (sensitivity, tingling, pins and needles, and numbness) or with motor (strength) or both".

In the US + ISB group, 6 patients described troubles with their nerves (4 altered sensation and 2 motor defecits). In the US + SSANB group, 2 patients described troubles with their nerves (2 altered sensation). In the A + SSANB group, 1 patient reported troubles with their nerves, by way of a muscle spasm for 30 minutes. There were many patients who did not submit responses for this question (US + ISB n = 11, US + SSANB n = 4, and A + SSANB n = 9); however, on both per-protocol analysis (χ^2 [2, n = 106[= 6.36, $P = .04$) and intention-to-treat analysis (χ^2 [2, n = 130] = 7.51, $P = .02$), a significant difference was found between the groups, with significantly more nerve complications in the US + ISB group.

Biceps tenodesis

Anecdotally, the anesthetists noted an increased pain response from patients intraoperatively as soon as the open subpectoral biceps tenodesis was performed, where indicated. A subgroup analysis was performed on patients receiving this procedure. Each block group was analyzed individually, comparing MME doses in patients who had a biceps tenodesis and those who did not—both intraoperatively and in PACU. As seen in Table VII, there was no significant difference in MME dose requirements between the groups; however, the small effect sizes would suggest that our sample size is likely not large enough to detect a difference.

General observations

Other reflections from the surgeons and anesthetists were that suprascapular block remained technically easy in patients with a larger BMI; however, the axillary nerve block became more difficult—it was more difficult to see the nerve under ultrasound and on occasions the needle length was shorter than the tissue span needed to be traversed to reach the nerve and excessive skin folding interfering with the needle placement.

There did not appear to be an associated learning curve with the US + SSANB or A + SSANB, in terms of perceived difficulty grading ($P = .25$) or differences in intraoperative MME doses of the first 5 consecutive blocks when compared to the final 5 blocks (US + SSANB $P = .34$, A + SSANB $P = .65$).

Finally, there were no reported respiratory complications noted that could be attributed to a phrenic nerve palsy (eg, difficulty weaning from ventilator, respiratory distress, or respiratory compromise postoperatively).

Discussion

This prospective, randomized, controlled study demonstrated that the ultrasound-assisted interscalene block required less MME doses perioperatively (intraoperatively and in PACU) when compared to the 2 methods of suprascapular nerve and axillary nerve blocks, which is consistent with previous literature.[10,26]

Although one cadaveric study showed that the use of ultrasound-improved accuracy of LA administration when compared to using surface landmarks,[12] our results show that the

two SSANB blocks have similar analgesic effects. To our knowledge, ours is the first study to compare the clinical efficacy *in vivo* of these 2 techniques.

A higher complication rate in the US + ISB group is consistent with literature,[10,26] with reported neurological complication rates as high as 16%.[10,18] Although none of our patients exhibited signs of phrenic nerve palsy with hemidiaphragm paralysis, this is a common complication, with reports of up to 100% transient hemidiaphragm paralysis.[20,28]

Motor blockade was difficult to assess due to high attrition rates and small sample size in our reported data, but historically this has been a disadvantage of the US + ISB,[21,26] causing patient dissatisfaction with hand and wrist motor and sensory blockade[7] and therefore one that would likely lead to higher satisfaction with the alternative, more targeted blocks like the SSANB.[3,5,21,26]

The technical difficulties of performing the axillary nerve block in patients with higher adiposity around the shoulder girdle has been discussed in the literature previously—it is known that excess subcutaneous fat impairs image quality by attenuating ultrasound signal.[1]

Postdischarge pain reporting and MME doses showed no difference between groups, which is not consistent with current literature.[26] A rebound pain phenomenon is reported with US + ISB, which causes increased pain scores and higher MME doses are required after discharge from PACU, once the dense blockade dissipates.[26]

What is of interest in our study is that despite having similar pain scores and MME doses to US + SSANB group, and fewer complications than US + ISB group, the A + SSANB group significantly reported that they would opt to not have that regional anesthesia again. This statement is of course difficult to interpret, as this is a subjective assessment,[11] with no internal control arm for the patients. Perhaps this could be clarified with a group which received no regional anesthesia or performed prospective tests on patients who have sequential bilateral procedures.

There were several other limitations to this study. The procedures were heterogenous in terms of type and number performed and some procedures are more likely to be suited to a suprascapular and axillary nerve block than others. For example, a subscapularis repair is not covered by this block[3,21] and no block technique has good coverage for an open biceps tenodesis.[26,27] Thus, our study design was underpowered to perform a subgroup analysis on this. Furthermore, the secondary parameters of whether an open biceps tenodesis or presence of motor blockade was likewise underpowered to provide meaningful commentary on these factors. Other limitations are that the time taken to perform the different blocks was not recorded; this would be a useful parameter to collect in future, with the view to aid theatre throughput. Finally, data loss was an issue for this prospective study, necessitating the use of intention-to-treat analysis.[8] This type of analysis, in assuming the "worst case scenario," tends to lead to conservative results.[8] This data loss from some aspects of our reporting, including testing of the motor block extent in recovery and patient responses to our questionnaire is considerable and could lead us open to Type II error or false negative findings. Furthermore, this study did not account for preoperative opiate usage and the subsequent MME requirements for pain relief in opiate naïve compared for someone with opiate tolerance may lead to bias in our results.[4]

Interscalene block success and safety depends on the technical expertise of the anesthetist performing the block.[25] Our study sample was taken from an urban, private orthopedic hospital, where the anesthetists were all experienced in interscalene blocks. One may expect different results when using anesthetists not as experienced with the US + ISB technique.[25] In contrast, the SSANB was new for both the anesthetist and the surgeon. This was neither borne out in our results, in terms of intraoperative MME requirements (presumed efficacy of block), nor in terms of perceived difficulty. It is tempting to therefore conclude that there is a minimal learning curve associated with the two types of SSANBs. However, what is more likely is that this is a reflection of the small numbers of surgeons and anesthetists participating in the study, therefore small sample size of the presumed "learning curve". What is evident is that there is reasonable pain relief achieved with both types of SSANB, with few complications.

Conclusion

Our study found that US + ISB provided the most benefit for intraoperative and PACU room analgesia, however, it has higher nerve-related complication rates, and does not have lasting superior analgesic effect past the perioperative period. The combined SSANB (either using US or arthroscopic-assisted landmark technique) is a reasonable alternative when the US + ISB is contraindicated, such as when phrenic nerve compromise is unacceptable. This arthroscopically assisted technique is a useful alternative when an experienced regional anesthetist is not available.

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