Correspondence to:

Dr. Sandra Flohr-Madsen,

Department of Anaesthesiology,

Sørlandet sykehus, N-4604 Kristiansand, Norway.

Phone: +47 45676264. Fax: +47 38073686.

E-mail: sandra.flohr@gmx.de

A randomised placebo controlled trial comparing the effect on hand supination of the addition of a suprascapular nerve block to infraclavicular brachial plexus blockade.

Sandra Flohr-Madsen,[1] Lars M. Ytrebø,[2] Katrin Valen,[3] Tom Wilsgaard,[4] Øivind Klaastad[2]

1 Consultant Anaesthetist, 2 Consultant Anaesthetist and Professor of Anaesthesiology, 3 Consultant Plastic Surgeon, 4 Professor of Statistics University Hospital of North Norway and UiT-The Arctic University of Norway, Tromsø, Norway

Short title: Improving hand position in dorsal hand surgery

Keywords: Infraclavicular nerve block; peripheral nerves: anatomy; suprascapular nerve block; ultrasound; upper extremity nerve blocks: indications

Summary

Some surgeons believe that infraclavicular brachial plexus blocks tend to result in supination of the hand/forearm, which may make surgical access to the dorsum hand more difficult. We hypothesised that this supination may be reduced by the addition of a suprascapular nerve block. In a double blind randomised placebo controlled study our primary outcome measure was the amount of supination (as assessed by wrist angulation) 30 minutes after infraclavicular brachial plexus block, with (suprascapular group) or without (control group) a supplementary suprascapular block. All blocks were ultrasound-guided. The secondary outcome measure was an assessment of the intra-operative position of the hand. Considering only patients with successful nerve blocks, the mean (SD) wrist angulation was lower (33 (27) vs. 61(44); p=0.018) and assessment of the hand position was better (11/11 vs. 6/11 rated as "good"; p = 0.04) in the suprascapular group. The addition of a suprascapular nerve block to an infraclavicular brachial plexus block can provide a better hand/forearm position for dorsal hand surgery.

Infraclavicular brachial plexus blocks can provide anaesthesia and analgesia for surgical procedures distal to the shoulder. However, for dorsal hand surgery some surgeons have observed that the lateral sagittal infraclavicular block [1] tends to result in supination of the hand and thereby making surgical access awkward.

The usual practical solution is that the surgical assistant manually maintains the patient’s hand in pronation, but this limits the assistant's capacity for other intraoperative tasks. An alternative solution is the use of a surgical hand immobiliser (lead hand). This, however, impedes the surgeon's ability to easily assess the hand in different positions and may strain the dorsal skin of the fingers, which is more vulnerable than the palmar side to the effects of pressure. To our knowledge the reasons for hand supination following infraclavicular brachial plexus block have not been described in the literature.

Supination of the hand and forearm usually occurs by lateral rotation of the radius, but when the upper limb is extended, supination may also be caused by lateral rotation of the humerus. The responsible distal muscles are supinator and biceps brachii, which are innervated by the radial and musculocutaneous nerves, respectively. These nerves are blocked by infraclavicular brachial plexus blocks [1,2] and, therefore, should not cause supination. The relevant proximal muscles for supination are infraspinatus, supraspinatus, posterior fibres of deltoid, teres minor and the long head of triceps [3,4]. Contraction of the latter three muscles are also inhibited during the lateral sagittal infraclavicular brachial plexus block via its effect on the axillary and radial nerves[2]. However, the main lateral rotator of the humerus is infraspinatus muscle which (along with supraspinatus muscle) is innervated by the suprascapular nerve. This nerve is not reported to be affected by lateral sagittal infraclavicular brachial plexus block.

We therefore hypothesised that the addition of a suprascapular nerve block to lateral sagittal infraclavicular brachial plexus block would reduce supination and thereby improve upper limb positioning for dorsal hand surgery. Our primary outcome measure was to compare the amount of supination (as assessed by wrist angulation) in patients 30 minutes after lateral sagittal infraclavicular brachial plexus block, with and without an additional suprascapular nerve block. Our secondary outcome measure was the surgeons' rating of the adequacy intraoperative hand/forearm position.

Methods

The study was approved by the regional ethical committee of North Norway. The trial was registered at www.clinicaltrials.gov (NCT02035774) and performed at the University Hospital of North Norway in Tromsø from January-April 2014 in accordance with the Helsinki declaration. After written informed consent we recruited 30 patients scheduled for dorsal hand surgery under brachial plexus blockade using the following inclusion criteria: age 18-70 years; body mass index (BMI) 20-36 $kg.m^{-2}$; and ASA physical status 1-3. We did not study patients who were not able to fully extend and abduct the arm or pronate their hand (≤ 15°). Other exclusion criteria included: pregnancy; coagulation disorders; allergy to local anaesthetics; atrioventricular block; cardiac pacemaker; peripheral neuropathy; drug-treated diabetes; and use of anticoagulation drugs other than acetylsalicylic acid or dipyridamol.

Participants were randomly allocated on a 1:1 basis to suprascapular or control group, using computer-generated patient numbers in sealed envelopes. The suprascapular group had suprascapular nerve block (4 ml ropivacaine 5 $mg.ml^{-1}$) and the control group a sham suprascapular nerve block (4 ml 0.9% saline). Both groups then had a lateral sagittal infraclavicular brachial plexus block (31 ml ropivacaine 7.5 $mg.ml^{-1}$). A study nurse opened the randomisation envelope and provided either ropivacaine or saline in an unlabelled syringe for the suprascapular nerve block procedure. Thus the patient, block performer, assistant and assessor were all blinded to the group allocation.

The blocks were performed by the first author, who was experienced with both nerve blocks. Standard monitoring included pulse oximetry, electrocardiogram and non-invasive blood pressure. The patients received intravenous midazolam (0-2 mg) and/or fentanyl (0-50 μg) for comfort.

The suprascapular nerve block was performed according to the method described by Siegenthaler et al. [5] with small modifications; we preferred having the patients in semi-lateral position with slightly elevated upper body. For ultrasound guidance we used the SonoSite Edge unit (SonoSite, Inc., Bothell, WA, USA) with a 50-mm linear array transducer (Hfl50x, 15-6 MHz). It was initially positioned immediately cranial and parallel to the middle of the clavicle to provide a cross-sectional view of the subclavian artery and the brachial plexus. Maintaining a short-axis view of the brachial plexus, the transducer was moved cranially to identify the superior trunk. By slowly returning the transducer to initial position, we could observe the suprascapular nerve diverging from its trunk. (Video 1, supplementary digital material). The suprascapular nerve was identified in the most craniolateral part of the brachial plexus cluster area. Tracing it laterally, we slowly slid the transducer to an oblique sagittal position, in the posterior cervical triangle. The position of accompanying vessels, ribs and pleura were carefully observed during the procedure. Before insertion of the block needle, the skin was infiltrated with 2 ml lidocaine (10 $mg.ml^{-1}$) and then using an in-plane technique the block needle tip (SonoPlex Stim cannula 22-G x 80 mm; Pajunk®, GmbH, Geisingen, Germany) was positioned just caudal or lateral to the suprascapular nerve. Correct identification of the nerve, caudal to the omohyoid muscle, was confirmed by electric nerve stimulation (Stimuplex® HNS12, B.Braun, Melsungen, Germany), eliciting palpable contractions of the infra- and supraspinatus muscles. We aimed to surround the nerve with 4-ml of the study fluid (ropivacaine or 0.9% saline), if necessary by repositioning the needle (Video 2, supplementary digital material). The needle tip position relative to the suprascapular nerve was monitored by ultrasound, electric nerve stimulation and measurement of the injection pressure (B-Smart™; Concert Medical LLC, Norwell, MA, USA). Motor response at a current of < 0.5 mA, 0.1 ms or injection pressure ≥ 103 kPa (15 psi) necessitated a small retraction of the needle. All patients subsequently received ultrasound-guided lateral sagittal infraclavicular block as described previously [1].

We recorded the sensory-motor status of the upper limb and the wrist angle before the blocks (baseline), 15 min, 30 min and 60 min after the blocks and then prior to the start of surgery. The wrist angle was measured by an electronic water level apparatus (Limit, Luna AB, Alingsås, Sweden). It was positioned dorsally on the wrist, between the styloid processes of radius and the ulna. The patient was supine on a horizontal table and the upper limb fully extended in 75° abduction, while the hand was voluntarily and maximally pronated. The wrist angle was the angle between the table plane (at 0°) and the plane contacting the dorsal aspect of the wrist at the interstyloid level, and was recorded as the mean of three measurements.

We performed sensory testing of all nerves distal to the elbow and the axillary nerve with ice cubes in a glove using the following scale: 3= normal cold feeling; 2 = reduced cold feeling (hypoalgesia); 1 = no cold feeling, but feels touch (analgesia); and 0 = no cold or touch feeling (anaesthesia). Muscle strength was assessed using a modified five-point scale [6]

(Table 1). Suprascapular nerve power was tested by lateral rotation of the humerus against manual resistance, while the arm was adducted and the elbow flexed at 90°. The other motor nerves tested were the axillary, musculocutaneous, radial, median and ulnar.

The suprascapular nerve block was judged as successful if the motor score was ≤ 2 after 30 minutes and infraclavicular brachial plexus block suuceesful if the sensory score for each of the five nerves distal to the elbow was 0 or 1 [1,2]. Patients with an incomplete infraclavicular block received supplementary peripheral nerve block(s), as indicated by the site of surgery. The surgeons assessed the intraoperative position of the hand/forearm as either “good” or “poor” without knowing the group allocation of the patients.

We recorded the incidence of adverse events including paraesthesia, vessel puncture, systemic local anaesthesia toxicity and Horner’s syndrome. Respiratory function was assessed clinically and by a chest radiograph taken approximately 75 minutes after block completion. All patients were followed up either in the surgical outpatient clinic or by a telephone call one to two weeks after the operation.

The study was powered to show a difference in wrist angulation 30 minutes after completion of the two nerve blocks. Clinical experience indicated that surgeons would not be satisfied with a wrist angle greater than 20°. We assumed the suprascapular group would achieve a wrist angle of ≤ 20° and performed a power calculation anticipating a minimal angle difference of 20° between the suprascapular and the control group using a standard deviation equal to 5° and 10° in the groups, respectively. The study only needed five patients in each group when using a significance level of 5% and a power of 80%. However, the number of participants was increased to 30 patients, to ensure sufficient power to detect a smaller group difference and to account for drop-outs. With 11 patients in each group the study had 80% power to detect a difference of approximately 10°. Ordinary linear regression models were used to assess change in wrist angle from baseline to follow-up measurement at 30 minutes. Linear mixed models were used to test for differences from baseline over four repeated measures (15 min, 30 min, 60 min and before surgery in theatre). An unstructured covariance matrix was specified to control for dependencies between repeated observations. In separate models, two-way interactions were assessed by including cross-product terms between group and indicator variables of time. In all regression models with angle as the dependent variable we adjusted for the baseline value of angle. Residual analyses verified the model assumptions. Mann-Whitney U test was used to assess differences in lateral rotation force of the humerus at each time point and the surgeons’ evaluation of the hand position was analysed using the Fischer´s Exact Test for categorical data.

In separate analyses, we used the intention-to-treat principle and assessed group differences for all 30 randomised patients without exclusion of patients with unsuccessful suprascapular and/or lateral sagittal infraclavicular brachial plexus blocks. Statistical analyses were performed using the Statistical Package for Social Sciences (SPSS) program version 21.0 for Windows (SPSS Inc., Chicago, IL, USA).

Results

We screened 31 patients and recruited 30 to this study. One of the screened patients was excluded because she was not able to pronate the hand ≤ 15° (Fig. 1). Baseline patient characteristics were similar in both groups (Table 2).

The suprascapular nerve was identified in all patients by ultrasound guidance and confirmed by electrical nerve stimulation. The nerve was successfully blocked in 12/15 patients in the suprascapular group and in 2/15 patients in the control group. Medial spread of the local anaesthetic to the lateral aspect of the plexus was noted in three patients from the suprascapular group and in four patients from the control group. Suprascapular nerve block characteristics are presented in Table 3.

The infraclavicular brachial plexus block was successful in 24 of 30 patients. For the subsequent main analyses of the primary and secondary aims, we did not include patients with a failed suprascapular nerve block and/or lateral sagittal infraclavicular brachial plexus block.

When only considering the patients with successful nerve blocks, we found a significantly lower mean (SD) wrist angulation at 30 minutes in the suprascapular group compared to the control group, when adjusted for baseline (Fig. 2a; (33 (27) vs. 61 (44); $p=0.018$). Mean wrist angulation adjusted for the baseline was also lower in the suprascapular group over all repeated time points (Fig 2a; $p=0.014$). The difference between the two groups did not vary over time as the test of interaction between time and group was not significant ($p=0.23$). However, when all patients were considered in the intention-to-treat analysis the observed reduction in wrist angulation at 30 minutes in the suprascapular group was no longer significant (35 (28) vs. 52 (41); $p=0.12$), nor was the test for group difference over all repeated time points ($p=0.23$) (Fig. 2b).

As shown in Table 4a, we found a reduction in power of lateral rotation of the humerus in the suprascapular group at 30 minutes ($p<0.0001$); this difference was also significant for other time points ($p<0.001$). Muscle force decreased more rapidly in the suprascapular group compared to the control group. The intention-to-treat analysis showed a similar reduction in power of lateral rotation of the humerus in the suprascapular group at 30 minutes ($p<0.001$) and at all time points thereafter ($p\leq0.002$) (Table 4b).

The surgeons' assessment of the hand/forearm position was rated as good for all 11 patients in the suprascapular group. This was in contrast to the control group where only six out of 11 achieved a good position ($p=0.04$). In the intention to treat analysis more patients in the suprascapular group were rated by the surgeon as having a good hand position (15/15 vs. 10/15 respectively; $p=0.04$).

None of the patients in either group required supplementary peripheral nerve blocks for surgery. Interestingly, the axillary nerve was well blocked in all patients of both groups. Thirty minutes after the blocks and in the operating theatre all patients demonstrated anaesthesia or analgesia in this nerve's innervation area and were paralytic for elevation of the upper limb in the parasagittal plane (supplementary material, Fig. S1). Regarding other terminal nerves potentially allowing supination, in both groups the musculocutaneous (supplementary material, Fig. S2) and the radial (supplementary material, Fig. S3) had reductions in power (power score ≤ 2) when tested at 30 minutes and in theatre.

No patient demonstrated signs of systemic local anaesthetic toxicity. In the suprascapular group there was one vascular puncture of the axillary artery and transient paraesthesia in two other patients. None of the patients complained of respiratory distress. Chest radiograph did not demonstrate pneumothorax or signs of phrenic nerve palsy in any patient. Three patients in the control group demonstrated temporary Horner’s syndrome. All patients except one expressed a wish for a similar anaesthetic technique should they require similar surgery. Follow-up by the surgeons revealed no patients with sensory/motor deficit or soft tissue injury.

Discussion

When only considering patients with successful blocks, our study confirmed the surgical observation that a lateral sagittal infraclavicular brachial plexus block is likely to cause supination, as demonstrated by the increase in wrist angulation (supination) in the control group. The novel combination of a suprascapular nerve block and infraclavicular brachial plexus block, reduced the amount of supination allowing for a superior hand position for surgery.

However, in both groups in this study there was large amount of variability in wrist angulation after the blocks. In an attempt to explain this, it is necessary to review some functional shoulder anatomy. The two major muscular forces that determine the position of the scapula in the transverse plane are serratus anterior (innervated by the long thoracic nerve) and pectoralis minor (innervated by lateral and medial pectoral nerves). These muscles pull the scapula anteriorly along the rib cage, while trapezius (innervated by the accessory nerve) and rhomboid major and minor (innervated by the dorsal scapular nerve) pull it posteromedially. Infraclavicular blocks, which target the cords of the brachial plexus, are likely to have an effect on the lateral and medial pectoral nerves, since they originate from these structures. In some patients the local anaesthetic theoretically may also reach the long thoracic nerve, but is unlikely to reach the more distant dorsal scapular and accessory nerves. This could result in posteromedial displacement of the scapula, which is associated with lateral orientation of the glenoid cavity, and lateral rotation of the humerus/supination of the forearm and hand, when the elbow is extended. Hypothetically, this might explain why some of the patients in the suprascapular group developed a large degree of supination.

Thirty minutes after the blocks seven out of 11 patients in the suprascapular group had wrist angles above 20° (supplementary material Table S5a and S5b). It may then be a surprise that all of them obtained a good rating by the surgeons for their hand/forearm position. This can be explained by the fact that surgeons' assessment of hand position was undertaken after a median time of 2.3 h after performance of the blocks. By that time wrist angulation had improved and only three patients had angles above 20°. Moreover, all 11 patients had become paralytic for lateral rotation of the humerus. When the surgeons pronated the hands of these patients, we assume that they sensed no or minimal muscular resistance and this probably facilitated hand positioning and favoured a positive score. The delay in starting of surgery was due to two factors. First, we were interested in the effect of the suprascapular nerve block and the lateral sagittal infraclavicular brachial plexus block on supination over different time periods up to 60 minutes after nerve blockade. Second, our method for the suprascapular nerve block lacked documentation as to whether it affects the phrenic nerve. We therefore took a chest radiograph as soon as possible after the measurements at 60 minutes. The combination of these two variables resulted in a marked delay in starting surgery.

The results from the intention-to-treat analyses showed no differences in wrist angulation between the groups. However, the power of lateral rotation of the humerus and the surgeons' assessment of the hand/forearm position were significantly different between the two groups. We only included patients with successful blocks in the statistical analyses of the primary and secondary outcome measures. This was done to detect group differences which could not be explained by unsuccessful nerve blocks. Clinicians should be aware of this difference when they consider whether this novel block combination would be a useful addition to their clinical practice.

To block the suprascapular nerve we chose the novel ultrasound-guided method described by Siegenthaler et al. with an anterior supraclavicular approach [5]. Their study was based on investigations using both cadavers and volunteers, but needles were only inserted in the cadavers. They found that their method offered easier identification of the nerve than the classical posterior approach [7,8]. Prior to the start of our study, there was only one single case study published in which the Siegenthaler et al. method had been applied [9]. After completion of our study, Rothe et al. published encouraging results in 12 volunteers who, in the sitting position, received suprascapular blocks using 1ml lidocaine 20 $mg.ml^{-1}$ [10]. Their blocks were successful in eight of 11 attempted cases. The minimum effective dose/volume for successful suprascapular nerve block is currently not known. We chose 4 ml ropivacaine (5.0 $mg.ml^{-1}$), which may be larger than required [10]. However, the higher volume was selected to minimise the risk of a failed suprascapular nerve block. Nevertheless, three of 15 patients had failed suprascapular nerve block in spite of the nerve being completely surrounded by the local anaesthetic in all patients. Interestingly, in some patients we observed that the suprascapular nerve was surrounded by a hyperechoic, 1-2 mm thick ring. Most likely, it represents dense perineural connective tissue, which would be expected to impede local anaesthetic penetration to the nerve. Unfortunately, we did not systematically record the presence of such a ring, so whether it is causally related to block failure remains an open question. Regarding the lateral sagittal infraclavicular brachial plexus block, we surprisingly experienced several failures. Our dose was 31 ml ropivacaine (7.5 $mg.ml^{-1}$), which is in accordance with our recently published study on minimum effective volume [1]. The high number of failures questions if that volume is too low and underlines the uncertainty in making estimates of the true minimum effective volume [11].

Two limitations of our study should be discussed. First, supination was not measured between the performance of the two nerve blocks. Therefore, we could not determine the precise degree to which a suprascapular nerve block reduces the supination associated with infraclavicular brachial plexus blockade. Second, data related to our primary (wrist angulation) and secondary (hand position) aim were not obtained at the same time point after the nerve blocks. However, we consider wrist angulation and power of lateral rotation of the humerus to be the main determinants of optimal hand/forearm positioning for dorsal hand surgery.

This study also demonstrates that our block combination has a satisfactory effect on the two most important nerves of the shoulder, namely the suprascapular nerve and the axillary nerve. We therefore believe that the novel combination of suprascapular nerve block and infraclavicular brachial plexus block should be assessed for use as an analgesic technique for shoulder surgery and shoulder pain states, as a potentially useful peripheral alternative to the interscalene block [12,13].

In conclusion, the addition of a successful suprascapular block to a successful lateral sagittal infraclavicular brachial plexus block results in less wrist supination and an improved hand/forearm position in patients scheduled for dorsal hand surgery.

Acknowledgements

1. Per Brodal, Professor of Anatomy, Department of Anatomy, University of Oslo, Norway and Jan Due, Associated Professor of Surgery. Department of Urology and Endocrinology, University Hospital of North Norway, contributed substantially to this article with stimulating discussions and suggestions.
2. Frode Abrahamsen, web designer and Jan Fredrik Franzen, photographer, University Hospital of North Norway edited video files and took photographs during this study.
3. Simon Davis, Senior Lecturer, University of Tromsø, The Arctic University of Norway edited the English language.

Financial support and sponsorship

1. This study received departmental funding from the Department of Anaesthesiology, University Hospital of North Norway.
2. Secma AS, Trondheim, Norway provided the ultrasound unit.
3. Concert Medical LLC provided the B-smart pressure manometers.

Competing interests

None.

References

1. Flohr-Madsen S, Ytrebo LM, Kregnes S, Wilsgaard T, Klaastad O. Minimum effective volume of ropivacaine 7.5 mg/ml for an ultrasound-guided infraclavicular brachial plexus block. *Acta Anaesthesiologica Scandinavica* 2013; **57:** 495-501.
2. Sauter AR, Dodgson MS, Stubhaug A, Halstensen AM, Klaastad O. Electrical nerve stimulation or ultrasound guidance for lateral sagittal infraclavicular blocks: a randomized, controlled, observer-blinded, comparative study. *Anesthesia and Analgesia* 2008; **106:** 1910-5.
3. Waldeyer A. *Anatomie des menschen*. Berlin: Walter de Gruyter & Co, 1965.
4. Woodburne R. *Essentials of Human Anatomy*, 6th edn. Oxford: Oxford University Press, 1978.
5. Siegenthaler A, Moriggl B, Mlekusch S, et al. Ultrasound-guided suprascapular nerve block, description of a novel supraclavicular approach. *Regional Anesthesia and Pain Medicine* 2012; **37:** 325-8.
6. Paternostro-Sluga T, Grim-Stieger M, Posch M, et al. Reliability and validity of the Medical Research Council (MRC) scale and a modified scale for testing muscle strength in patients with radial palsy. *Journal of Rehabilitation Medicine* 2008; **40:** 665-71.
7. Harmon D, Hearty C. Ultrasound-guided suprascapular nerve block technique. *Pain Physician* 2007; **10:** 743-6.
8. Peng PW, Wiley MJ, Liang J, Bellingham GA. Ultrasound-guided suprascapular nerve block: a correlation with fluoroscopic and cadaveric findings. *Canadian Journal of Anaesthesia* 2010; **57:** 143-8.
9. Hackworth RJ. A new and simplified approach to target the suprascapular nerve with ultrasound. *Journal of Clinical Anesthesia* 2013; **25:** 347-8.
10. Rothe C, Steen-Hansen C, Lund J, Jenstrup MT, Lange KH. Ultrasound-guided block of the suprascapular nerve - a volunteer study of a new proximal approach. *Acta Anaesthesiologica Scandinavica* 2014; **58:** 1228-32.
11. Saranteas T, Finlayson RJ, Tran de QH. Dose-finding methodology for peripheral nerve blocks. *Regional Anesthesia and Pain Medicine* 2014; **39:** 550-5.
12. Liu SS, Gordon MA, Shaw PM, Wilfred S, Shetty T, Yadeau JT. A prospective clinical registry of ultrasound-guided regional anesthesia for ambulatory shoulder surgery. *Anesthesia and Analgesia* 2010; **111:** 617-23.

13. Price DJ. The shoulder block: a new alternative to interscalene brachial plexus blockade for the control of postoperative shoulder pain. *Anaesthesia and Intensive Care* 2007; **35:** 575-81.

Table 1. Modified Medical Research Council scale of muscle power.

5	Normal power
4+	Active movement against gravity and resistance (>50% of normal power)
4-	Active movement against gravity and resistance (<50% of normal power)
3	Active movement against gravity
2	Active movement with gravity eliminated
1	Flicker or trace contraction
0	No contraction

Table 2. Characteristics of study patients scheduled for dorsal hand surgery. Values are number or mean (SD).

	Suprascapular Group (n=15)	Control Group (n=15)
Age	52.9 (14.5)	45.2 (17.4)
Male sex	6	5
Body mass index; $kg.m^{-2}$	26.7 (3.0)	25.2 (4.1)
Left handed	9	9

All patients received a lateral sagittal infraclavicular brachial plexus block. Patients in the suprascapular group received an additional suprascapular nerve block whilst the control group patients had a sham suprascapular nerve block performed.

Table 3. Suprascapular nerve block characteristics. Values are median (IQR [range]).

Suprascapular nerve diameter; mm	1.3 (1.2-1.4[1.0-1.7])
Distance from the suprascapular nerve to the brachial plexus*; mm	6.5 (5.0-10.5[2.0-17.0])
Depth from the skin to the suprascapular nerve†; mm	10.5 (9.0-14.0[5.0-17.0])
Nerve stimulator current response; mA	0.5 (0.5-0.7[0.3-1.7])
Pre-scanning time‡; min	5.6 (4.7-6.8[3.7-8.2])
Block performance time§; min	5.0 (3.5-6.0[2.6-13.6])
Time from end of local anaesthetic injection until start of surgery; h	2.3 (2.0-3.2[1.7-4.4])

*Distance from the most medial aspect of the suprascapular nerve to the most lateral aspect of the brachial plexus. † Measured to the closest aspect of the suprascapular nerve. ‡Pre-scan time was the time from the first ultrasound view until insertion of the needle. § Block performance time was the time from first insertion to final withdrawal of the block needle.

Table 4. Power for lateral rotation of the humerus at different time points for patients in the suprascapular and control groups who had successful nerve blocks. Values are median (IQR [range]).

	Suprascapular group	Control group
Baseline	5(5-5[5-5])*	5 (5-5[5-5])*
15 min	2(1-4[1-4])	4.5(4-4.5[4-5])
30 min	1(0-1[0-2])	4(4-4.5[1-5])
60 min	0(0-0[0-1])	4(4-4.5[0-4.5])
Theatre	0(0-0[0-1])	4(2-4[0-4.5])

All patients received a lateral sagittal infraclavicular brachial plexus block. Patients in the suprascapular group received an additional suprascapular nerve block whilst the control group patients had a sham suprascapular nerve block performed. * All patients had a power score of 5 at baseline prior to performance of the block (s)

Table 4b. Power for lateral rotation of the humerus at different time points for all patients in the suprascapular and control groups. Values are median (IQR [range]).

	Suprascapular group	Control group
Baseline	5(5-5[5-5])*	5 (5-5[5-5])*
15 min	4(1-4[1-4.5])	4.5(4-4.5[4-5])
30 min	1(0-2[0-4])	4(4-4.5[0-5])
60 min	0(0-1[0-4])	4(4-4.5[0-4.5])
Theatre	0(0-0[0-4])	4(2-4.5[0-4.5])

All patients received a lateral sagittal infraclavicular brachial plexus block. Patients in the suprascapular group received an additional suprascapular nerve block whilst the control group patients had a sham suprascapular nerve block performed. * All patients had a power score of 5 at baseline prior to performance of the block (s)

Figure legends

Figure 1. CONSORT flow diagram.

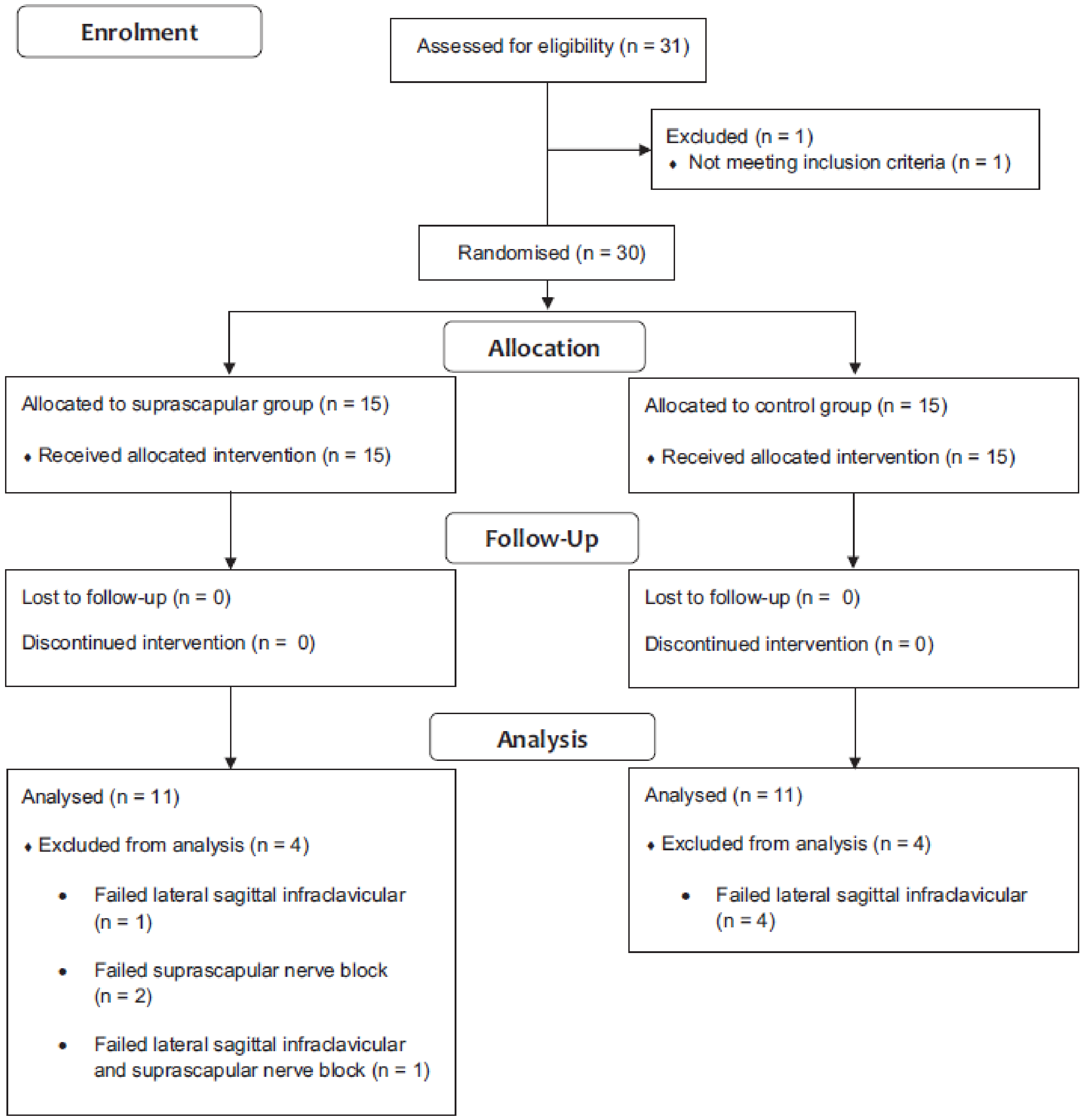


Figure 2A. Mean wrist angulation (degrees) at different time points in patients with successful blocks. Suprascapular group (filled bars, n=11) and control group (open bars, n=11). Error bars indicate 1 SD. In the first group the patients received both a suprascapular nerve block and a lateral sagittal infraclavicular block. In the control group the patients had a sham suprascapular nerve block and a lateral sagittal infraclavicular block. Baseline indicates status prior to the blocks.

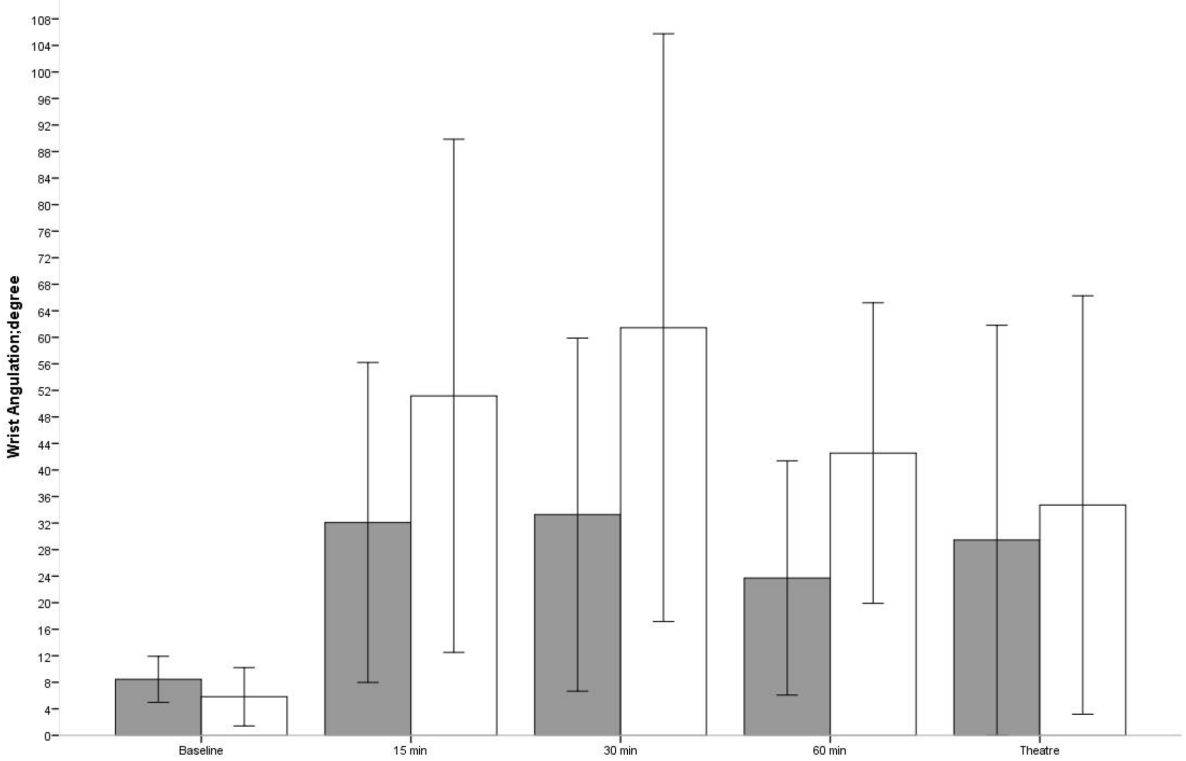
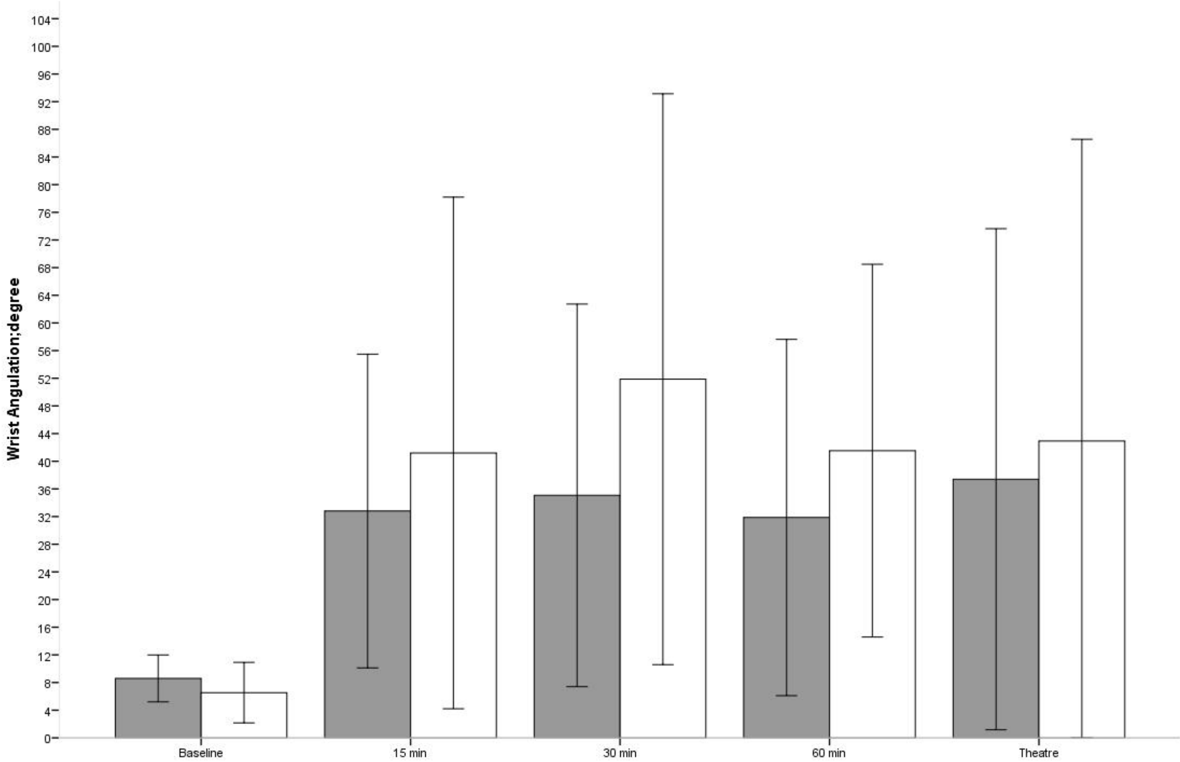


Figure 2B. Mean wrist angulation (degrees) at different time points of all patients, including those with a failed suprascapular nerve block or lateral sagittal infraclavicular block. Suprascapular group (filled bars, n=15) and control group (open bars, n=15). Error bars indicate 1 SD. In the first group the patients received both a suprascapular nerve block and a lateral sagittal infraclavicular block. In the control group the patients had a sham suprascapular nerve block and a lateral sagittal infraclavicular block. Baseline indicates status prior to the blocks.



Legends for supplemental material

Figure S1. Axillary nerve function. The axillary nerve was tested by elevation of extended arm in the parasagittal plane. Suprascapular group (filled bars, n=11) and control group (open bars, n=11). Error bars indicate 1 SD. In the first group the patients received both a suprascapular nerve block and a lateral sagittal infraclavicular block. In the control group the patients had a sham suprascapular nerve block and a lateral sagittal infraclavicular block. Baseline indicates status prior to the blocks. We applied the modified Medical Research Council scale to assess muscle power (Table 1). Normal muscle power = 5 and no muscle contraction = 0.

Figure S2. Musculocutaneous nerve function. The musculocutaneous nerve was tested by flexion of the elbow, while avoiding pronation of the forearm. Suprascapular group (filled bars, n=11) and control group (open bars, n=11). Error bars indicate 1 SD. In the first group the patients received both a suprascapular nerve block and a lateral sagittal infraclavicular block. In the control group the patients had a sham suprascapular nerve block and a lateral sagittal infraclavicular block. Baseline indicates status prior to the blocks. We applied the modified Medical Research Council scale to assess muscle power (Table 1). Normal muscle power = 5 and no muscle contraction = 0.

Figure S3. Radial nerve function. The radial nerve was tested by extension of the wrist. Suprascapular group (filled bars, n=11) and control group (open bars, n=11). Error bars indicate 1 SD. In the first group the patients received both a suprascapular nerve block and a lateral sagittal infraclavicular block. In the control group the patients had a sham suprascapular nerve block and a lateral sagittal infraclavicular block. Baseline indicates status prior to the blocks. We applied the modified Medical Research Council to assess muscle power (Table 1). Normal muscle power = 5 and no muscle contraction = 0.

Table S4a.