

# A combination of infraclavicular and suprascapular nerve blocks for total shoulder arthroplasty: A case series

Dario Musso<sup>1</sup>  | Øivind Klaastad<sup>2</sup> | Lars M. Ytrebø<sup>1</sup> 

<sup>1</sup>Department of Anaesthesiology, University Hospital of North Norway and Acute and Critical Care Research group, UiT - The Arctic University of Norway, Tromsø, Norway

<sup>2</sup>Department of Anaesthesiology, University Hospital of North Norway and Institute of Clinical Medicine, UiT - The Arctic University of Norway, Tromsø, Norway

## Correspondence

Dario Musso, Department of Anaesthesiology, University Hospital of North Norway and Acute and Critical Care Research Group, UiT - The Arctic University of Norway, Tromsø, Norway.  
Email: dario.davide.musso@unn.no

## Abstract

**Background:** Shoulder arthroplasty is associated with significant post-operative pain. Interscalene plexus block is the gold standard for pain management in patients undergoing this surgery, however, alternatives are currently being developed. We hypothesized that a combination of anterior suprascapular nerve block and lateral sagittal infraclavicular block would provide effective post-operative analgesia. Primary aims for this study were to document numeric rating scale (NRS) pain score and use of oral morphine equivalents (OMEq) during the first 24 hours after surgery. Secondary aim was to determine the incidence of hemidiaphragmatic paralysis.

**Methods:** Twenty patients (ASA physical status I-III) scheduled for shoulder arthroplasty were studied. Four mL ropivacaine 0.5% was administered for the suprascapular nerve block and 15 mL ropivacaine 0.75% for the infraclavicular block. Surgery was performed under general anaesthesia. Paracetamol and prolonged-release oxycodone were prescribed as post-operative analgesics. Morphine and oxycodone were prescribed as rescue pain medication. Diaphragm status was assessed by ultrasound.

**Results:** Median NRS (0-10) at 1, 3, 6, 8 and 24 hours post-operatively were 1, 0, 0, 0 and 3, respectively. NRS at rest during the first 24 post-operative hours was 4 (2.5-4.5 [0-5]), median (IQR [range]). Maximum NRS was 6.5 (5-8 [0-10]) median (IQR [range]). Total OMEq during the first 24 post-operative hours was 52.5 mg (30-60 [26.4-121.5]) median (IQR [range]). Hemidiaphragmatic paralysis was diagnosed in one patient (5%).

**Conclusions:** The combination of suprascapular and infraclavicular nerve block shows an encouraging post-operative analgesic profile and a low risk for hemidiaphragmatic paralysis after total shoulder arthroplasty.

**Institutional review board contact information:** The present study received ethical approval on 2nd November 2018 from the Regional Ethics Committee, REK nord, TANN-bygget, UiT - The Arctic University of Norway, 9037 Tromsø, Norway (reference 2018-2081). Institutional Board approval number 02-19 was issued by Nordland Hospital in Bodø, Parkveien 95, 8005 Bodø, Norway on 28th January 2019. Institutional Board approval number 01-20 was issued by Sørlandet Hospital in Kristiansand, Lundsiden, 4604 Kristiansand S, Norway on 15th January 2020.

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## 1 | INTRODUCTION

Shoulder surgery is frequently associated with high levels of post-operative pain, which may require analgesia with opioids for several days.<sup>1</sup> The use of regional anaesthetic techniques is therefore recommended. Interscalene brachial plexus block is currently the gold standard for intraoperative and post-operative pain management in patients undergoing shoulder surgery. However, in recent years there has been increasing research into alternatives to the classic interscalene block due to a wide spectrum of complications, with the risk of hemidiaphragmatic paresis of prominent interest.<sup>2-5</sup> The innervation of the shoulder joint is provided by several nerves<sup>6,7</sup>: subscapular, axillary, lateral pectoral and suprascapular nerve. The subscapular, axillary and lateral pectoral nerve can be blocked with a single injection as distal as at the cord level with the infraclavicular block, while the suprascapular nerve must be blocked separately. In a previous randomized placebo-controlled study,<sup>8</sup> we explored the effects of an anterior suprascapular block (SSNB) in patients undergoing hand surgery under regional anaesthesia, provided by a lateral sagittal infraclavicular block (LSIB). The diaphragmatic function was assessed by chest x-ray and none of the 15 patients showed any sign of ipsilateral phrenic palsy. We have also showed that a combination of peripheral nerve blocks allowed patients to undergo arthroscopic shoulder surgery without the need for opioids or an artificial airway.<sup>9</sup> The patients received a combination of superficial cervical plexus block, SSNB and LSIB. More recently, we have determined the minimum effective local anaesthetic volume needed to block shoulder relevant nerves with the LSIB-method.<sup>10</sup> Data indicated a significantly reduced total volume of local anaesthetics needed to anesthetize the shoulder. Accordingly, we hypothesized that a combination of anterior suprascapular nerve block and lateral sagittal infraclavicular block of the posterior and lateral cords would provide effective post-operative analgesia for patients undergoing shoulder arthroplasty. Primary aims for the current study were to document numeric rating scale (NRS) and use of oral morphine equivalents (OMEq) during the first 24 hours after surgery. Secondary aim was to determine the incidence of ipsilateral hemidiaphragmatic paralysis 30 minutes after the blocks.

## 2 | METHODS

In this prospective case series, 20 patients scheduled for shoulder arthroplasty were included. The study was approved by the Institutional Boards at the University Hospital of North Norway (registration number 2018-2081 REK Nord, 2nd November 2018), Nordland Hospital in Bodø (registration number 02-19, 28th January 2019), and Sørlandet Hospital in Kristiansand (registration number 01-20, 15th January 2020). It was also registered at [www.clinicaltrials.gov](http://www.clinicaltrials.gov) (registration number NCT 03877835, 18th March 2019). The study was performed at the University Hospital of North Norway in Tromsø, Nordland Hospital in Bodø, and Sørlandet hospital in Kristiansand, from March 2019 to August 2020, in accordance with

### Editorial Comment

There is no generally agreed upon single approach to regional anaesthesia for shoulder arthroplasty. In this prospective series, a combination of two blocks is examined, and found to be promising.

the Helsinki Declaration. Written informed consent was obtained and the following inclusion criteria were applied: 18-80 years old, BMI 20-35 kg m<sup>-2</sup> and ASA physical status 1-3. Exclusion criteria included: pregnancy, severe respiratory disease, use of anticoagulation drugs other than acetylsalicylic acid or dipyridamole, allergy to local anaesthetics, patients on regular opioids, atrioventricular block, pacemaker and peripheral neuropathy.

All patients received oxygen supplementation by a nasal cannula. No premedication was given. Standard monitoring included pulse oximetry, electrocardiogram and non-invasive blood pressure.

All blocks were performed by DM. LMY assessed neurological status in all patients, before and 30 minutes after the block, but was not present during the procedure. The patients were placed supine with slightly elevated upper body. All blocks were ultrasound-guided, using a SonoSite S-II unit (SonoSite, Inc). A 38 mm linear array probe 6-13 MHz was applied. The initial needle insertion counted as the first pass. Moreover, a nerve stimulator response by a current  $\leq 0.3$  mA, 0.1 ms and 2 Hz defined the need for a small retraction of the needle. Additional passes were defined as needle advancement upon a retraction of at least 10 mm. A pre-scan was carried out to optimize the settings of the ultrasound apparatus. Skin preparation was performed using chlorhexidine 0.5%. The probe was covered with a sterile transducer cover and sterile ultrasound gel was used. A skin wheal was raised with 1-2 mL lidocaine 1% before insertion of an ultrasound echogenic 22G  $\times$  80 mm needle (PAJUNK® GmbH Medizintechnologie, Geisingen, Germany).

The supraclavicular approach to the suprascapular block was first described by Siegenthaler et al.<sup>11</sup> The suprascapular nerve is usually the most cranio-lateral nerve emerging from the supraclavicular brachial plexus. The ultrasound probe was placed on the supraclavicular fossa to identify the brachial plexus. Subsequently, the plexus was followed proximally until the suprascapular nerve was observed branching from the superior trunk. The nerve was then followed back distally, until it was visualized deep to the omohyoid muscle. The local anaesthetic was injected at the most lateral transverse view of the nerve that could be obtained with the in-plane technique, while advancing the needle from posterolateral to anteromedial. The local anaesthetic dose was 4 mL ropivacaine 0.5%.

For the infraclavicular block of the posterior and lateral cord, the needle insertion point was 0.5-1.0 cm caudal to the lower edge of the clavicle, just medial to the coracoid process. Needle advancement was in the parasagittal plane, with continuous observation of the needle tip, using the in-plane technique. Considering the artery as a clock face with 12 o'clock ventral, the local anaesthetic was

injected as a single deposit of 15 mL ropivacaine 0.75% between 8 and 9 o'clock.<sup>10</sup>

Total block performance time was defined as the time interval between contact of the ultrasound probe with the patient for the suprascapular block and the withdrawal of the needle for the infraclavicular block. Dexamethasone (4 mg) was administered intravenously, as a block adjuvant, after the completed block procedure.

Subsequently, all patients underwent general anaesthesia with endotracheal intubation using target-controlled infusion (TCI) anaesthesia with propofol and remifentanyl. During the surgery all subjects were placed in the beach chair position and no other opioids were administered. The surgical incision was infiltrated with 20 mL bupivacaine 0.25% with adrenaline 5 µg mL<sup>-1</sup> at the end of surgery.

All patients received 1 g paracetamol four times daily and 10 mg prolonged-release oxycodone tablets twice a day. First dose was given post-operative at 6:00 PM in the post-anaesthesia care unit (PACU), rescue pain medication was given as intravenous morphine. In the hospital ward, rescue pain medication was given as oxycodone, either orally or intravenously.

## 2.1 | Block assessment

Sensory-motor status of the upper limb was assessed by LMY before the blocks and 30 minutes after block completion. Sensory testing was performed by applying an ice cube to the cutaneous innervation areas of the axillary and musculocutaneous nerves. The following scale was used: 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 power was assessed using a modified seven-point scale (Table 1).<sup>12</sup> The suprascapular nerve block was tested by the force for lateral rotation of the humerus against manual resistance, while the arm was adducted and the elbow flexed at 90°.

Block success was assessed 30 minutes after withdrawal of the needle from the last of the two blocks. The block combination was considered successful if it met the following three criteria: (a) the suprascapular nerve block had a motor score ≤4-; (b) the axillary nerve sensory score was 0 or 1; (c) the musculocutaneous nerve sensory score was 0 or 1, or if the motor score was ≤4-. As previously mentioned, the suprascapular and the axillary nerves are of direct interest for the anaesthesia of the shoulder. The musculocutaneous nerve test was used as a surrogate test for the lateral cord, where the lateral pectoral nerve is of most interest. Since anastomoses

between the median and musculocutaneous nerves<sup>13</sup> may interfere with sensory testing of the lateral cord, the lateral cord block was judged with both a sensory and a muscle power score.

The incidence of adverse events was recorded, including paraesthesia, vessel puncture, systemic local anaesthetic toxicity, Horner's syndrome, dyspnoea, hoarseness and dysphagia. A lung ultrasound scan was performed within 15 minutes after completed procedure to look for signs of pneumothorax.

Diaphragm status was assessed by a blinded investigator (LMY) with the use of ultrasound before and 30 minutes after the blocks were performed. A 2-5 MHz curvilinear US transducer (SonoSite, Inc) were used in all subjects; the liver and spleen served as acoustic windows on the right and left side, respectively. Hemidiaphragmatic paralysis was defined as the absence of diaphragmatic motion during normal respiration, coupled with absent or (paradoxical) cranial diaphragmatic movement when the patient forcefully sniffed. Patients with a positive ultrasound scan underwent a chest x-ray to confirm the diagnosis.

## 2.2 | Post-operative assessment

NRS (0-10) pain score was recorded at 1, 3, 6, 8 and 24 hours after arrival to the PACU. Occurrence of post-operative nausea and vomiting (PONV) in the PACU was registered. All patients were interviewed by DM after the first post-operative day and opioid consumption was converted to OMEq.<sup>14</sup> Static median NRS pain score and maximum NRS pain score during the first 24 post-operative hours were recorded. Conversion factors are presented in Table 2.

As this study was an exploratory case series, no formal power calculation was performed. A priori, it was decided that the inclusion of 20 patients would provide sufficient information to serve as a hypothesis-generating data source. Descriptive characteristics are presented as mean (standard deviation), median (interquartile range and range) or number, as appropriate. Analyses were performed using the Statistical Package for Social Sciences (SPSS) program version 26.0 for Windows (SPSS Inc).

## 3 | RESULTS

Twenty-eight consecutive patients scheduled for shoulder arthroplasty were screened. Of these, 20 patients fulfilled the inclusion

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 1** Modified Medical Research Council scale of muscle power<sup>1</sup>

criteria (Tromsø: 9, Bodø: 9, Kristiansand: 2). One patient did not receive total arthroplasty and was therefore excluded from the data analyses. Consort flow diagram is presented in Figure 1. Patient characteristics are presented in Table 3.

The block combination was successful in 18 of 19 patients (95%) after 30 minutes. The failed block was due to late onset of the SSNB in patient #6, but met the success criteria after 35 minutes. We applied the intention-to-treat principle and therefore included all 19 patients in the subsequent analyses.

Time to pain onset was 12.7 (0-19.5 [0-21.7]) median (IQR [range]) hours. During the first 24 hours, pain score at rest was 4 (2.5-4.5 [0-5]), median (IQR [range]). Maximum pain score was 6.5 (5-8 [0-10]) median (IQR [range]). Median NRS values 1, 3, 6, 8 and 24 hours after arrival to the PACU are shown in Figure 2. Cumulative OMEq over time, with and without the scheduled prolonged-release oxycodone, are shown

**TABLE 2** OMEq conversion factors applied for 1 mg of different opioids

	OMEq
Morphine p.o.	1
Morphine iv	3
Oxycodone p.o.	1.5
Oxycodone iv	3
Tramadol p.o.	0.2
Codeine p.o.	0.13

Note: Adapted from Nielsen et al<sup>2</sup>

in Table 4. Median consumption of OMEq during the first 24 post-operative hours was 52.5 (30-60 [26.4-121.5]) (IQR [range]) mg.

None of the patients reported dysphagia, dyspnoea and hoarseness. No cases of Horner's syndrome were observed and none of the patients showed ultrasonographic signs of pneumothorax. One patient (5%) was diagnosed with hemidiaphragmatic paralysis, which was confirmed by chest x-ray. Hemidiaphragmatic function resumed when the local anaesthetic effect had worn off, and this was documented by a new chest x-ray on the first post-operative day.

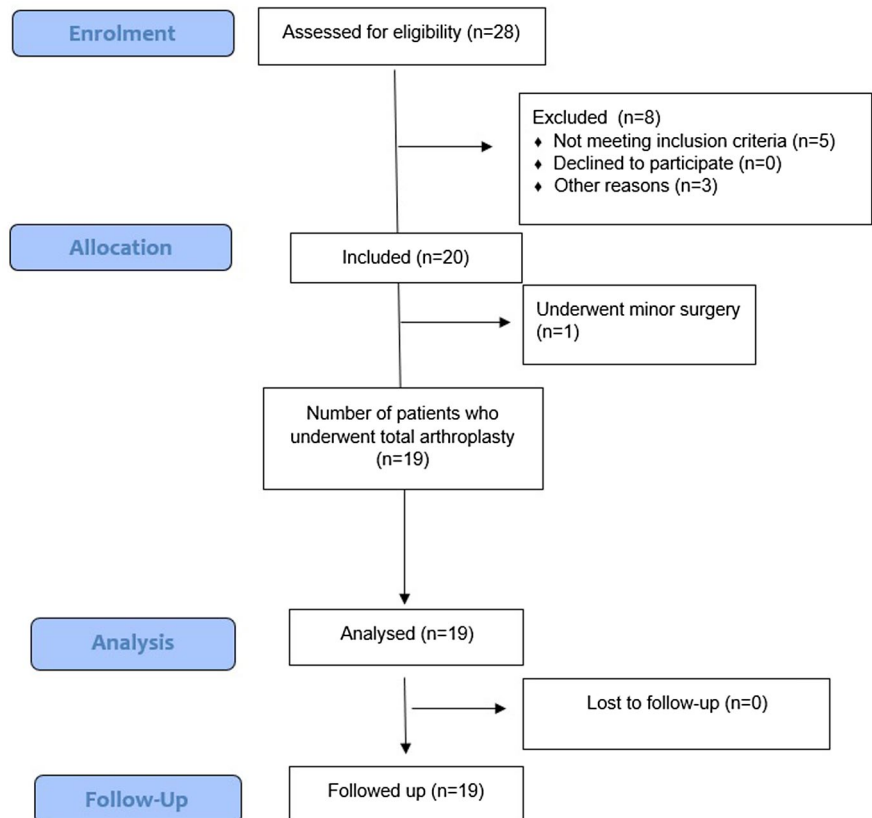
Individual block data are presented in Table 5. Total block performance time was 7.2 (6.8-7.8 [6.3-10.5]), median (IQR [range]) minutes. Time from end of local anaesthetic injection until the first NRS measurement was 6.7 (5.3-7.4 [4.6-9.3]), median (IQR [range])

**TABLE 3** Characteristics of study patients scheduled for total shoulder arthroplasty (n = 19)

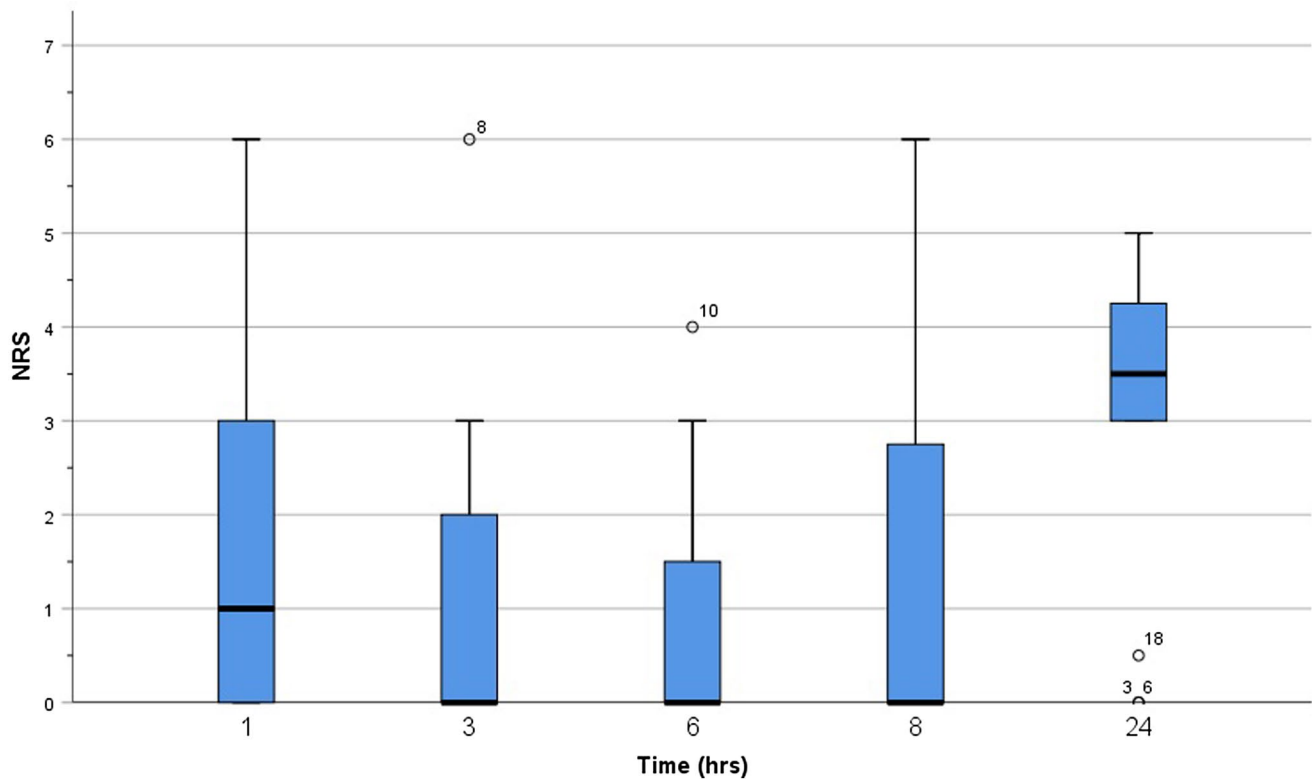
Age (yr)	69.9 (5.2)
gender (male/female)	10/9
Body mass index; kg m <sup>-2</sup>	29.2 (2.6)
ASA physical status (I/II/III)	1/15/3
Types of prosthesis (anatomic/reverse)	9/10
Side (right/left)	7/12

Note: Continuous variables are presented as mean (standard deviation); categorical variables are presented as counts.

Abbreviation: ASA, American Society of Anaesthesiologists.



**FIGURE 1** Consort flow diagram [Colour figure can be viewed at wileyonlinelibrary.com]



**FIGURE 2** NRS at different timepoints. Boxplot showing median, quartiles, range and outliers [Colour figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

**TABLE 4** Cumulative doses of rescue OMEq and total OMEq over time. Values are median (IQR [range])

	PACU	0-8 hrs	0-24 hrs
Rescue OMEq	0 (0-0 [0-24])	0 (0-0 [0-31.5])	22.5 (7.5-30 [0-91.5])
Total OMEq	0 (0-0 [0-24])	15 (15-15 [15-46.5])	52.5 (30-60 [26.4-121.5])

Note: Total OMEq = Rescue OMEq + regular OMEq prescribed.  
Abbreviation: PACU, Post Anaesthesia Care Unit.

hours. The median duration of surgery was 1.8 (1.7-2.5 [1.5-3.2]) (IQR [range]) hours.

In the PACU, no patient suffered from PONV. Three patients required intravenous morphine and mean NRS in this group of patients was 3.5. The mean morphine dose administered to these three patients was 5.1 mg.

## 4 | DISCUSSION

In this case series, we explored a combination of an infraclavicular brachial plexus block and anterior suprascapular nerve block in 20 patients receiving total shoulder arthroplasty surgery under general anaesthesia. A successful block was achieved in 95% of patients, with short performance time and a good safety profile. We reported one case of hemidiaphragmatic paralysis (5%). The median NRS pain

**TABLE 5** Individual block performance data (n = 19). Values are median (IQR [range])

	SSNB	LSIB	Total
Performance time (min)	3.2 (2.8-3.6 [2.3-6.4])	3.0 (2.7-3.3 [2.3-4.2])	7.2 (6.8-7.8 [6.3-10.5])
Number of passes (n)	1 (1-1 [1-2])	1 (1-1 [1-2])	2 (2-3 [2-3])
Paraesthesia (n)	0	2	2
Vascular puncture (n)	0	0	0
Local anaesthetic systemic toxicity (n)	0	0	0

Abbreviations: SSNB, suprascapular nerve block; LSIB, lateral sagittal infraclavicular block.

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score at 1, 3, 6 and 8 hours post-operatively were low, though a noticeable increase in score was observed after the nerve blocks wore off. Median use of OMEq during the first 24 post-operative hours was 52.5 mg.

In recent years, we have witnessed an increasing interest in alternative peripheral nerve blocks to provide analgesia for shoulder

surgery.<sup>4,5</sup> This has resulted in a plethora of studies investigating nerve blocks from nerve root to terminal nerve level. Our focus has been at the cord level and, therefore, on the infraclavicular block. The rationale for this is simple. One of the most distal approaches described for shoulder analgesia is by injection close to terminal nerves, namely the combination of suprascapular and axillary nerve blocks. These distal blocks may provide good post-operative analgesia after shoulder arthroscopy, but their use in more extensive surgery is not recommended.<sup>15-17</sup> This is allegedly due to the contributions of proximal branches from the axillary nerve, the subscapular and lateral pectoral nerves, all arising from the posterior and the lateral cord of the brachial plexus. Hence, the infraclavicular block allows blocking of all these nerves with a single injection and is theoretically expected to result in a denser block. The infraclavicular block dose was extrapolated by data from a recent minimum effective volume (MEV) publication,<sup>10</sup> where we calculated a MEV<sub>50</sub> of 7.8 mL and estimated a MEV<sub>95</sub> of 9.0 mL. However, in the current study, we opted for a higher volume (15 mL), to prevent the risk of inadequate post-operative pain coverage.

To our knowledge, the minimum effective dose for a successful SSNB is currently unknown. A lower volume for a successful block has been described,<sup>18</sup> but the clinical analgesic effect of this approach remains unexplored. Nonetheless, we have previously shown that 4 mL ropivacaine 0.5% provided satisfying post-operative analgesia after shoulder arthroscopy.<sup>9</sup>

Paracetamol and oxycodone were prescribed as regular medication, with morphine and oxycodone as rescue pain medications. However, prescription of a wider multimodal pain medication strategy could potentially have reduced OMEq consumption. Administration of adjuvants are known to prolong block duration of peripheral nerve blocks<sup>19</sup> and in this study we opted for 4 mg dexamethasone administered intravenously. It is possible to speculate that a higher dose<sup>20</sup> or a combination of adjuvants<sup>21,22</sup> could have resulted in longer lasting blocks and thus lower total consumption of OMEq.

Our block combination does not aim to provide surgical anaesthesia, but rather provide effective post-operative analgesia. It is therefore not unexpected that a few patients experienced some level of pain in the PACU. Nevertheless, the median NRS in the immediate post-operative setting was 1 and rescue medication was only required in three patients with mean NRS of 3.5. Block duration could not be accurately determined since block effects wore off during the night and most patients struggled to exactly recall the time that sensory function was restored. However, they could place with ease the pain onset on a timeline. Therefore, the time from the retraction of the block needle to first report of pain was used as a surrogate for block duration. It is worth acknowledging that this could be a conspicuous underestimation of the real block duration, considering the broad discrepancy between time to first reported pain and time to reported restored sensory status (12.7 hours vs 19.8 hours). The consumption of extra OMEq, beyond the pre-scheduled analgesic regime, is clearly concentrated between 8 and 24 hours after the arrival to the PACU and therefore after the effect of the blocks

has worn off. As a result, even if no patients suffered from PONV in the PACU, five experienced opioid-induced nausea or vomiting. Further modifications including dose adjustments, type and dose of adjuvants applied, catheter-based techniques, as well as design of a more complex multimodal analgesic regime may prolong pain relief and thus improve NRS results and OMEq consumption.

Despite several modifications, no single intervention on the interscalene technique seems to decrease the incidence of phrenic palsy below 27%.<sup>4</sup> In the present study, we report one case of hemidiaphragmatic paralysis, which accounts for a 5% incidence. Unfortunately, the mechanisms for how the phrenic nerve became anaesthetised can only be speculated. In this patient (#8) the ultrasonographical visualisation of the SSN proved to be challenging and the nerve was eventually blocked in a more cranial position, closer to the cervical structures, with possible cranial spread to the phrenic nerve. Clinicians should be aware of this possibility and be vigilant during the ultrasonographic phase, in order to optimize the subsequent injection of local anaesthetic.

Our study presents some further limitations. The NRS scale is a validated pain scoring tool but relies on an accurate patient response. At times, it was challenging to assess average pain score during the day, as some patients struggled to recall pain levels and others struggled to understand the meaning of this score. To overcome this limitation, OMEq consumption was chosen as an additional primary aim. The option of patient-controlled analgesia (PCA) was considered but dismissed due to logistical issues. NRS assessments at 1, 3, 6, 8 and 24 hours after the arrival to the PACU although arbitrary, are considered to be clinically relevant time points.

As an observational case series, this study carries some intrinsic limitations that would otherwise be addressed in a randomized control trial and therefore warrants further investigation. However, as both the NRS pain scores and the OMEq consumption during the first post-operative day were promising, this block combination appears comparable with other shoulder arthroplasty studies where interscalene blockade has been applied.<sup>23-26</sup>

In summary, the combination of infraclavicular and suprascapular nerve blocks shows an encouraging post-operative analgesic profile after total shoulder arthroplasty. However, randomized controlled trials should be performed to compare this block combination with other shoulder blocks.

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## CONFLICT OF INTEREST

The authors have no conflicts of interest.

## ORCID

Dario Musso  <https://orcid.org/0000-0001-5860-5473>

Lars M. Ytrebø  <https://orcid.org/0000-0002-6531-7872>

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