Prospetive randomized comparison of ultrasound-guided and neurostimulation techniques for continuous interscalene brachial plexus block in patients undergoing coracoacromial ligament repair

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Background. There are few data comparing the onset time of interscalene brachial plexus block performed using ultrasound (US) guidance or nerve stimulation (NS) technique for elective coracoacromial ligament repair.

Methods. Fifty ASA I–III patients were randomly allocated to receive a continuous interscalene brachial plexus block with 20 ml of 1% ropivacaine with either NS or US guidance. The time of block performance, number of skin punctures and needle redirections, inadvertent vascular punctures, and procedure-related pain scores were recorded. The onsets of sensory and motor blocks in the distribution of radial, axillary, and musculocutaneous nerves were blindly assessed every 5 min until 30 min from the end of local anaesthetic (LA) injection. Intraoperative fentanyl, general anaesthesia (GA) requirements, postoperative pain scores, LA consumption, and patients' requirements for subcutaneous morphine during the first 24 h were compared.

Results. Block onset times were similar. The time to complete the block and the number of skin punctures and vascular punctures were significantly lower in Group US. There were no differences in needle redirections, incidence of paraesthesiae, intraoperative fentanyl consumption, and requirements for GA or postoperative morphine. The US group required significantly less LA only at 16 h after surgery and had lower pain scores at rest at 24 h after surgery.

Conclusions. Block onset times and success rate were similar whether NS or US was used, although US guidance allowed shorter procedural times, fewer needle punctures, and fewer vascular punctures.

Keywords: acute pain; nerve stimulation, orthopaedic surgery regional anaesthesia; ropivacaine; ultrasonography

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Ultrasonography is a useful tool for regional anaesthesia.¹² By comparison with nerve stimulation (NS) techniques, ultrasound (US) guidance offers some advantages: a direct visualization of anatomic structures, helping to minimize vascular punctures, and a dynamic vision of needle advancement and local anaesthetic (LA) spread.³⁴ Although no significant differences in the incidence and severity of postoperative neurological symptoms have been reported,³ US guidance has been shown to reduce the number of needle redirections⁶ ⁷ and to enhance block success rate when performing interscalene block.⁵ US guidance has also been shown to improve peripheral nerve block onset times when compared with a neurostimulation technique,⁹ although very few studies specifically addressed this issue for the interscalene block.¹⁰ ¹¹

The present study compares real-time US guidance and electrical NS in terms of the onset time for interscalene brachial plexus anaesthesia. We hypothesized that direct visualization of neural structures under US guidance might lead to better LA disposition around the roots of the plexus, thus improving onset times.
Methods

The study was approved by the local research ethics committee (University of Parma, Italy) and registered at the US National Institutes of Health website clinicaltrials.gov (NCT00702416). After written informed consent, we enrolled 50 ASA I–III patients undergoing elective coracocluamoial ligament repair for rotator cuff disorders.

We excluded patients aged younger than 18 yr or older than 85 yr, unable to express informed consent, with a known allergy to study medications, chronic opioid use, ipsilateral upper limb neurological deficits, or contraindications to continuous block placement.

After arrival in the operating theatre, an 18 G i.v. catheter was placed at the forearm opposite to the surgical side. Standard monitoring was used throughout the procedure, including non-invasive arterial pressure measured with an automated cuff, ECG (lead II), and pulse oximetry. Each patient was positioned supine, with the head turned to the opposite side and the ipsilateral arm adducted at the shoulder. All patients received i.v. midazolam 0.03 mg kg$^{-1}$ before the block.

Using a computer-generated sequence of random numbers and a sealed envelope technique, all patients were randomly allocated to receive a continuous interscalene brachial plexus block with 20 ml of 1% ropivacaine (Naropina, AstraZeneca Italia, Basiglio, MI, USA) using either neurostimulation or US guidance. All blocks were performed by two senior anaesthetists (G.D., A.T.) experienced in both regional anaesthetic techniques.

In the US group (US), after adequate skin disinfection and sterile field, nerve location was performed using a 5 cm, 10–12 MHz linear probe (LOGIQ E; GE Healthcare, Milan, Italy) covered with a sterile sheet. First, the brachial plexus was identified by placing the US probe immediately superior and parallel to the clavicle. The subclavian artery was identified on its short axis and the brachial plexus was identified. While maintaining the brachial plexus in the centre of the image, the probe was moved in a cephalad direction until the brachial plexus could be identified between the anterior and middle scalene muscles. After LA skin infiltration (lidocaine 1% 2 ml), an 18 G, 50 mm, short-bevel needle was inserted with an in-plane approach and advanced towards the nerve trunks (C5, C6, C7). LA was injected in increments to surround all of the nerve trunks, while intermittently aspirating to rule out intravascular location. A 20 G catheter was then inserted through the needle and advanced to a depth of 3 cm beyond the needle tip between C5 and C6 nerve trunks.

In the neurostimulation group (NS), skin landmarks were drawn, including the cricoid cartilage, the two heads of the sternocleidomastoid muscle and the interscalene groove. A horizontal line was drawn at the level of the cricoid cartilage to intersect laterally the interscalene groove, defining the needle insertion point. An 18 G, 35 mm, short-bevel needle was connected to a nerve stimulator, initially set up to deliver 1.0 mA intensity current (2 Hz, 0.2 ms).

After LA skin infiltration (lidocaine 1% 2 ml), the needle was inserted through the skin with a 45° angle and moved caudally towards the brachial plexus until deltoid motor response was elicited. The position of the needle was adjusted to maintain the proper twitch, while the intensity of stimulation was progressively reduced to 0.5 mA current.

A stimulating perineural catheter was then inserted through the needle and advanced to maintain the adequate motor response at $\leq0.4$ mA. LA was injected in increments, while aspirating the catheter intermittently.

During the procedure, the time of block performance, the number of skin punctures, and needle redirections were recorded by a nurse. Block performance time was defined as the time interval between the first US scan and needle removal at the end of the block in Group US and as the time interval between identification of anatomical landmarks and needle removal at the end of the block in Group NS. A skin puncture was defined as any new needle insertion through the skin, while a needle redirection was defined as any needle withdrawal of at least 10 mm with subsequent forward movement. Any unexpected vascular punctures and eventual paraesthesiae were recorded. Pain intensity related to the procedure was assessed at the end of the block using an 11-point verbal numerical rating scale (NRS) from 0, no pain, to 10, worst imaginable pain, by a blinded observer, who was not present during block placement.

The onsets of sensory and motor blocks in the distribution of the three nerves were blindly assessed every 5 min until 30 min from the end of the LA injection.

Sensory block was assessed as the loss of pinprick sensation in the territory of distribution of the axillary, radial, and musculocutaneous nerves, with the same stimulus delivered to the opposite side. Motor block was defined as the loss of patient’s strength in arm abduction, forearm flexion, and extension, therefore assessing the three territories of distribution of the axillary, musculocutaneous, and radial nerves.

We defined as block onset time or readiness to surgery (primary endpoint) the interval between the end of LA injection and the last achieved sensory block in the three territories of distribution evaluated.

In the case of pain or discomfort during surgery, we administered incremental i.v. boluses of fentanyl 50 μg and recorded the number of patients who required fentanyl. In the case of block failure or patient discomfort unresponsive to fentanyl during the procedure, general anaesthesia (GA) was administered and the block was recorded as ‘failed’.

After surgery, both groups received patient-controlled regional analgesia (PCRA) with ropivacaine 0.2% (infusion rate 4 ml h$^{-1}$, bolus 2 ml every 15 min). All patients also received paracetamol 1 g i.v. every 8 h for the first 24 h after operation. Subcutaneous (s.c.) morphine (5 mg) was added as rescue medication for breakthrough pain if the pain score was $>4$, despite i.v. paracetamol and interscalene PCRA.

Postoperative pain was evaluated by means of an NRS (0–10) for pain at rest and pain during mobilization of the shoulder every 8 h after interscalene block completion. The
The mean (SD) time to readiness to surgery (block onset for interscalene block was 10 (5) min.11 The sample size in this study was calculated with a two-sided test to detect a 5 min difference in readiness for surgery, considering this study was estimated based. The secondary outcome measures were additional analgesic requirements during surgery, incidence of paraesthesiae during the anaesthetic procedure, incidence of blood aspiration during the anaesthetic procedure, number of needle redirections for block performance, procedure-related pain, postoperative pain at rest and during movement, and PCRA LA consumption.

A previous study found that a mean [standard deviation (so)] onset time to readiness for surgery using 1% ropivacaine for interscalene block was 10 (5) min.11 The sample size in this study was calculated with a two-sided test to detect a 5 min difference in readiness for surgery, considering α=0.05, β=0.90, and on so=5 min.

Data distribution was evaluated with the Kolmogorov–Smirnov test. Continuous variables are represented as mean (so) if normally distributed or as median (range) for non-parametric data. Continuous variables are represented as numbers or percentages and were analysed using analysis of variance for repeated measures. Categorical variables were evaluated with the χ² test, applying the Yates correction. A P-value of <0.05 was considered significant.

Results

Patient and surgical characteristics were similar in the two groups (Table 1).

There were no significant differences between groups in onset times for sensory or motor block in both (Table 2). The mean (so) time to readiness for surgery (block onset time) was similar: 18 (7) min in Group NS and 15 (9) min in Group US (P=0.407).

Block performance in Group US required significantly less time, fewer skin punctures and fewer needle redirections, although no differences were found in terms of procedure-related NRS values (Table 3).

Accidental aspiration of blood was seen in three patients in Group NS (30%) but no patients in Group US (P=0.041). There were no differences in the incidence of paraesthesiae during LA injection, fentanyl consumption, or requirements for GA.

NRS for pain at rest and during movement after surgery was similar, except for NRS at rest 24 h after operation (Fig. 1a and b). Postoperative morphine requirements during the first 24 h were comparable: six patients in Group NS and seven patients in Group US required 5 mg s.c. morphine once during the 24 h observation period.

Results Data presented as mean (range) for age, mean (so) or median (range)

<table>
<thead>
<tr>
<th>Group ENS</th>
<th>Group US</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>57 (32–79)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>78 (17)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>169 (9)</td>
</tr>
<tr>
<td>Surgical duration (min)</td>
<td>69 (32)</td>
</tr>
<tr>
<td>ASA physical status</td>
<td>II (I–III)</td>
</tr>
</tbody>
</table>

Table 2 Mean (so) block onset times. There were no significant differences between the groups

<table>
<thead>
<tr>
<th>Sensory onset time</th>
<th>Motor onset time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group NS</td>
</tr>
<tr>
<td>Axillary nerve (min)</td>
<td>15 (6)</td>
</tr>
<tr>
<td>Radial nerve (min)</td>
<td>16 (6)</td>
</tr>
<tr>
<td>Musculocutaneous nerve (min)</td>
<td>17 (6)</td>
</tr>
</tbody>
</table>

Table 3 Procedure-related variables. Data presented as mean (so) or median (range). *Procedure time, P=0.01; **skin punctures, P=0.01; ***needle redirections, P=0.02

<table>
<thead>
<tr>
<th></th>
<th>Group NS</th>
<th>Group US</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procedure time (min)</td>
<td>8 (5)</td>
<td>5 (3)*</td>
</tr>
<tr>
<td>Number of skin punctures</td>
<td>1 (1–4)</td>
<td>1 (1–2)**</td>
</tr>
<tr>
<td>Number of needle redirections</td>
<td>3 (1–15)</td>
<td>2 (1–4)**</td>
</tr>
<tr>
<td>NRS values for procedural pain</td>
<td>4 (0–8)</td>
<td>2 (0–7)</td>
</tr>
</tbody>
</table>

PCRA LA consumptions were lower at 16 h after operation in Group US, but there were no differences at 8 and 24 h (Table 4).

There were no significant differences in postoperative nausea and vomiting. No neurological deficits or incidences of LA toxicity occurred.

Discussion

In this study, we found that sensory and motor block onset times were similar in patients undergoing interscalene block with 20 ml of 1% ropivacaine for coracoacromial ligament repair whether the block was placed using US guidance or NS. However, other procedure-related variables, such as the time to complete the block, number of skin punctures, number of needle redirections, and the incidence of accidental intravascular needle placement, were lower when US guidance was used.

The quality of intraoperative anaesthesia was similar, suggesting that either technique is suitable for providing anaesthesia for coracoacromial ligament repair.
A recent systematic review of randomized controlled trials comparing US guidance and NS for upper and lower extremity nerve blocks suggested that there is some evidence that US guidance provides a modest improvement in block onset and quality. Our study demonstrates instead that US and NS guidance are comparable in terms of block onset time and, therefore, readiness for surgery. Some reasons for the modest differences between US and control techniques in previous studies may be the small sample sizes of the published studies: this may also apply to our study.

Similar to the previous work by Liu and colleagues, we found no significant difference in terms of block success rate between the two techniques. Conversely, Kapral and colleagues recently reported greater block success for surgical anaesthesia with US compared with a nerve stimulator technique for interscalene block. A recent meta-analysis also demonstrated shorter procedural times and a reduced risk of vascular puncture using US guidance for nerve localization.

Although published data show contrasting, we did not find any major clinical difference in postoperative pain scores. It is known that shoulder surgery can cause severe postoperative pain and continuous interscalene block with basal LA infusion, and patient-controlled boluses is the most effective analgesic technique after both major and minor shoulder surgeries. We found a statistically significant difference in LA consumption only at 16 h after operation: at this time point, both techniques provided comparable pain relief, although US guidance allowed lower LA consumption. Despite this lower LA consumption at 16 h, patients in the US group had significantly less pain at 24 h (Fig. 1a). We would argue that, when properly used by patients, the opportunity to self-administer additional boluses through the interscalene catheter has guaranteed low postoperative pain scores with both techniques. When LA consumption is comparable between the two groups, such as at 24 h in our study, some difference in terms of pain scores might become evident. This may be due to a more precise plexus location and catheter placement under US guidance. Nevertheless, these differences between groups in pain scores at rest and LA consumption at 24 and 16 h, respectively, although statistically significant, are not clinically relevant.

There are several limitations to this study, including the partial blinding during the study investigation: we could not maintain blinding when collecting the time of block performance, number of skin punctures, and needle redirections. A ‘dummy’ US scan and nerve stimulator for each respective group would have facilitated blinding. Nevertheless, those variables were registered according to protocol definition by a nurse, supposedly less biased than the block performer. All subsequent variables were recorded by residents, who were blinded and unaware of the block procedure.

Patients could receive s.c. morphine injection by a ward nurse if required after operation. There was no difference in requests for morphine. Alternatively, we could have provided patients with a morphine patient-controlled analgesic (PCA) pump. This may have allowed more accurate comparison of postoperative morphine requirements, but we considered...
that providing our patients with two PCA pumps (one for the interscalene catheter and the other for i.v. morphine) would have been confusing, thus we preferred a PCRA pump alone.

In conclusion, we found that neurostimulation and US guidance provided comparable block onset times and success rates in patients undergoing interscalene block with 20 ml of 1% ropivacaine for coracocromial ligament repair. The time required, number of needle punctures, number of needle redirections, and incidence of inadvertent intravascular needle placement were lower when blocks were performed using US guidance.

**Declaration of interest**

None declared.

**Funding**

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**References**