ORIGINAL INVESTIGATION

An alternative approach for blocking the superior trunk of the brachial plexus evaluated by a single arm clinical trial

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KEYWORDS
Ultrasoundography; Brachial plexus; Nerve block

Abstract

Background: Interscalene brachial plexus block is associated with phrenic nerve paralysis. The objective of this study was to evaluate an alternative approach to interscalene brachial plexus blocks in terms of efficacy, grade of motor and sensory blockade, and phrenic nerve blockade. Methods: The study was prospective and interventional. The ten living patients studied were 18 to 65 years old, ASA physical status I or II, and submitted to correction of rotator cuff injury. A superior trunk blockade was performed at the superior trunk below the omohyoid muscle, without blocking the phrenic nerve. The needle was advanced below the prevertebral layer until contacting the superior trunk. In order to guarantee the correct positioning of the needle tip, an intracluster pattern of the spread was visualized. The block was performed with 5 mL of 0.5% bupivacaine in ten patients. In the six cadavers, 5 mL of methylene blue was injected. Diaphragmatic excursion was assessed by ultrasonography of the ipsilateral hemidiaphragm. In three patients, pulmonary ventilation was evaluated with impedance tomography. Pain scores and analgesic consumption were assessed in the recovery room for 6 hours after the blockade. Results: In the six cadavers, methylene blue didn’t reach the phrenic nerve. Ten patients underwent arthroscopic surgery, and no clinically phrenic nerve paralysis was observed. No patient reported pain during the first 6 hours. Conclusions: This study suggests that this new superior trunk approach to block the superior trunk may be an alternative technique to promote analgesia for shoulder surgery in patients with impaired respiratory function.

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Introduction

Interscalene Brachial Plexus Block (ISB) is the most commonly performed regional anesthesia technique for perioperative shoulder analgesia. This technique promotes the blockade of all fibers responsible for the innervation of the bone and muscular components of the shoulder, promoting effective postoperative analgesia. However, in the ISB, the local anesthetic is injected close to the phrenic, causing blocking of this nerve in practically 100% of cases when large volumes of local anesthetic are administered. Therefore, ISB technique may be contraindicated in patients with limited pulmonary reserve or who do not tolerate a 25% reduction in lung capacity. Low volumes of local anesthetics have been used to allow phrenic nerve sparing. Despite the low-volume technique has reduced the incidence of hemi-diaphragmatic paralysis to 27–45%, the incidence of phrenic nerve block is still high.

An alternative to ISB could be the superior trunk block and the sub-omohyoid suprascapular nerve block. Some studies have shown that both techniques promote similar analgesic effect as the ISB for shoulder surgeries, therefore, they may be substitutes for ISB to allow phrenic nerve sparing.

However, recent studies have shown that those two techniques could compromise respiratory function through phrenic nerve block. One hypothesis for this impairment of the respiratory function could be the endpoint of injection chosen by the authors. The most common anatomical variations are: C5 root emerging anterior to the anterior scalene muscle and following its path between the anterior scalene muscle and the sternocleidomastoid muscle until it reaches the remainder of the plexus in the supraclavicular area; C5 root emerging from its foramen, inside anterior scalene muscle, transfixing it and following its path between the anterior scalene muscle and the sternocleidomastoid muscle until finding the remainder of the plexus in the supraclavicular area; and C5 and C6 roots emerging from its foramens inside anterior scalene muscle and transfixing it to find the remainder of the plexus in the supraclavicular area (Figure 1). This variation keeps superior trunk structures nearer to the phrenic nerve for a longer pathway or delay the formation of the superior trunk. In this case, C5 reaches the remaining of brachial plexus only in the supraclavicular area because it might travel around the antero-lateral border of the anterior scalene muscle.

An intra-cluster injection in the superior trunk below the prevertebral layer of the deep cervical fascia in the supraclavicular area could limit the dispersion to the phrenic nerve without compromising analgesic effect for patients undergoing shoulder surgery.

The aim of this study was to evaluate the analgesic effect and the respiratory function after a block of the superior trunk in the area below the omohyoid muscle.

Methods

Study design: The study was prospective and a descriptive single-arm clinical trial.

Settings: The data of the patients were collected at the Hand and Upper Limb Surgery Section. The cadaver data were collected at the Service of Verification of Deaths.

Register: The study was registered at ClinicalTrials NCT03512990.

Ethical aspects

The study was performed after approval by the Ethics Committee (CEP 1350/2017; Adress: Rua Botucatu 740; Reference person: Miguel Roberto Jorge), and written informed consent was obtained from the participants. It was conducted according to ethical principles and the Declaration of Helsinki.

Inclusion and exclusion criteria

Participants

Ten living patients of both genders aged between 18 and 65 years, American Society of Anesthesiologists (ASA) physical status I or II, body mass index of less than 35 kg.m² and were submitted to shoulder correction of rotator cuff injury, were included. Patients with cognitive impairment, infection at the blockade puncture site, coagulopathy, using anticoagulants, allergic to drugs, and pregnant were excluded from the study.

Interventions

Block technique

The patients were monitored with cardioscope, noninvasive arterial blood pressure and pulse oximetry. The superior trunk blockade was performed with no sedation for better assessment of respiratory function. After antiseptic with chlorhexidine and local anesthesia with 1% lidocaine without epinephrine, a high-frequency linear transducer (M-Turbo R System, a 38X, 6–13 MHz, Fujifilm SonoSite Inc, Bothell, WA, USA) was used for the examination of the area. At the lower anterolateral side of the neck (posterior triangle), the brachial plexus was visualized in the scalene area. A careful examination of the region was carried out, identifying the transverse processes of the C7 and C6 roots. The transverse process of C7 has only a posterior tubercle while C6 has both tubercles. With these structures identified, it was possible to identify the roots of C5 and C6 and follow them until the moment they joined, forming the superior trunk. This junction usually occurs in the interscalene cleft, different anatomical variations of the C5 and C6 roots.

Once the superior trunk was identified, it was followed more distally until the supraclavicular area, below the omohyoid muscle, where it was possible to identify the suprascapular nerve outflow from the superior trunk.

The injection was performed at the point where the superior trunk was positioned in the supraclavicular area, distally to the point where the suprascapular nerve leaves the superior trunk of the brachial plexus.
of ketoprofen at the end of the surgery. Postoperative analgesia was assessed in the recovery room by numerical scale and supplementary morphine for 6 hours after blockade.

**Supplementary analgesia**
All the patients could take 2 mg of morphine every 10 minutes as needed at the postanesthetic care room, before leaving the hospital.

**Assessment**

**Analgesic effect**
An anesthesiologist not involved in the block evaluated the nerve blocks. The modified Bromage scale\textsuperscript{11} was used to assess motor function of the deltoideus and biceps muscles groups of the superior trunk. The sensory block was assessed using a pinprick test with a 25G hypodermic needle, a gauze, and alcohol. The thermal and painful sensitivities of the C5 and C6 dermatomes were examined. Blockade was considered positive when there was absence of thermal distinction, absence of pain to pinprick and motor function $\leq$ 2 by the modified Bromage scale. In the event of a failed block, an interscalene brachial plexus block with 5 mL of 0.5% bupivacaine at C7 level was performed.

Primary outcome was the analgesic effect, and the secondary outcome was the respiratory function.

**Phrenic nerve block**
The phrenic nerve block was assessed by ultrasound using the real-time movement of the ipsilateral diaphragm. Patients were asked to forcefully inhale through the nose in a sniffing fashion. The test was performed immediately before the block and at 30 minutes, 4 and 6-hours after blockade. The transducer was positioned at the midpoint of the clavicular lines and at the hemidiaphragm level on the ipsilateral side of the block. The movement of the diaphragm was evaluated with the patient in semi-seated position. Diaphragmatic excursion from baseline was measured in centimeters using the digital calipers. A decrease greater
than 75% was considered hemidiaphragmatic paralysis.\textsuperscript{12} In addition, in 3 cases, the evaluation of the respiratory function was performed using impedance tomography (Enlight 1800, Timpel Medical, Sao Paulo, SP, Brazil). This evaluation took place before the blockade, as well as 30 minutes and 4 hours after the blockade.

**Cadaver dissection**

Blocks were performed on six cadavers using the previously described technique, and only 5 mL of methylene blue was injected.

For the evaluation of the dispersion in cadavers, the cervical region was dissected, exposing the brachial plexus region from the interscalene cleft to the supraclavicular region.

**Results**

**Clinical evaluation**

Ten patients undergoing shoulder surgery due to rotator cuff injury received the selective superior trunk block. Participants data is in Table 1. In the evaluation of the blockade, all patients presented motor block of the biceps and deltoid muscles and experienced no pain to the pinprick in the C5 and C6 dermatomes (Figure 3).

No patient presented with phrenic nerve palsy when evaluated by diaphragm ultrasonography (Table 1). In addition, the three patients who were evaluated by impedance tomography showed no variation in the respiratory function.

All procedures occurred without complications. Regarding postoperative analgesia, no patient reported pain (score zero) until 6 hours after the blockade. They were discharged from the hospital without complications and didn’t need hospital readmission.

**Cadaver dissection**

In all dissections, it was observed that methylene blue dispersed inside the brachial plexus but did not reach the phrenic nerve neither by cephalic dispersion nor by medial dispersion (Figure 4). In addition, in all cases, the contrast showed that the solution reached the suprascapular nerve as well.

**Discussion**

The findings of this study suggest that an intra-cluster injection into the superior trunk, right where suprascapular nerve
is branching off, deep to the omohyoid muscle, is an easy, reproducible technique and may be an alternative to a classi
centric interscalene block.

This study shows that, by performing superior trunk
block, it was possible to promote satisfactory analgesic
effect for patients submitted to shoulder surgery, without
compromising respiratory function.

Due to respiratory complications associated with inter-
scale blockade, new techniques have been studied to
promote analgesic effect for shoulder surgeries. In 2014,
Burckett-St. Laurent et al. described the selective super-
ior trunk block. This procedure targets the C5 and C6
components of the brachial plexus more distally after they
unite into the superior trunk but before the suprascapular
nerve branches off. However, the incidence of diaphrag-
matic involvement may be indirectly proportional to the
distance from the nerve roots. Therefore, in this study, a
more distal block was chosen, in the supraclavicular area,
exactly where the suprascapular nerve is leaving the super-
ior trunk. The results of this study suggest that this more
distal approach may be as effective as the superior trunk
block described by those authors, but with the potential to
further decrease the chance of blocking the phrenic nerve.

Recently, Kim et al. (2019) presented a study with 4.8%
of phrenic paralysis with 15 mL of bupivacaine injected at
the superior trunk. Renes (2009) described a posterolat-
eral suprascapular nerve block was used as phrenic nerve
sparing. This approach is less suitable for shoulder surgery
because of reduced block effect to the suprascapular nerve.

According to the anatomy, the superior trunk is preserved
from the time that C5 and C6 join the same sheath, until
the suprascapular nerve leaves the common sheath that sur-
rounds the C5 and C6 neural structures. This takes place in
the supraclavicular area where the suprascapular nerve
starts its antero-posterior trajectory following the omohyoid
to scapula.

Kim et al. (2019) used the targeted level of insertion
for the injection immediately before the branching point
of the suprascapular nerve. We think that identifying the
suprascapular nerve branching inside the same sheath is not
the end of the superior trunk, but it is a nerve fascicle
seen inside the trunk. Just after the suprascapular exits this
sheath (in supraclavicular area) we can say that the superior
trunk is over and blockade for the shoulder might fail. So,

we propose a more distal approach to the superior trunk,
outside the interscalene cleft, in the supraclavicular area
where the first rib and the subclavian artery are visible.

In 2012, Siegenthaler et al. described the blockage of
the suprascapular nerve in the supraclavicular area, infe-
rior to the belly of the omohyoid muscle. However, because
of the proximity to the superior trunk, the fluid injected
at this point was expected to reach some regions of the
brachial plexus, which was recently been demonstrated in
the cadaver study of Shembi et al. (2019). The authors
showed that 5 mL of contrast injected around the supras-
capular nerve, below to the omohyoid muscle, reached the
superior and middle trunk of the brachial plexus.

The study of Abdallah et al., (2020) showed that supras-
capular route consistently blocks the superior trunk and
qualify it as an effective interscalene block alternative.

In addition, Shembi et al. (2019) also demonstrated that
in 20% of the cases, the dissections presented phrenic
nerve involvement, suggesting a possible risk of diaphrag-
matic hemiparalysis with this technique. Despite the similar
injection site to that of Sehmbi et al. (2019), this study
did not find the dispersion of contrast in the phrenic nerve
in any of the dissections. We believe that the difference
in results is due to the endpoint of the injection. Shembi
et al. (2019) performed the injection deep to the invest-
ing layer of deep cervical fascia, outside the prevertebral
layer of deep cervical fascia (brachial plexus sheath), later-
ally within the inferior posterior triangle of the neck. At this
point, the injection can be done in a loose fascial plane and
may allow larger dispersions reaching the phrenic nerve.
In our technique, it was performed as an intra-cluster injection
in the superior trunk deep to the prevertebral layer of the
deep cervical fascia which probably limited the dispersion
of contrast to the phrenic nerve.

It is known that the brachial plexus sheath or axil-
ary sheath is an extension of the prevertebral fascia that
extends from the neck to the axilla. Therefore, it proba-
bley prevents the latero-medial spread at this level, keeping
most of the injected fluid contained inside the brachial
plexus sheath. Moreover, when the blockade is performed
in the supraclavicular area, the injected fluid probably
flows more easily distal than proximal, as the scalenes mus-
cles make a constriction around the trunks, preventing the
injected fluid from reaching the phrenic nerve through prox-
imal (cranial) spread.

A topic point of our study was to evaluate the same
injection volume and location as the injection performed
on the cadavers. It was observed that the injection of this
volume using this technique was enough to promote satisfac-
tory analgesic effect for the patients submitted to shoulder
surgery, proving that the dispersion also reached the supras-
capular nerve.

In addition, the non-impairment of the respiratory func-
tion of these patients was recorded, suggesting that this
technique may be safe in patients with compromised res-
piratory function.

Therefore, new studies can evaluate if this technique
could be used as an anesthetic technique for shoulder
surgery. In this case, it has to be considered that most
the part of the skin around the shoulder is innervated by
supraclavicular nerves (C3–C4) that come from the super-
ficial cervical plexus and the nerve trajectory towards the

Figure 4 Brachial plexus dissection after methylene blue
injection showed that methylene blue was restricted to the
brachial plexus, without reaching the phrenic nerve. AS, Ante-
orier Scalene Muscle; MS, Medium Scalene Muscle; Blue Arrow,
Phrenic Nerve; Yellow arrow, Accessory nerve.
shoulder between the investing layer of the deep cervical fascia and the prevertebral layer of deep cervical fascia. The technique potentially spares those cutaneous branches. Therefore, light sedation is probably enough to tolerate this mild pain stimuli from arthroscopy portals, or better a local skin infiltration may be performed.

It was opted for 5 mL of methylene blue or local anesthetic because previous study has demonstrated that this volume is sufficient to promote analgesic effect for shoulder surgeries through the superior trunk block.11

In conclusion, this study demonstrates that a superior trunk block, below the omohyoid muscle may be an alternative technique to promote analgesic effect for shoulder surgery. Study limitations included lack of comparison with other techniques as well as a low number of participants.

Availability of data and material

With author and at Universidade Federal de São Paulo.

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Institutional.

Conflicts of interest

The authors declare no conflicts of interest.

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