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Minimum effective volume of 0.5% bupivacaine with epinephrine in ultrasound-guided interscalene brachial plexus block

L. F. R. Falcão, M. V. Perez*, I. de Castro, A. M. Yamashita, M. A. Tardelli and J. L. G. Amaral

Discipline of Anaesthesiology, Pain and Critical Care Medicine, Federal University of São Paulo-Paulista School of Medicine (Universidade Federal de São Paulo-Escola Paulista de Medicina—UNIFESP-EPM), Rua Napoleão de Barros, 715-5° andar—Hospital São Paulo, Vila Clementino, CEP: 04024-002 São Paulo, SP, Brazil

* Corresponding author. E-mail: anestesia.dcir@epm.br

Editor's key points

- Ultrasound-guided regional anaesthesia can reduce local anaesthetic volumes needed for effective analgesia.
- The minimum effective volume of 0.5% bupivacaine required for interscalene brachial plexus block was studied.
- A comprehensive assessment of sensory and motor changes was used along with pain scores.
- The MEV of 0.5% bupivacaine with epinephrine was found to be 0.95 ml.
- Further work is needed on block duration and dose variation.

Background. The use of ultrasound (US) in regional anaesthesia enables a reduction in the local anaesthetic volume. The present study aimed to determine the minimum effective volume (MEV_{90}) of 0.5% bupivacaine with epinephrine for interscalene brachial plexus block (ISBPB).

Methods. The volume of the anaesthetic was determined using a step-up/step-down method and was based on the outcome of the preceding block. A positive or negative block resulted in a 1 ml reduction or increase in volume, respectively. The success of the block was defined as the presence of motor block in three muscle groups and the absence of thermal and pain sensations in three dermatomes within 30 min of the injection. Diaphragmatic paralysis and analgesia were assessed at 30 min, 4, and 6 h.

Results. The MEV_{90} for US-guided brachial plexus block under the conditions of the present study was 0.95 ml [R^2: 0.97, 95% confidence interval (CI): 0.6–1.22 ml]. The estimated maximum volume that did not cause diaphragmatic block was 4.29 ml (R^2: 0.84, 95% CI: 3.56–4.98 ml). Effective postoperative analgesia was achieved with 2.34 ml (R^2: 0.87, 95% CI: 0.48–11.47 ml).

Conclusions. The MEV_{90} of 0.5% bupivacaine with epinephrine (1:200 000) for US-guided ISBPB was 0.95 ml. Adequate postoperative analgesia and a reduced incidence of diaphragmatic block can be obtained using from 2.34 to 4.29 ml.

ClinicalTrials.gov. Registry NCT01244932.

Keywords: anaesthetic, local; brachial plexus; bupivacaine; ultrasonography

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Interscalene brachial plexus block (ISBPB) is one of the most commonly used techniques for regional anaesthesia of the upper limbs. Before the introduction of ultrasound (US)-guided ISBPB, large volumes of local anaesthetics (LAs) were used to increase the success rate of this procedure. US-guided interscalene,[1–3] axillary,[4] femoral,[5 6] and ilioinguinal[7] blocks require lower LA doses. The maximum reduction in anaesthetic volume for ISBPB resulting in anaesthesia of the upper limb, adequate postoperative analgesia, and minimal influence on diaphragmatic block is unknown.

Despite these benefits, the interscalene approach may present risks and complications, and phrenic nerve paralysis has been described in as many as 100% of patients when using high volumes of LA,[8] a technique that is still widely used. Ventilation may consequently be compromised, thus restricting the use of this technique in patients with limited pulmonary reserve.

The present study was therefore conducted to identify the minimum effective LA volume (MEV_{90}) required for both adequate anaesthesia of the brachial plexus and minimization of the complications inherent in the interscalene procedure.

Methods

A step-up/step-down study, single blinded, was used to determine the MEV_{90} of 0.5% bupivacaine with epinephrine in US-guided ISBPB.

This protocol was approved by our institution's Research Ethics Committee (Ref: 1310/09) and registered at ClinicalTrials.gov under the protocol number NCT01244932. Patients

aged 21–65 yr who were candidates for an elective surgical intervention on the shoulder, with an indication for brachial plexus block for anaesthesia and analgesia, a physical condition of I or II according to the ASA, and a BMI <35 kg m^{-2}, were included in the study between 2010 and 2011 after written informed consent. Patients with chronic obstructive pulmonary disease, cognitive impairment or an active psychiatric condition, an infection at the site of the puncture for the block, coagulopathy, or a history of a bupivacaine allergy were excluded from the study.

After inclusion, patient characteristic data were recorded for all patients. The patients were then referred to the regional anaesthesia station, where the entire procedure and the differences between tactile and painful sensations were explained to achieve a greater accuracy of the collected information. Routine monitoring of the surgical procedure was performed.

The US-guided brachial plexus block was performed by a single experienced anaesthesiologist (MicroMaxx™; SonoSite, Bothell, WA, USA). The procedure was performed using a peripheral nerve stimulator (PNS), with a 50 mm, 22 G needle (Stimuplex™ A, B. Braun, Melsungen, Germany). The patient was placed in the dorsal decubitus position with the neck extended towards the contralateral side. Asepsis of the skin was achieved and a local infiltration was performed with 1 ml of 1% lidocaine. After US visualization of the nerve roots and the trunks of the brachial plexus between the anterior and middle scalene muscles, the identification of the injection site was confirmed using the PNS (1 Hz frequency, 0.1 ms pulse, 1 mA current) with a progressive reduction to 0.4 mA. When a maintained motor response was observed, 15 ml of 0.5% bupivacaine with epinephrine (1:200 000) was injected, with a direct view of the injection site. The injection was given in two equal aliquots of 7.5 ml: one between the upper and middle trunk and one between the middle and lower trunk of the brachial plexus. A single puncture was used for both injections.

The end of the second injection was considered time 0 for evaluating the effectiveness of the block. A blinded assistant, who was not present during the injection and who was unaware of the volume of anaesthetic used, was asked to assess the nerve blocks. The block was tested using motor, thermal, and pain assessments every 10 min for up to 30 min after the procedure. Upon an effective block, the subsequent patient received a reduction of 1 ml in the total volume of the anaesthetic. Upon failure of the block, the volume of LA was increased by 1 ml for the next patient, as recommended by the step-up/step-down method.[9]

The previously established criteria for a successful brachial plexus block were motor function ≤ 2, thermal sensitivity=0, and pinprick=0 in at least three of the tested regions when compared with the contralateral limb. The criterion for calculating the MEV_{90} for each individual trunk (upper, middle, lower) was a block of motor function ≤ 2, thermal sensitivity=0, and pinprick=0 in all of the regions and muscle groups that are innervated by the respective trunk, as shown:[10]

- Upper trunk: deltoid, biceps, C5, and C6.
- Middle trunk: triceps, extensor muscles of the fingers, and C7.
- Lower trunk: flexor and abductor muscles of the fingers, C8, and T1.

The modified Bromage scale[4] was used to evaluate motor function (Table 1). The evaluated muscles included the deltoid, biceps, triceps, finger flexors (median nerve), finger extensors (radial nerve), and finger abductors (ulnar nerve).

The assessment of thermal sensation in the upper limb was performed using gauze and alcohol. Pain sensation was assessed by a pinprick test using a 23 G needle. The thermal and pain sensitivities of dermatomes C4 to T1 were examined. The block was considered positive when there was absence of thermal distinction and absence of pain.

Phrenic nerve block was assessed via US using real-time movement of the diaphragm ipsilateral to the ISBPB at four distinct time points: immediately before the block and at 30 min, 4, and 6 h after the block. The US was positioned at the midpoint of the hemiclavicular and midaxillary lines, at the level of the hemidiaphragm on the ipsilateral side of the block. The US was performed using a curvilinear 2–5 MHz probe (MicroMaxx™) with the patient in the dorsal decubitus position while inhaling deeply. The excursion of the caudal diaphragm was designated positive, and paradoxical cephalic motion (negative) was considered paralysed.

Postoperative analgesia was assessed in the recovery room using a numeric pain rating scale (0 indicating no pain, 10 indicating the worst pain ever experienced) and the amount of analgesic used at two distinct times (4 and 6 h after the block) or when requested by the patient. The MEV_{90} for postoperative analgesia was estimated for complete absence of pain and no use of analgesics for 6 h.

After 30 min of evaluation, general anaesthesia was induced with 2–2.5 mg kg^{-1} propofol, 2.5 μg kg^{-1} fentanyl, and 0.5 mg kg^{-1} atracurium. The airway was maintained by tracheal intubation, and ventilation was provided with 40% oxygen and 60% nitrous oxide. General anaesthesia was maintained with 0.5–1% isoflurane. The patients who exhibited an increase in intraoperative heart rate or arterial pressure above 25% of the pre-induction baseline values received 25 μg of i.v. fentanyl. At the end of surgery, all

Table 1 Modified Bromage scale[4]

Degree	Definition
4	Full strength in relevant muscle groups
3	Strength reduction, but able to move against resistance
2	Ability to move against gravity, but not against resistance
1	Discrete movements (trembling) of muscle groups
0	Absence of movements