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SCIENTIFIC ARTICLE

Determination of the minimum effective volume of 0.5% bupivacaine for ultrasound-guided axillary brachial plexus block

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Abstract
Background and objective: The use of ultrasound for needle correct placement and local anesthetic spread monitoring helped to reduce the volume of local anesthetic required for peripheral nerve blocks. There are few studies of the minimum effective volume of local anesthetic for axillary brachial plexus block. The aim of this study was to determine the minimum effective volume (VE90) of 0.5% bupivacaine with epinephrine (1:200,000) for ultrasound guided ABPB.
Method: Massey and Dixon's up-and-down method was used to calculate the minimum effective volume. The initial dose was 5 mL per nerve (radial, median, ulnar, and musculocutaneous). In case of blockade failure, the volume was increased to 0.5 mL per nerve. A successful blockade resulted in decreased volume of 0.5 mL per nerve to the next patient. Successful blockade was defined as a motor block $\leq$2, according to the modified Bromage scale; lack of thermal sensitivity; and response to pinprick. The achievement of five cases of failure followed by success cases was defined as criterion to complete the study.
Results: 19 patients were included in the study. The minimum effective volume (VE90) of 0.5% bupivacaine with 1:200,000 epinephrine was 1.56 mL (95% CI, 0.99–3.5) per nerve.
Conclusion: This study is in agreement with some other studies, which show that it is possible to achieve surgical anesthesia with low volumes of local anesthetic for ultrasound-guided peripheral nerve blocks.

Introduction

Brachial plexus block is an anesthetic technique often used for upper limb surgical procedures. Axillary brachial plexus block (ABPB) is one of the most commonly used techniques to achieve upper limb regional anesthesia and it is performed

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by blocking the terminal branches of the brachial plexus, which include the musculocutaneous, ulnar, median, and radial nerves. It was believed that the failures or incomplete blockade due to this technique were the result of needle malposition or brachial plexus septa in the axillary region.[1–3] To increase the success rate, volume up to 80 mL have been reported.[4] However, the use of large volumes of local anesthetic increases the likelihood of systemic toxicity.[5,6] Thus, a possible technique to prevent this complication and increase patient safety would be to reduce the mass of the local anesthetic used during the procedure.

Currently, technologies such as peripheral nerve stimulator and ultrasound ensure the needle correct positioning in relation to the complex and reduce the need for high volumes of local anesthetic.[7–13] Some studies have shown that the use of ultrasound reduced the volume of local anesthetic for interscalenic brachial plexus block, femoral nerve block, and ilioinguinal/iliohypogastric nerve block without compromising the quality. However, there are few studies of the minimum effective volume of local anesthetic for ABPB. Therefore, this study was performed in order to calculate the minimum effective volume of 5% bupivacaine in 90% (VE90) of cases receiving ultrasound-guided axillary brachial plexus block.

Method

Study conducted at the surgical center of the Hand and Upper Limb Unit, with the coordination of the anesthesia service for the anesthesiology, intensive care and pain discipline, Universidade Federal de São Paulo/Escola Paulista de Medicina, from December 2011 to June 2012. The study was registered at Clinicaltrials.gov under the number NCT01421914.

After approval by the Ethics Committee of the Universidade Federal de São Paulo, patients scheduled to undergo hand surgery were invited to participate in the study. Inclusion criteria were age over 18 and under 65 years, informed consent (IC) signed by the patient, indication for brachial plexus block (anesthesia and analgesia) in candidates for elective hand surgery lasting less than 2 h, ASA physical status I or II according to the American Society of Anesthesiologists, and body mass index (BMI) <35 kg/m^2. Exclusion criteria were cognitive impairment or active psychiatric condition, infection at the blockade puncture site, bleeding disorders, and history of allergy to bupivacaine.

Protocol design

After inclusion in the study, all patients had their demographics recorded, followed by routine surgical monitoring with ECG, noninvasive blood pressure, and pulse oximetry. Intravenous access was made in the upper limb contralateral to the procedure and maintained with crystalloid infusion.

Axillary brachial plexus block was performed using ultrasound (M-Turbo R System with HFL 38$\times$ linear transducer 6–13 MHz, SonoSite, Bothell, WA USA) and a peripheral nerve stimulator (Stimuplex R DIG RC, B. Braum, Mellsung, Germany), with the patient in the supine position. The needle used was a 22 G $\times$ 50 mm (AEQ2250, BMD Group, Venezia, Italy). After disinfection and skin antisepsis with chlorhexidine, the puncture site was infiltrated with 1% lidocaine. After brachial plexus nerve visualization using ultrasound, the identification of structures was confirmed with a peripheral nerve stimulator. A starting dose of 5 mL of 0.5% bupivacaine with 1:200,000 epinephrine was injected around each nerve. The needle was repositioned during local anesthetic injection, and epidural injection was ensured by ultrasound image. The patient would have been removed from the study if there were a visual change in nerve diameter or if there were a significant pain during injection. In these cases, patients were followed postoperatively for possible intraneural injection.

The end of local anesthetic injection was considered time zero to assess the blockade effectiveness. An observer who was not present during the procedure and was blinded to the volume of anesthetic used evaluated the nerve blocks studied. This assessment was done every five 5 min until surgical anesthesia was achieved or up to 30 min after local anesthetic injection.

The blockade success or failure led to the reduction or increase in the volume of local anesthetic for the next patient, respectively. When the blockade was considered effective, the subsequent patient received a reduction of 0.5 mL in the local anesthetic volume. In case of blockade failure, patients received supplemental block at the elbow level, and the local anesthetic volume for the next patient was increased by 0.5 mL. After blockade evaluation, the patients were released to the surgical procedure. During the surgical procedure, patients received propofol 15–25 mcg/kg/min for sedation. Moreover, if the patient reported pain during the procedure, the blockade was considered as a failure and general anesthesia was performed.

After surgery, the patient was admitted to the post-anesthesia care unit (PACU) and remained monitored (ECG, noninvasive blood pressure, and pulse oximetry) until meeting the required conditions for outpatient discharge. Postoperative analgesia was assessed in the PACU using a visual analog scale 3 h after the blockade.

Assessment of ABPB success

A successful blockade was considered when there were motor function $\leq$2 according to the modified Bromage scale, lack of thermal sensitivity and response to pinprick in the regions of the median, ulnar, musculocutaneous, and radial nerves. Furthermore, the procedure should be done without additional analgesia to confirm the anesthetic procedure success.

Assessment of motor function

For motor function evaluation, the modified Bromage scale was used (Table 1).

The following tests were used to assess motor function: finger flexion (median nerve), wrist extension (radial nerve), thumb adduction (ulnar nerve), and elbow flexion (musculocutaneous nerve). Values $\leq$2 according to the modified Bromage scale were considered successful blockade.