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Original contribution

Effective volumes of 1.5% mepivacaine with different sodium concentration for ultrasound guided popliteal block

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ABSTRACT

Study objective: To determine if a solution of 1.5% mepivacaine diluted with 5% dextrose, which decreases the sodium concentration by 30%, results in reduced volume requirements for a complete sensory block, in the case of an ultrasound guided popliteal nerve block.
Design: A randomized controlled study.
Setting: Operating room.
Patients: We included seventy ASA 1–3 patients, undergoing unilateral "hallux valgus" repair under ultrasound guided popliteal nerve block.
Interventions: An ultrasound guided popliteal nerve block was performed on all patients, with 1.5% mepivacaine using the normal dilution (ND group, thirty-five patients) or the 5% dextrose dilution (D5 group, thirty-five patients). Starting with 25 ml in each group, increasing or decreasing it by 1 ml on subsequent patients, depending on the success or failure in the previous one (Dixon's "up-and-down" sequential allocation).
Measurements: Effective dose in 50, 90, and 95% of patients (ED50, ED90, and ED95) of 1.5% mepivacaine in both groups. Onset time and duration of the blocks, side effects, and neurological complications.
Main results: There were no statistically significant differences between ED50 in ND group (6.2 ml; 95% confidence interval, 5.2–7.5), and D5 group (5.8 ml; 95% CI, 5.1–7). Also no statistically significant differences in ED90 (7.7 ml, 95% CI 6.9–8.1 in the D5 group; 7.8 ml, 95% CI 7–8.1 in the ND) or in ED95 (7.9 ml, 95% CI 7.1–8.2 in the D5 group; 8 ml, 95% CI 7.2–8.2 in the ND) were found. Onset time for a complete sensory block in D5 group was 14 min (95% CI, 12–17) and 15 min in ND (95% CI, 13–18), $p = 0.66$. Neither severe side effects, nor neurological complications were reported.
Conclusions: A dilution of 1.5% mepivacaine with 30% less sodium concentration does not decrease volume requirement for ultrasound guided sciatic nerve block at popliteal level.

1. Introduction

Sodium channels in the nerve membrane determine neuronal excitability. These channels are influenced by the ionic composition of extracellular and intracellular fluids, as by drugs such as local anesthetics (LA) [1]. In the presence of LA, sodium channels are less likely to open in response to depolarization [2]. Nerve excitability may be amplified by increasing the concentration of extracellular sodium, potentially altering the analgesic effect of local anesthetics. Available commercial preparations of local anesthetics contain a high concentration of sodium chloride (NaCl). 1% mepivacaine contains 8 $mg \cdot ml^{-1}$ (137 $mmol \cdot l^{-1}$) of NaCl, while 2% mepivacaine contains 7 $mg \cdot ml^{-1}$ (120 $mmol \cdot l^{-1}$) [3]. Dhir et al. found that a dilution of ropivacaine with 5% dextrose resulting in a lower NaCl concentration of the LA mixture provides an earlier onset of the axillary plexus block [4].

Based on the physiology of nerve excitability, we proposed that a LA with lower NaCl concentration could provide a good quality of nerve block with less volume of LA.

The hypothesis of our study was that a solution of 1.5% mepivacaine diluted with 5% dextrose (decreasing thus the sodium concentration by 30%), would result in reduced LA volume requirements for ultrasound (US) guided popliteal nerve block, in patients undergoing unilateral "hallux valgus" repair surgery. To achieve this outcome, we compared the Effective Dose in 50% of patients (ED50) of 1.5% mepivacaine obtained in both groups using the "up-and-down" method described by Dixon [5,6]. So far, the volume of local anesthetic for ultrasound guided popliteal block has only been reported in one study, in which the ED 50 and ED 95 volumes of 0.5% ropivacaine were 6 ml and 16 ml, respectively [7].

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2. Materials and methods

Institutional ethics committee approval for the study protocol (Ethics committee and clinical research, CEIC, "*La Paz*" University Hospital, HULP code: 3839) was obtained on March 21, 2013. The study was registered at the ISRCTN registry (reference number: ISRCTN 13419503) and conducted from April 2013 to February 2014. After obtaining the written informed consent, patients scheduled for unilateral "hallux valgus" repair under popliteal sciatic nerve block were prospectively enrolled in this study. Consolidated Standards of Reporting Clinical Trials (CONSORT) guidelines were followed during the design and description of the study [8]. Inclusion criteria were: patients scheduled for unilateral "hallux valgus" surgery repair by "Chevron" osteotomy, intended to be operated by the same surgical team, age between 18 and 80 years old, physical status ASA 1–3, and body mass index (BMI) <35 $kg \cdot m^{-2}$. Exclusion criteria were: patient refusal or lack of written informed consent, the existence of any regional anesthesia contraindication, inability to distinguish the popliteal nerve with ultrasound, cognitive impairment, chronic use of opioids and/or neuroleptic drugs, pregnancy, peripheral neuropathy, and allergy to drugs used in the study.

The same anesthesiologist, an expert in US-guided regional anesthesia, performed all the US-guided popliteal blocks and prepared the dilutions [9]. This anesthesiologist had the volume's sequence, and calculated the volume for each patient following the sequence of successes and failures. The initial volume of 1.5% mepivacaine injected in both groups was 25 ml. Before conducting this study, the volume used in our center for this block was between 20 and 40 ml. Also, we chose this volume based on studies where nerve blocks were performed using the nerve stimulation technique published before our study began, given that so far, no study had calculated the volume for ultrasound-guided popliteal block [10,11]. The volumes administered to subsequent patients of each group were determined by the success or failure of the block in the previous one of the same group, following the "up-and-down" allocation technique [5]. If the previous patient had acquired a complete sensory block, the next patient of the same group had the volume of 1.5% mepivacaine decreased by 1 ml, and increased by 1 ml if the block had failed in the previous one. Also, patients were randomly allocated to receive 1.5% mepivacaine with our normal dilution (normal group: 1% mepivacaine with 2% mepivacaine at the same proportion, resulting in a concentration of 7.5 $mg \cdot ml^{-1}$ of NaCl, and pH 6.28) or a dilution with 5% dextrose (dextrose group: three quarters of 2% mepivacaine plus one quarter of 5% dextrose, therefore with the same concentration of mepivacaine as the other group, but resulting in a concentration of 5.25 $mg \cdot ml^{-1}$ of NaCl, and pH 6.41) for the popliteal block, using a computer randomization sequence. We assigned patients to one of the groups in the pre-anesthetic visit (we wrote the group in a paper that was placed in the patient's clinical history).

When the patient arrived in the operating room, we applied standard monitoring (non-invasive arterial blood pressure, heart rate, and pulse oximetry), and placed a 20-gauge IV catheter. We also applied them a nasal cannula with oxygen at three liters per minute, and administered them 0.02 $mg \cdot kg^{-1}$ of midazolam before the block. We then placed the patient in prone position, and disinfected the popliteal area with alcoholic chlorhexidine. We performed the blocks 45 to 30 min before the surgery started. Once the block's medication was ready, the anesthesiologist checked the Ultrasound (Esaote MyLab™ 25, Esaote Group, SpA.) and covered the probe with a sterile sheath. The anesthesiologist placed the ultrasound probe (linear scan probe of 7.5–12 MHz) parallel to the popliteal crease, and identified the sciatic nerve division into its two branches: the tibial and peroneal nerves. He inserted the needle (Contiplex® D 18G, catheter set for a continuous nerve block of B.·Braun Melsungen AG) in plane with the probe, and performed infiltration with the volume and dilution assigned to each patient. The end of the injection of the local anesthetic was noted as time zero for subsequent evaluation of the blockade. Once the corresponding volume was infiltrated, the anesthesiologist placed a perineural catheter under ultrasound guidance through the needle, for the administration of new bolus of local anesthetic in case of ineffectiveness of blockade at 30 min. Patients were blinded to the volume and dilution of mepivacaine used in the block. After fixation of the catheter, the patient turned to the supine position and the same anesthesiologist proceeded to perform an US-guided femoral nerve block to cover the region innervated by the internal saphenous nerve (for the patient to tolerate tourniquet placement on the calf).

An anesthesiologist blinded to the volume and dilution used in the patient, evaluated the sensory and motor blocks. He/she assessed sensory and motor blocks after five minutes of time zero, and every five minutes until the two blocks were complete, or up to 30 min. Sensory block was assessed by "pinprick test" in the central sensory region of each branch of the sciatic nerve (the plantar region for the tibial branch, and the dorsolateral region of the foot for the peroneal nerve). It was compared to the same stimulus in the contralateral foot, on a three-point scale (0 = normal sensation, 1 = the patient felt the touch but did not feel the pain, and 2 = absence of sensation). A complete sensory block was defined as a score of 2 in both territories. Motor block was assessed asking the patient to perform plantar flexion (to evaluate the tibial nerve) and dorsiflexion (to evaluate the peroneal component). Motor block was scored using a three-point scale too (0 = normal movement, 1 = decrease of mobility compared with the contralateral foot, and 2 = inability to move the ankle). We considered total motor block as a score of 2.

If a complete sensory block was acquired 30 min or less after time zero, we considered it as a success. But if these patients referred discomfort once the surgery has begun, and needed a supplemental bolus of local anesthetic through the catheter, we considered the blockade as failed. Also, if within 30 min the sensory block was not complete, we considered this block as failed, and we administered an additional dose of local anesthetic (10 ml of 2% lidocaine) by the perineural catheter. If it was still not enough, an infusion of propofol at 1–2 $mg \cdot kg^{-1} \cdot h^{-1}$ was started, considering it as supplementary sedation, increasing the dose and administering fentanyl if it was necessary (propofol doses above 2 $mg \cdot kg^{-1} \cdot h^{-1}$ and/or the need of IV fentanyl was considered as general anesthesia). Once the surgery was completed, we proceeded to the withdrawal of the perineural catheter, and patient was transferred to the post-anesthetic care unit. There, a study collaborator informed the patients to note block resolution time, as it would be asked the next day. Patients were discharged home on the same day, after pain control and block resolution.

A study collaborator, blinded to the volume and dilution used in each patient, conducted a telephone interview 24 h after the procedure. In this interview, he/she asked the patient about time for block resolution. The collaborator also asked about side effects such as sensory loss, paresthesias, or any other complication derived from the blockade. If the

Table 1
Anthropometric characteristics of both groups. Continuous variables are presented as mean (±SD). Categorical variables are presented as numbers (percentage).

	Normal group (n = 35)	Dextrose group (n = 35)	p
Age, y	57 (14)	62 (15)	0.13
Weight, kg	63 (10)	65 (10)	0.41
Height, cm	160 (7)	159 (8)	0.58
BMI[a], kg/m^2	24 (3)	26 (3)	0.15
Gender			
Male	1 (3%)	4 (11%)	0.35
Female	34 (97%)	31 (89%)	0.35
ASA[b] physical status			
I	7 (20%)	6 (17%)	0.87
II	23 (66%)	25 (71%)	0.8
III	5 (14%)	4 (12%)	0.9

[a] BMI: body mass index.
[b] ASA: American Society of Anaesthesiologists.