Original Article

What is the minimum effective anesthetic volume (MEAV90) of 0.2% ropivacaine required for ultrasound-guided popliteal-sciatic nerve block?

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Abstract

Background and Aims: Popliteal-Sciatic nerve block under Ultrasound Guidance (USG) using a local anesthetic agent like Ropivacaine is an established technique for providing analgesia and muscle relaxation for lower limb surgeries with minimal untoward events. Establishing the minimal volume of 0.2% ropivacaine required to provide intraoperative and postoperative analgesia will further reduce the drug requirements and adverse effects toward the patient.

Material and Methods: This randomized prospective observational blinded study was done in a tertiary care referral hospital in South India over 9 months from August 2017 till April 2018. The block was performed on all recruited patients under ultrasound guidance with a starting volume of 16 ml 0.2% ropivacaine. Duration of time for loss of pin-prick sensation around the sole of the foot (tibial nerve) and the lateral malleolus (common peroneal nerve) was noted. If successful, the volume of the drug for subsequent patients was randomized by lottery method to either be kept the same or reduced. If the block failed, the subsequent patient recruited would have an increased volume of drug injected.

Results: By Probit regression analysis using the biased coin up-and-down method we found that 9.3 ml (MEAV90) of 0.2% ropivacaine was sufficient for providing adequate analgesia. Factors such as patient age or weight had no role in efficacy of the block. There were no adverse effects such as allergy to the drug or systemic toxicity noted in the studied patients.

Conclusion: 9.3 ml of 0.2% ropivacaine is sufficient to provide analgesia (assessed by pin-prick) in 90% of patients undergoing popliteal-sciatic block for lower limb surgeries.

Keywords: Minimum effective anesthetic volume, popliteal-sciatic, ropivacaine, ultrasound

Introduction

Popliteal-Sciatic nerve block using a local anesthetic agent is a well-established technique for providing analgesia and muscle relaxation for lower limb surgeries.[1-3] Addition of ultrasound guidance (USG) improves the precision of the technique by direct visualization of the drug spread in real time. A reduced volume and dose can reduce the incidence of systemic and neuro-toxicity. It may also reduce complications such as local anesthetic overdose, intravascular injections, or incomplete blocks.[4-7]

Patients with co-existing illnesses presenting for lower limb surgeries would benefit from the advantages of regional analgesia over general anesthesia. Ultrasound-guided Popliteal-Sciatic nerve block is easy to learn, and has advantages over sub-arachnoid anesthesia in that there is no sympathetic blockade and subsequent bradycardia or

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hypotension, and avoids post-dural-puncture headache and urinary retention.

This study was carried out to determine the minimum effective anesthetic volume (MEAV90) of 0.2% ropivacaine for popliteal-sciatic nerve block under ultrasound guidance.

Material and Methods

This prospective, observational study was done in a tertiary care referral center in central Kerala between August 2017 and April 2018. Based on proportion of outcome observed in an earlier study by Taha *et al*[11] with 95% confidence level and 15% relative allowable error, the minimum sample size was calculated to be 28. However we chose a larger sample size for better study quality. Since our Centre had a high turnover of patients undergoing regional anesthesia, we were confident we could reach our set value of 50 patients. After obtaining clearance from the ethical and research committees, 50 patients of ASA physical status I-III between 18 and 80 years of age presenting for below-knee surgery requiring a popliteal-sciatic block were recruited for the study after taking informed consent. Patients who were allergic to local anesthetics, those on chronic analgesic therapy, poorly controlled diabetics (HbA1C >8%) and those with clinical bleeding manifestations were excluded from the study. All eligible patients had their pre-anesthetic reports looked over, their details noted down, and pre-medicated with 10 mcg of dexmedetomidine and 2 mg of midazolam. All blocks were administered as per the study protocol under ultrasound guidance (Sonosite M Turbo, linear transducer probe of 6-13 Mhz. FUJIFILM Sonosite, Inc. Worldwide Headquarters, 21919 30th drive SE, Bothell, WA) using a 25 gauge Quincke spinal needle (B.Braun Medical Pvt. Ltd) by the same consultant anaesthesiologist with substantial expertise in ultrasound-guided nerve blocks for all cases [Figure 1]. The spread of the drug was directly visualized under ultrasound guidance around both the tibial and common peroneal nerves [Figure 2]. If the patient was unwilling to give consent, the block was administered as per hospital protocol. A supplemental saphenous nerve block was administered with 0.2% ropivacaine to achieve total analgesia of the lower limb. The volumes of all supplemental blocks were pre-calculated to be within the safe dose, and not included in the final analysis. After the patient had received the block under ultrasound guidance, the blinded observer clinically assessed the degree of sensory loss over the lateral malleolus and sole of the foot at 5, 10, 15, 20, 25, 30 minutes from the time of drug injection to note the time of onset of the drug. The starting volume of 0.2% ropivacaine was 16 ml and was increased or decreased by 2 ml in subsequent cases depending on patient response. If the block was effective, then the next patient was randomized by lottery method on whether to receive the block with 2 ml less than previously given, or at the same dose. If the block failed then the patient was given alternative methods of pain relief prior to surgery or intra-operatively, and the subsequent patient was given a dose 2 ml higher than the previous one.

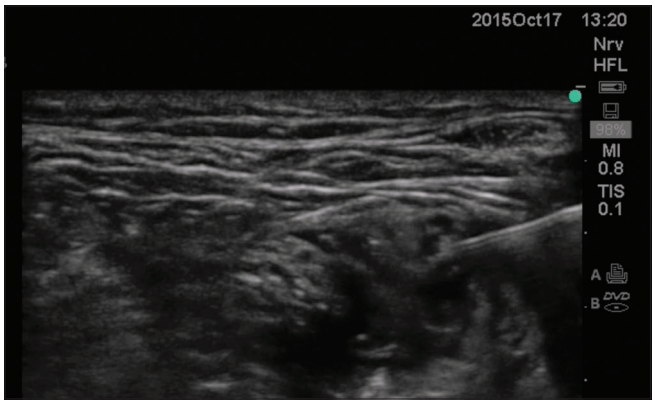
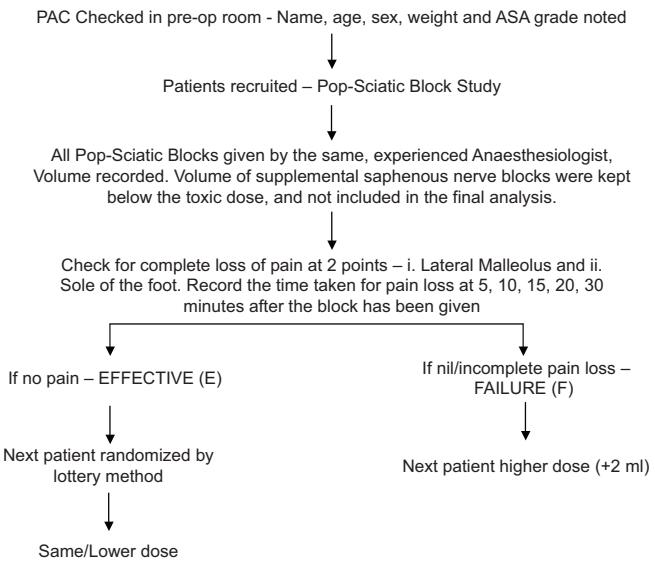


Figure 1: USG Pop-sciatic block with 0.2% ropivacaine while visualizing the needle tip

The efficacy of the block was graded based on the patients' ability to perceive a pin-prick sensation on the blocked limb compared to the contralateral side within the given time of 30 minutes from administering the block. The pinprick was given at 2 locations - just below the lateral malleolus (common peroneal nerve) and the sole (tibial nerve). The end result was classified as Effective or Failed. The block was deemed as Effective if there was a complete loss of sensation within 30 minutes of block administration, and the block was deemed as Failure if after 30 minutes of block administration, there was either an incomplete loss of sensation, or no loss at all.



Statistical analysis

The statistical software used was IBM SPSS version 20. The primary outcome was estimation of the MEAV90 of

0.2% ropivacaine providing analgesia to pin-prick sensation in 90% of patients. The value was calculated using the biased coin up-and-down technique with Probit Analysis. Secondary outcomes as to whether there was a correlation in the minimum volume to the patients' weight or age calculated using Pearson's Correlation test, with a P value <0.05 considered as significant.

Results

50 patients were recruited into the study, of which 37 were male and 13 were female. The majority of patients belonged to the ASA II category. The starting volume of 0.2% ropivacaine was 16 ml, going up or down by 2 ml each time depending on patient response and the doses were randomized according to study protocol [Graph 1]. The progression of drug administration proceeded in a sequential up and down manner [Graph 2]. There were no adverse drug reactions noted in any of the patients. MEAV90 was found to be 9.3 ml by Probit regression analysis. Interestingly, the volume was found to be independent of the patients' age or weight in producing adequate analgesia [Table 1], with administered doses far less than the patients' normal weight-based dose producing adequate analgesia. Out of 50 patients recruited, 47 blocks were deemed effective, while 3 were failed blocks [Graph 3]. Those patients were given either procedural sedo-analgesia or GA at the discretion of the treating anesthesiologist. There were no postoperative complications noted for any of the patients.

Discussion

Ropivacaine is a long-acting amide local anesthetic which has less motor blockade than bupivacaine,[8] but equivalent sensory blockade,[9,10] with less incidence of cardiotoxicity. An earlier study by Taha noted that the minimum concentration of ropivacaine required to produce analgesia in 95% of patients was 0.167% for Femoral Nerve block,[11] and Davies *et al.* found the Minimum Effective Anesthetic Concentration of ropivacaine for 90% of patients (MEAC90) undergoing popliteal-sciatic nerve block to be 0.139%.[12] We established that the MEAV90 of 0.2% ropivacaine for ultrasound-guided popliteal-sciatic nerve block was 9.3 ml by Probit regression analysis. This is on par with a similar study by Bang *et al.*, which ascertained the MEAV90 of 0.75% ropivacaine to be 8.9 ml using a similar study design.[13] The slight increase in volume for our study was likely due to the reduced concentration used, which was 0.2%. All popliteal-sciatic blocks administered by us were supplemented with a saphenous nerve block for total analgesia of the lower limb as described by Canales *et al.*,[14] but only the areas supplied by the terminal branches

Table 1: Pearson correlation between age and weight for drug efficacy

Variables	Volume given		
	n	Pearson Correlation	*P*
Age	50	-0.025	0.862
Weight	50	-0.116	0.422

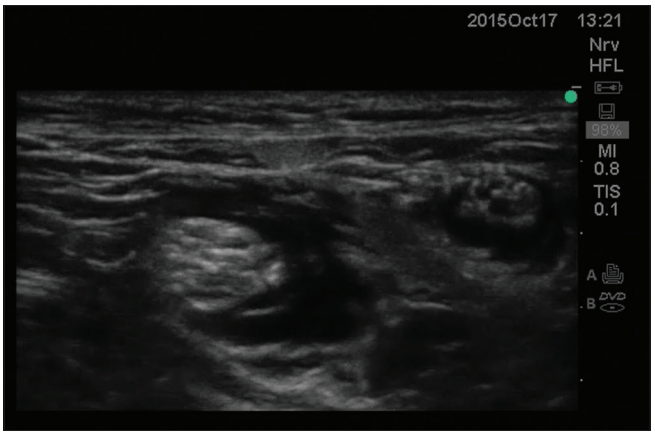
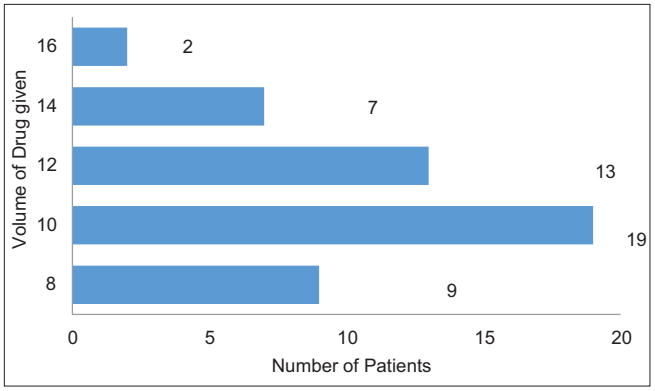
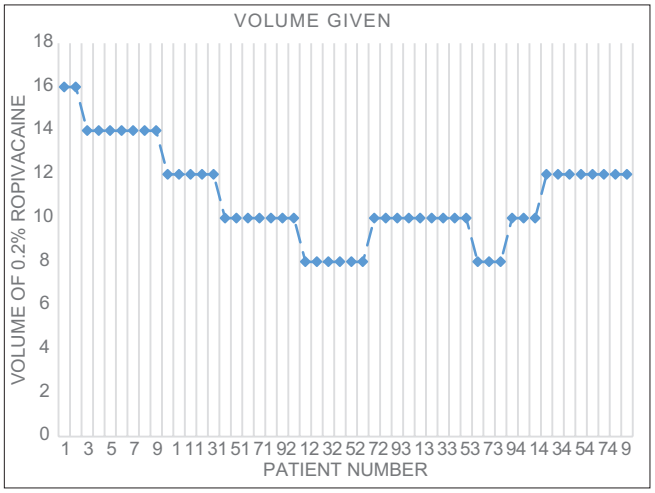


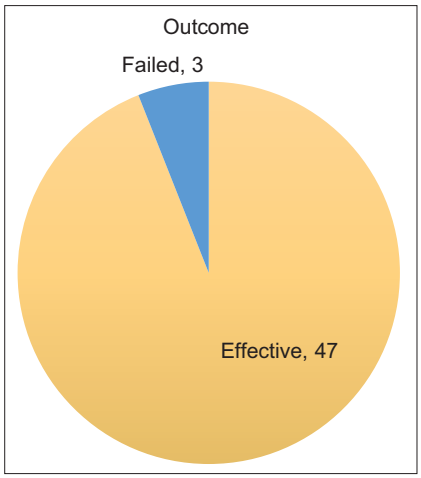
Figure 2: Adequate spread of LA around the tibial and common peroneal nerves



Graph 1: Volume of 0.2% ropivacaine given



Graph 2: Up-and Down graph showing the volume of 0.2% Ropivacaine given per patient



Graph 3: Distribution of subjects based on the outcome of intervention

of the sciatic nerve were tested before surgery. We used the In-plane needling technique with sub-paraneural injection as described by Perlas *et al*.[15] Sub-paraneural injection is effective and safe,[15] however Cappelleri *et al*. showed that even intraneural injection can have a faster onset with a relatively comparable margin of safety,[16] with care to avoid intra-fascicular injection. One limitation of our study was that the same anesthesiologist had to administer the blocks for all the patients to reduce bias and another blinded anesthesiologist had to test all the patients to prevent analysis bias. Ultrasound-guided blockade is a skill-based technique, and anaesthesiologists of differing skill levels may not have the same results. Thus, injection of a small volume of local anesthetic requires precision and vast experience with USG based techniques.

Conclusion

Ultrasound-guided popliteal-sciatic nerve block with 9.3 ml of 0.2% ropivacaine can provide satisfactory analgesia in 90% of patients undergoing unilateral below-knee surgeries. The volume injected is independent of the patient's age and weight. Visualizing the spread of the drug around the nerve after sub-paraneural injection was sufficient in assessing the quality of the block. There were no adverse effects noted from the procedure.

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Conflicts of interest
There are no conflicts of interest.

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