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Median effective volume of ropivacaine 0.5% for ultrasound-guided adductor canal block

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Abstract

Objective: This study aimed to identify the median effective volume of ropivacaine 0.5% for ultrasound-guided adductor canal block (ACB).

Methods: Thirty-two patients received ultrasound-guided ACB for knee arthroscopic meniscectomy. The criterion for successful ACB was the loss of pinprick sensation in the saphenous area (medial knee, leg, and foot). The volume of ropivacaine 0.5% in each case was determined using the up-down method and used for calculating the median effective dose.

Results: The mean age, weight, and height of patients were 28.6 ± 7.1 years, 68.2 ± 10.6 kg, and 172.5 ± 6.4 cm, respectively. Among patients who received 18- and 15-mL doses, ACB was successful in all four cases. Among patients who received a 12-mL dose, ACB was effective in eight and ineffective in two cases. Among patients who received a 10-mL dose, ACB was successful in six and unsuccessful in seven cases. In patients who received an 8-mL dose, ACB was ineffective in all five cases. The median effective volume of ropivacaine 0.5% was 10.4 mL (95% confidence interval, 9.1–11.4 mL). In all effective cases, the median quadriceps strength was grade 5.

Conclusions: The median effective volume of ropivacaine 0.5% is 10.4 mL for ultrasound-guided ACB.

Keywords

Adductor canal block, ropivacaine, saphenous nerve, ultrasonography, knee arthroscopic meniscectomy, effective dose, quadriceps femoris muscle

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Introduction

Adductor canal block (ACB) is typically used for treating pain after surgery of the inside lower leg and ankle.[1,2] Recently, ACB was shown to provide a similar degree of analgesia as femoral nerve block after total knee arthroplasty and additionally preserve muscle strength better than femoral nerve block.[3]

The saphenous nerve is the longest cutaneous branch of the femoral nerve. The saphenous nerve can be blocked by ACB without affecting use of the quadriceps femoris muscle. However, because the adductor canal runs in continuation of the femoral triangle, excess anesthetic volume can spread to the common femoral nerve. The ideal volume should provide saphenous nerve block, while avoiding femoral nerve block and adverse effects on quadriceps strength.[4] Patients usually receive ACB with ropivacaine 0.5% for arthroscopic knee surgery.[5,6] However, no studies have reported the median effective dose (ED_{50}) of ropivacaine 0.5% for this procedure. Therefore, this study aimed to investigate the median effective volume of ropivacaine 0.5% for ultrasound-guided ACB.

Materials and methods

Ethical approval

All study methods were approved by the Beijing Jishuitan Hospital Institutional Review Board. Written informed consent was obtained from all patients for being included in the study.

Recruitment

Thirty-two patients (American Society of Anesthesiologists grades I–II) aged 18 to 45 years, who underwent knee arthroscopic meniscectomy were enrolled in this study. The exclusion criteria were allergy to local anesthetics, coagulation abnormalities, ACB puncture point infection, diabetes, and peripheral neuropathies.

Anesthesia

Standard monitoring in the operating theater included electrocardiography, noninvasive measurement of arterial blood pressure, and pulse oximetry. All of the patients received 500 mL of Ringer's lactate solution intravenously before ACB and 5 L/minute oxygen through a mask during ACB. All of the patients received ultrasound-guided (SonoSite M-Turbo; Bothell, WA, USA) ACB with ropivacaine 0.5%. Briefly, the patients were placed in the supine position, with the leg slightly rotated out. A high-frequency ultrasound probe was placed on the anteromedial part of the thigh, halfway between the superior anterior iliac spine and patella.[7] The sartorius muscle, femoral artery, and adductor canal were identified (Figure 1). Using an in-plane technique, a 22-gauge Tuohy needle (B. Braun Medical, Melsungen, Germany) was inserted lateral to the ultrasound probe, through the sartorius muscle, until the tip of the needle was in a position lateral to the femoral artery. Ropivacaine (NAFG; AstraZeneca, Mölndal, Sweden) 0.5% was then injected (Figure 2).

Sensory and quadriceps strength assessment

Sensory block was evaluated after 30 minutes. The criterion for successful ACB was the absence of pinprick sensation in the saphenous area (medial knee, leg, and foot). According to the Dixon sequential allocation[8,9] and the result of a preliminary experiment, the initial dose of ropivacaine was set as 18 mL. Increases or decreases in the dose of ropivacaine were set at 1:1.2 on the basis of the response of the previous patient (effective or ineffective). The study was concluded when eight effective/ineffective

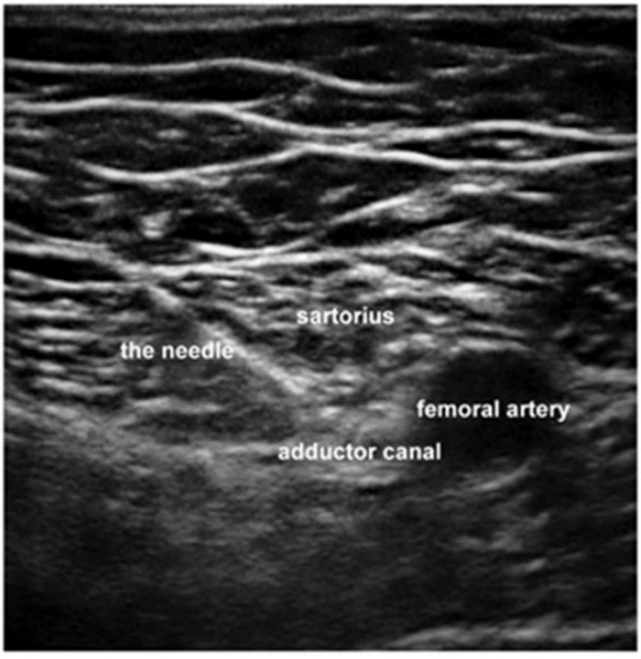

Figure 1. Ultrasound image of the adductor canal and puncturing needle.

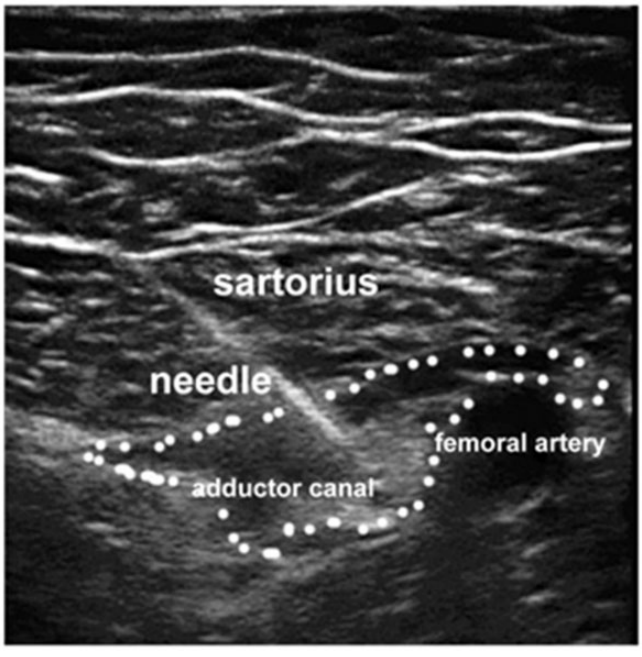

Figure 2. Ultrasound image of the site of ropivacaine injection (white dots).

crosses were observed. The quadriceps strength was assessed after 30 minutes. The following 5-grade scale was used to quantify quadriceps strength: 1 = could not contract; 2 = could contract, but the contraction could not cause the knee joint to move; 3 = could bear gravity, but could not bear any substantial resistance; 4 = could bear substantial resistance; and 5 = could bear full resistance.

Statistical analysis

Demographic data are expressed as number or mean ± standard deviation. ED_{50} values were determined using the method of Dixon and Massey.[10] Analyses were performed with SPSS 15.0 for Windows (SPSS, Chicago, IL, USA) and Excel 2003 (Microsoft Corporation, Redmond, WA, USA). The grades of quadriceps strength are expressed as median and quartile range (Q25–Q75).

Table 1. Participant demographic characteristics.

Characteristic	Value
Patients	32
Sex (M/F)	19/13
Age (years)	28.6 ± 7.1
Weight (kg)	68.2 ± 10.6
Height (cm)	172.5 ± 6.4

Data are expressed as number or mean ± standard deviation. M: male, F: female.

Results

Complete data were obtained for all 32 patients in this study. The patients' demographic data are shown in Table 1. The results of effective and ineffective blocks are shown in Figure 3. One patient received an 18-mL dose, three patients received 15 mL, 10 patients received 12 mL, 13 patients received 10 mL, and five patients received 8 mL. Among patients who received 18 and 15-mL doses, ACB was successful in all four cases. Among patients who received a 12-mL dose, ACB was effective in eight and ineffective in two cases. Among patients who received a 10-mL dose, ACB was successful in six and unsuccessful in seven cases. In patients who received an 8-mL dose, ACB was ineffective in all five cases. Accordingly, the ED_{50} of ropivacaine 0.5% for ultrasound-guided ACB was determined to be 10.4 mL (95% confidence interval, 9.1–11.4 mL).

In all effective cases, the median quadriceps strength was grade 5 (4–5). There were

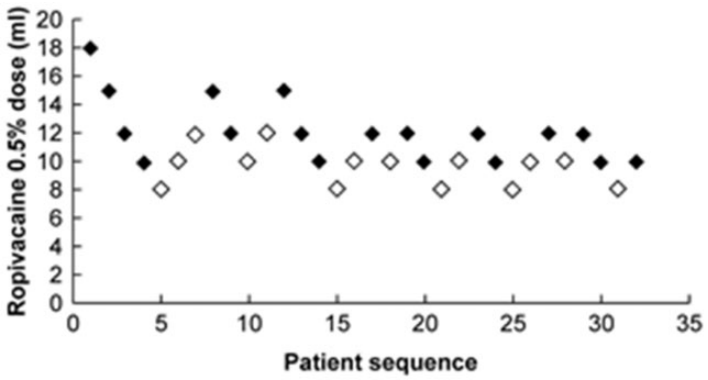

Figure 3. Sequential responses to effective (black) and ineffective (white) ropivacaine 0.5% doses by the up-down method.

no significant differences in quadriceps weakening in response to different volumes of local anesthetic in all effective cases.

Discussion

In this study, we investigated the median effective volume of ropivacaine 0.5% for ultrasound-guided ACB using up-down sequential analysis in patients who underwent knee arthroscopic meniscectomy. The up-down method, also known as the method of Dixon and Massey, is a simple and quick method for identifying ED_{50} values and is commonly used in anesthesia research.[8–10] The initial dose of ropivacaine used in this study was 18 mL and this dose was based on the results of a preliminary experiment. To the best of our knowledge, this is the first study to assess the median effective volume of ropivacaine 0.5% for ultrasound-guided ACB.

Ropivacaine is a widely used local anesthetic for regional anesthesia. Ropivacaine 0.5% provides the same extent of sensory block as ropivacaine 0.75%, with an appropriate block duration when used for regional anesthesia.[11,12] Therefore, the 0.5% formulation is not uncommon in clinical applications. Several clinical reports have described the use of ropivacaine ACB for postoperative analgesia after knee surgery and in combination with sciatic nerve block as an anesthetic technique for hind foot and ankle surgery.[13–15] Few studies have reported the use of ropivacaine 0.5% for ultrasound-guided ACB in arthroscopic knee surgery.[5,6,16]

In ACB, the saphenous nerve can be blocked by a 30-mL volume of local anesthetic to provide moderate postoperative pain relief after knee surgery.[17–20] Using dye injection, Andersen et al.[21] reported that a volume of 15 mL was sufficient to spread throughout and beyond the adductor canal (both proximally and distally) in cadaver lower limbs. In contrast, Jæger et al.[22] found that, for ACB, the dose closest to the ED_{95} of lidocaine 1% that was needed to fill the adductor canal distally was 20 mL. However, in their study, there was no significant correlation between ropivacaine volume and proximal spread or muscle strength. Moreover, Andersen et al.'s[21] study on cadavers was limited by reduced tissue elasticity of cadavers relative to living subjects, as well as potentially altered pressure conditions. This is because the femur was cut from the cadaver close to the apex of the femoral triangle. In another study, there was no significant difference in the effect of ACB with 10 mL versus 30 mL of ropivacaine 0.1%.[23] Ropivacaine 0.1% is rarely used in the clinical setting. For this reason, we needed to conclusively determine the ED_{50} of a higher concentration of ropivacaine in the present study.

In this study, the median quadriceps strength was 5 (4–5) in all effective cases. There were no significant differences in quadriceps weakening in response to different volumes of local anesthetic in all effective cases, which is similar to previous studies.[22,23]

In a previous study, 45% of patients who received ultrasound-guided ACB with 10 mL of ropivacaine 0.5% showed complete absence of pinprick sensation in the saphenous area at 30 minutes post-injection.[24] This result is consistent with our finding that the median effective volume of ropivacaine 0.5% for ultrasound-guided ACB was 10.4 mL.

Our study has some limitations. First, sensory block was evaluated by testing the loss of pinprick sensation. Therefore, variation in subjective evaluation among patients might have affected the accuracy of the results. Second, we did not evaluate the duration of ropivacaine 0.5% ACB because Jæger et al.[25] found that increasing the dose of lidocaine by a constant volume of 20 mL had no effect on ACB duration. Finally, to decrease the number of patients

who experienced an unsatisfactory blockade, for ethical concerns, we ended the study when eight effective/ineffective crosses were observed. Enrollment of additional subjects might have improved the accuracy of our ED_{50} assessment.

In conclusion, our study shows that the ED_{50} of ropivacaine 0.5% for ultrasound-guided ACB is 10.4 mL. This finding has practical utility in future surgical applications.

Declaration of conflicting interest

The authors declare that there is no conflict of interest.

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