Femoral Nerve Block Using 0.25% or 0.5% Bupivacaine for Analgesia after Arthroscopic Anterior Cruciate Ligament Reconstruction

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Background: *Femoral nerve block (FNB) with varying concentrations of bupivacaine is often used for postoperative analgesia after anterior cruciate ligament (ACL) reconstruction.*
Objective: *To determine whether FNB using 0.25% or 0.5% bupivacaine provided better analgesia with less effect on quadriceps strengths after ACL reconstruction.*
Material and Method: *One hundred patients were randomized to receive FNB with 20 mL of 0.25% or 0.5% bupivacaine. Data regarding demographic, effectiveness of FNB, time to first pain, time to first analgesic, pain scores, morphine use, and recovery of sensory and motor function were recorded.*
Results: *Median time to first morphine requirement was 12 hours in 0.5% bupivacaine group and 10 hours in 0.25% bupivacaine group (p = 0.048). Pain score at 18 hours was lower in 0.5% bupivacaine group compared with 0.25% bupivacaine group (p = 0.001). When specify to the patellar tendon graft subgroup, the patients requiring morphine were 70% in 0.5% bupivacaine group and 90% in 0.25% bupivacaine group (p = 0.03). No differences were found in demographic data, effectiveness of FNB, time to first pain, morphine consumption, and recovery of sensorimotor function.*
Conclusion: *FNB with 0.5% bupivacaine provided longer time to first analgesic and lower narcotic requirements after patellar tendon graft ACL reconstruction when compared to 0.25% bupivacaine. Both concentrations showed similar effect on quadriceps strengths.*

Keywords: *Femoral nerve block, 0.5% bupivacaine, 0.25% bupivacaine, Arthroscopic anterior cruciate ligament (ACL) reconstruction*

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Arthroscopic anterior cruciate ligament (ACL) reconstruction is a commonly performed procedure for ACL injuries due to this procedure leaves small surgical incisions and accelerates postoperative ACL rehabilitation. However, post arthroscopic pain remains significant. The approaches for postoperative pain control are quite varied. Several studies[1-6] have reported the effective analgesia provided by femoral nerve blocks (FNBs). However, FNBs have been used with varying types, concentrations, and amounts of local anesthetic. The results of these variations are equivocal[7,8]. Moreover, FNBs have effects on both sensory and motor nerves. The resulting quadriceps muscle weakness is of concern to patients and physicians and leads to delayed ambulation and rehabilitation[9-11]. Therefore, the prospective, randomized, double-blinded study was designed to determine whether 0.5% bupivacaine or 0.25% bupivacaine provided better analgesia with less effect on quadriceps muscle strengths.

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Material and Method

After Institutional Review Board approval and written informed consent, 100 American Society of Anesthesiologists (ASA) physical status I-II patients, aged 18 years or older, scheduled for elective arthroscopic ACL reconstruction were prospectively recruited into the study. Exclusion criteria included patient refusal of either spinal block or FNB, weight less than 50 kg, previous knee surgery, preexisting neurologic deficit, or allergy to local anesthetics or medications used in the protocol. Patients who had contraindication to regional anesthesia such as coagulopathy, local infection were also excluded. All patients were instructed preoperatively in the use of a

numeric rating scale (NRS) scores, in which 0 = "no pain" and 10 = the "worst pain you can imagine". In addition, they were asked to note the first time they feel pain and need the analgesic drug after surgery.

Patients were blinded, stratified according to graft type (patellar tendon or hamstring autografts), and allocated by block randomization generated by a random number table into two groups as follows: Group B2.5 received 0.25% bupivacaine and Group B5 received 0.5% bupivacaine. The sham block group was not designed because the ethics committee did not approve it. Allocation concealment was done by using opaque sealed envelopes that would not be open until the day of surgery. All patients were monitored with electrocardiography, non-invasive blood pressure, and pulse oximetry. Baseline sensory and motor examinations of the femoral nerve were obtained. After sedation with intravenous (IV) midazolam 2 mg and fentanyl 50 micrograms, FNBs were performed with 22-gauge 50-mm Stimuplex® insulated needles (B Braun, Melsungen, Germany) using a peripheral nerve stimulator guided technique and confirmed by the presence of quadriceps contractions at 0.30 to 0.50 mA. All blocks were performed by residents supervised by the staff anesthesiologists, who were unaware of the concentration of local anesthetic solution injected. After negative aspiration for blood, patients in each group received 20 ml of either 0.25% or 0.5% bupivacaine that prepared by one of the authors, who was not involved in further patient evaluation. The assessor who was not present during block placement, and was blinded to the injected concentration evaluated the effectiveness of FNBs at 5, 10, and 15 minutes after injection. Sensory block was assessed as a reduction of sensation to cold tested with the swab soaked with alcohol delivered anteriorly above the patella and compared with the same stimulation on the contralateral side[12]. Motor block was assessed as ability or inability to extend the affected leg against gravity with the hip passively flexed at 45 degrees compared with the contralateral leg[13]. After that, all patients received spinal anesthesia with 15 mg of 0.5% hyperbaric bupivacaine. Intraoperative sedation with an IV propofol infusion or midazolam was administered upon patient's request. Postoperative analgesia consisted of 500 mg oral acetaminophen every six hours starting at ward and 400 mg oral celecoxib once a day beginning the morning after surgery. Intravenous morphine 3 mg was given every three hours as needed for a NRS pain score 3 or above.

Data were collected by two assessors blinded to group assignment. Time from end of surgery to first pain and first requirement of morphine were noted. The NRS scores were obtained every six hours and cumulative doses of morphine were recorded at 12, 24, and 36 hours after surgery. A return of quadriceps strength and sensation were evaluated at 24 and 36 hours after FNBs. The occurrence of unwanted events, including paresthesia, dysesthesia, motor deficits, dizziness, nausea, vomiting, back pain, or urinary retention, was recorded.

A sample size of 50 in each group would provide 80% power to detect a difference in duration of analgesia means of four hours assuming that the common standard deviation is 7 with a 0.05 two-sided significance level[7]. PASW Statistics for windows version 18.0 (Chicago: SPSS Inc.) was used for statistical analysis. Discrete categorical data are presented as n (%); continuous data as mean ± SD. Differences in demographic, surgical, anesthetic, and postoperative data were tested by using independent t-test or Mann-Whitney U test for continuous data and chi-square test or Fisher's exact for categorical data. Cumulative morphine consumption was analyzed by Mann-Whitney U test and adjusted p-value with Bonferroni's method. Time to first morphine requirement was analyzed using log-rank test and Kaplan-Meier curve. Statistical significance was accepted at p-value of less than 0.05.

Results

One hundred patients were enrolled in the present study, with 50 patients in each group. No patient was excluded from the study. There were no significant differences between the groups with respect to sex, age, body mass index, ASA physical status classification, and the graft type used with or without meniscus repair (Table 1). Operation time, tourniquet time, and time to perform FNB did not differ significantly between the two groups. All patients received FNBs with similar minimal stimulating current for eliciting a quadriceps contraction. There were no statistically significant differences in the percentage of patients with decreased anterior thigh sensation and inability to extend knee at 5, 10, and 15 minutes after the FNBs were performed (Fig. 1). At 15 minutes, 90% of group B2.5 and 90% of group B5 patients had a sensory block (p = 1.00) whereas 75% of group B2.5 and 77% of group B5 patients had a motor block (p = 0.67). There were no complications associated with the FNBs.

Table 1. Patient characteristics and perioperative data

Variables	0.25% bupivacaine (n = 50)	0.5% bupivacaine (n = 50)	*p*-value
Sex: male	47 (94%)	47 (94%)	1.00
Age (year)	27.7±5.6	30.2±8.7	0.09
BMI (kilogram per square meter)	24.6±3.1	24.6±3.0	0.94
ASA physical status I	47 (94%)	48 (96%)	1.00
Graft			0.55
BPTB	39 (78%)	40 (80%)	
Hamstring	11 (22%)	10 (20%)	
Meniscus: repair	29 (58%)	30 (60%)	0.84
FNB time (minute)	4.0 (1, 20)	3.5 (1, 23)	0.65
MSC (milliampere)	0.4±0.1	0.4±0.1	0.13
Operation time (minute)	118.6±27.9	119.3±27.7	0.89
Tourniquet time (minute)	114.6±17.3	118.2±24.2	0.40
Cumulative MO requirement (milligram)			
12 hours	6 (0, 16)	3 (0, 15)	0.12[#]
24 hours	9 (0, 25)	6 (3, 21)	0.07[#]
36 hours	9 (3, 31)	6 (3, 21)	0.06[#]
48 hours	9 (3, 37)	6 (3, 21)	0.09[#]

BMI = body mass index; ASA = American Society of Anesthesiologists; BPTB = bone-patellar tendon-bone; FNB time = time to perform femoral nerve block; MSC = minimal stimulating current; MO = morphine
Data are presented as numbers (%), means ± SD or median (min, max)
[#] Mann-Whitney U test and adjusted *p*-value with Bonferroni's method = 0.05/4 = 0.0125

There was no significant difference between the groups for duration of analgesia. Median (95% confidence interval [CI]) time to first pain was eight hours (7.6-8.5) in group B2.5 and eight hours (7.3-8.7) in group B5 (p = 0.35). Fig. 2 showed significant difference in the time to first analgesic. Median (95% CI) time to first morphine requirement was 10 hours (9.1-10.9) in group B2.5 and 12 hours (10.3-13.7) in group B5 (p = 0.048). There were no significant differences in cumulative morphine consumption at any time in either group (Table 1). Eighty-six percent of the patients in group B2.5 and 74% of the patients in group B5 needed rescue

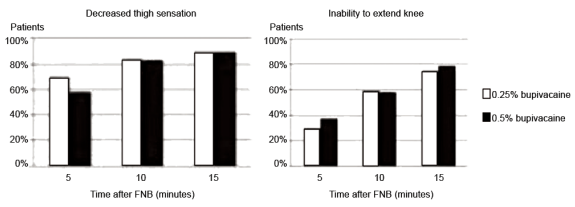

Fig. 1 The effectiveness of femoral nerve block (FNB). No differences were shown between the groups regarding to a reduction of sensation on anterior thigh and an inability to extend knee after FNBs at any time point.

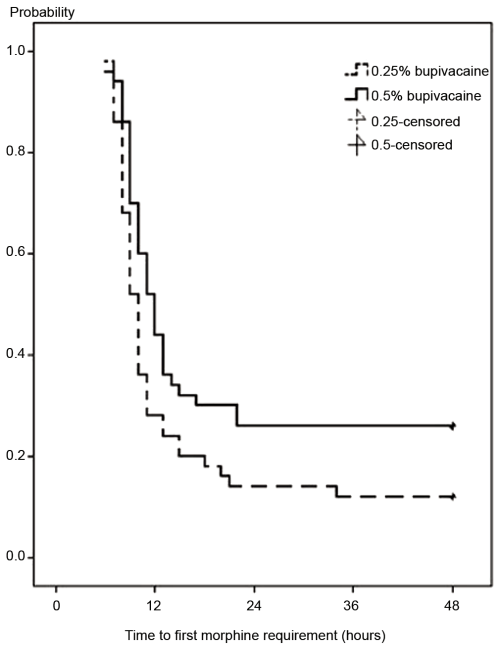

Fig. 2 Kaplan-Meier curve showing significant difference in the time to first analgesic. Median time to first morphine requirement was 12 hours in group 0.5% bupivacaine and 10 hours in group 0.25% bupivacaine (p = 0.048).

Table 2. Analgesic requirement based-on graft types

Variables	BPTB graft			Hamstring graft		
	B2.5 (n = 39)	B5 (n = 40)	*p*-value	B2.5 (n = 11)	B5 (n = 10)	*p*-value
Time to first MO (hour)	10 (9.1-10.9)	12 (9.9-14.1)	0.01*	10 (0.0-20.8)	11 (9.5-12.5)	0.58
Time to first pain (hour)	8 (7.6-8.4)	8 (7.2-8.8)	0.26	9 (7.4-10.6)	8 (7.1-8.9)	0.99
Patients requiring MO	35 (90%)	28 (70%)	0.03*	8 (73%)	9 (90%)	0.59
Cumulative MO requirement (mg)						
12 hour	3 (0, 9)	3 (0, 15)	0.42#	6 (0, 16)	3 (3, 6)	0.06#
24 hour	9 (0, 21)	6 (3, 21)	0.08#	10 (3, 25)	6 (3, 15)	0.35#
36 hour	9 (3, 30)	6 (3, 21)	0.04#	11.5 (3, 31)	9 (3, 18)	0.50#
48 hour	9 (3, 30)	6 (3, 21)	0.05#	11.5 (3, 37)	9 (3, 18)	0.59#

BPTB = bone-patellar tendon-bone; B2.5 = group 0.25% bupivacaine; B5 = group 0.5% bupivacaine; MO = morphine; mg = milligram

Data are presented as numbers (%), median (min, max), median (95% confidence interval lower–upper bound)

Adjusted *p*-value with Bonferroni's method = 0.05/4 = 0.0125

* Statistical significance, *p*-value <0.05

analgesics during 48 hours after surgery. Even though seven patients in group B2.5 as compared with 13 patients in group B5 did not need any morphine supplementation, there was no significant difference between both groups ($p = 0.13$). Further subgroup analysis for each surgical graft type (bone-patellar tendon-bone autograft [BPTB] or hamstring autograft) was performed to identify statistical significance. When specify to BPTB subgroup, the number of patients requiring morphine was significantly lower in group B5 than in group B2.5 (70% versus 90%, $p = 0.03$) (Table 2). In addition, median time to first morphine requirement was significantly longer in group B5 than in group B2.5 (12 hours versus 10 hours, $p = 0.01$). No significant differences were found in the time to first pain and amount of morphine used between the groups. For hamstring subgroup, no significant differences were found between the two groups.

Regarding NRS scores (Fig. 3), the only difference was at 18 hours postoperatively, with group B5 having a significantly lower score than group B2.5 ($p = 0.001$). The recovery of anterior thigh sensation and ability to extend knee were not different in both groups (Fig. 4). Group B2.5 and group B5 had similar incidence of nausea/vomiting (4% versus 12%), dizziness (4% versus 2%), back pain (2% versus 0%) and urinary retention (18% versus 24%). In addition, patient satisfaction was similar between the groups

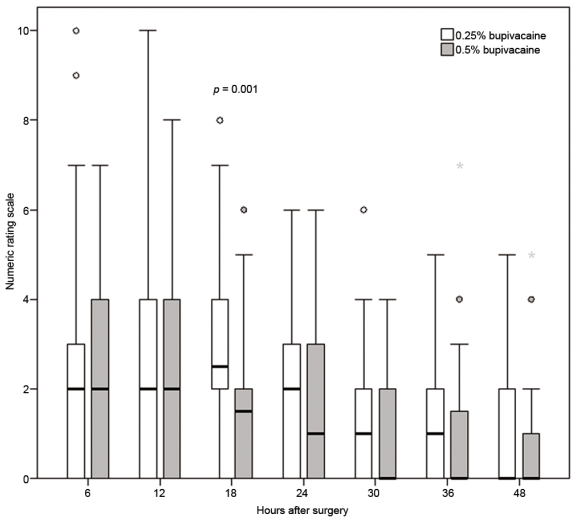

Fig. 3 Pain scores at different times after surgery. The numeric rating scale scores were significantly lower in group 0.5% bupivacaine than in group 0.25% bupivacaine only at 18 hours postoperatively ($p = 0.001$). Data are shown as median (horizontal bar) with 25th-75th (box) and 10th-90th (whiskers) percentiles, * extreme value, ° outlier.

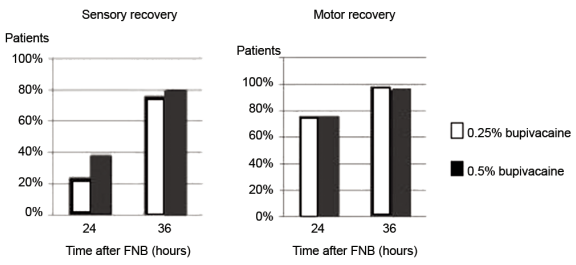

Fig. 4 The recovery of sensory and motor function. There were no differences between the groups in recovery of sensation on anterior thigh and quadriceps muscle strength. Muscle strength was assessed as ability to extend knee. FNB = femoral nerve block.

with 94% for group B2.5 and 100% for group B5. The length of hospital stay was three days (2, 4) for group B2.5 and three days (3, 6) for group B5.

Discussion

In the present study, FNB for arthroscopic ACL reconstruction with 0.5% bupivacaine significantly provided longer time to first morphine requirement than FNB with 0.25% bupivacaine. Although this may not be clinically significant because of a difference of only two hours, the study showed that FNB is effective in reducing additional parenteral narcotic required in the first 10 hours postoperatively. Regarding NRS scores, the only difference was at 18 hours after surgery, with group 0.5% bupivacaine having a significantly lower score than group 0.25% bupivacaine. Nonetheless, both groups had postoperative pain scores not more than 4 for the first 24 hours and not more than 2 during 24 to 48 hours. This finding suggested that FNB with bupivacaine reduces postoperative pain for the first 48 hours after arthroscopic ACL reconstruction. To clarify the result, subgroups for each surgical graft type comparisons were performed. For BPTB subgroup, FNB with 0.5% bupivacaine still provided longer time to first morphine requirement when compared to 0.25% bupivacaine. Furthermore, the number of patients receiving FNB with 0.5% bupivacaine requested supplementary morphine less than patients receiving FNB with 0.25% bupivacaine. On the contrary, the hamstring subgroup did not show any differences between the two concentrations used. This may be explained by the innervation distribution. The femoral nerve supplies the anterior thigh, anterior knee, and medial leg[14], whereas the sciatic nerve supplies the hamstring muscles[14]. However, the findings of the present study support use of a preoperative FNB for postoperative pain relief and using 0.5% bupivacaine tends to be superior to 0.25% bupivacaine for BPTB graft ACL reconstruction.

In contrast to the present study, Mulroy et al[7] compared the efficacy of FNB using placebo, 0.25% or 0.5% bupivacaine in patients undergoing ACL reconstruction. They found no differences in the pain scores, duration of analgesia and requests for pain medication between 0.25% and 0.5% bupivacaine. However, this study is difficult to compare because of variation in technique. In Mulroy's study, 50 mL of 0.25% bupivacaine was instilled into the knee joint at the beginning of surgery. When patients first began to perceive pain in the recovery room, either a sham FNB or an FNB with 25 mL of either 0.25% or 0.5% bupivacaine with 1:200,000 epinephrine was performed.

In addition to postoperative pain relief, recovery of motor function after knee surgery is another concerns. The femoral nerve supplies motor innervation to the sartorius, quadriceps femoris, and pectineus muscles[14]. Hence, FNB results in quadriceps weakness[9-11]. Prolonged quadriceps weakness is associated with functional disability, delayed ambulation and rehabilitation, increased risk of postoperative falls[15-17], and prolonged hospital stay. However, the present study found no difference between the groups regarding to the recovery of anterior thigh sensation and ability to extend knee. Noteworthy, other factors such as tourniquet induced nerve dysfunction and patient positioning during operation may affect motor strength postoperatively[6]. In addition, inadequate pain control may diminish the patient's cooperation to perform the test.

A limitation of the present study may be the measurements used. More reliability and validity measurements[10,11,18] may be used to discriminate the effects of FNB with the different concentrations of bupivacaine on degree of motor block. A second limitation was that the authors had no time to evaluate the effectiveness of FNBs until all patients had signs of a sensory or motor block before surgery.

In conclusion, FNB with 0.5% bupivacaine provided longer time to first analgesic and lower narcotic requirements after BPTB graft ACL reconstruction when compared to 0.25% bupivacaine. Both concentrations showed a similar effect on quadriceps strengths. Further studies are needed to seek the suitable techniques and drugs to provide postoperative pain relief while maintain quadriceps strengths.

What is already known on this topic?

ACL reconstruction is a painful surgery. Inadequate postoperative pain relief may delay recovery and rehabilitation. Femoral nerve block with various concentrations of bupivacaine has been shown to be safe and effective in pain control[1-3] but accompanies with temporary quadriceps muscle weakness[9-11].

What this study adds?

FNB with 0.5% bupivacaine provided longer time to first analgesic and lower narcotic requirements after BPTB graft ACL reconstruction when compared

to 0.25% bupivacaine. Both concentrations showed similar effect on quadriceps strengths.

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Potential conflicts of interest

None.

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การศึกษาผลการระงับปวดภายหลังการผ่าตัดส่องกล้องสร้าง anterior cruciate ligament เปรียบเทียบระหว่างการทำ femoral nerve block ด้วยยาชา bupivacaine 0.25% หรือ 0.5%

อริศรา เอี่ยมอรุณ, สุวิมล ต่างวิวัฒน์, บุศรา ศิริวันสาณฑ์, ปฐม ห์ลีละเมียร, ญาดา เลิศเพ็ญเมธา, สโรจน์ ศิริมะณีวัฒนา, สุดคนึง สุรเชษฐพงษ์, สุปราณี ปวงจันทร์

ภูมิหลัง: การระงับปวดภายหลังการผ่าตัดส่องกล้องสร้าง anterior cruciate ligament (ACL) นิยมทำ femoral nerve block (FNB) โดยใช้ยาชา bupivacaine ขนาดความเข้มข้นที่แตกต่างกัน

วัตถุประสงค์: การศึกษานี้ต้องการเปรียบเทียบระหว่างการทำ FNB โดยใช้ยาชา bupivacaine 0.25% หรือ 0.5% ว่ายาชา bupivacaine ความเข้มข้นขนาดใด ที่ให้ผลการระงับปวดได้ดีกว่า และมีผลต่อกำลังกล้ามเนื้อ quadriceps น้อยกว่า

วัสดุและวิธีการ: ผู้ป่วยจำนวน 100 ราย ที่มารับการผ่าตัดส่องกล้องสร้าง ACL จะถูกแบ่งออกเป็น 2 กลุ่มเท่า ๆ กัน ให้ได้รับการทำ FNB โดยใช้ยาชา bupivacaine 0.25% หรือ 0.5% จำนวน 20 มิลลิลิตร ข้อมูลผู้ป่วยจะถูกบันทึก เพื่อเปรียบเทียบประสิทธิภาพของการทำ FNB เวลาที่ปวดแผลครั้งแรก เวลาที่ขอยาระงับปวดครั้งแรก คะแนนความปวด จำนวนยามอร์ฟีนที่ใช้ทั้งหมด และกำลังของกล้ามเนื้อ quadriceps

ผลการศึกษา: ผู้ป่วยในกลุ่ม bupivacaine 0.5% ต้องการยาระงับปวดครั้งแรกที่เวลา 12 ชั่วโมงหลังผ่าตัด ในขณะที่ผู้ป่วยในกลุ่ม bupivacaine 0.25% ต้องการยาระงับปวดครั้งแรกที่เวลา 10 ชั่วโมงหลังผ่าตัด ($p = 0.048$) คะแนนความปวดแผลของผู้ป่วยในกลุ่ม bupivacaine 0.5% ที่เวลา 18 ชั่วโมงหลังผ่าตัด น้อยกว่ากลุ่ม bupivacaine 0.25% อย่างมีนัยสำคัญ ($p = 0.001$) เมื่อศึกษาในกลุ่มย่อยที่ใช้ patellar tendon graft มาสร้างเอ็นเส้นใหม่ พบว่าจำนวนผู้ป่วยในกลุ่ม bupivacaine 0.25% (90%) ต้องการยามอร์ฟีนเพื่อระงับปวดเพิ่มเติมมากกว่ากลุ่ม bupivacaine 0.5% (70%) อย่างมีนัยสำคัญ ($p = 0.03$) นอกจากนี้ไม่พบว่ามีความแตกต่างกันในลักษณะของประชากร ประสิทธิภาพของการทำ FNB เวลาที่ปวดแผลครั้งแรก จำนวนยามอร์ฟีนที่ใช้ทั้งหมด ความรู้สึกชาที่หลงเหลืออยู่ และการฟื้นตัวของกำลังกล้ามเนื้อ quadriceps

สรุป: การทำ FNB โดยใช้ยาชา bupivacaine 0.5% ให้ผลการระงับปวด ภายหลังการผ่าตัดส่องกล้องสร้าง ACL ด้วย patellar tendon graft นานกว่า ผู้ป่วยต้องการยาระงับปวดน้อยกว่า โดยมีผลต่อกำลังของกล้ามเนื้อ quadriceps ไม่แตกต่างกัน เมื่อเปรียบเทียบกับการใช้ยาชา bupivacaine 0.25%