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Original article

THE EFFECT OF PERIPHERAL NERVE BLOCKS ON QUADRICEPS MUSCLE STRENGHT IN KNEE LIGAMENTOPLASTY

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Abstract

Introduction: *Adequate pain control following ligamentoplasty, plays an important role in early mobilization of the patient. The aim of this study was to determine whether with the adductor canal block we can preserve quadriceps muscle strength better than with the femoral nerve block. Secondary end points were pain, additional analgesic request and patient satisfaction.* ***Methods:*** *In this controlled clinical trial, 80 ASA 1 or 2 patients for ligamentoplasty were divided in two groups. Group 1 received an adductor canal block for postoperative analgesia. Group 2 received femoral nerve block. As a rescue analgesic we used tramadol 100 mg. Following parameters were measured: mean dynamometer reading during knee extension at 6, 12 and 24 hours postoperatively as a percentage of the baseline measurement preoperatively, pain during rest at 6, 12 and 24 hours postoperatively, time of the first request of tramadol, the amount of tramadol requested for the first twelve hours and the second twelve hours (12–24 h) postoperatively and the satisfaction score.* ***Results:*** *A significant difference was found in the quadriceps muscle strength measurement at six and 12 hours postoperatively between the groups. There was not a significant difference in the pain scores, in the time of first request of tramadol and the amount requested, between the two groups. There was not a significant difference in the satisfaction score.* ***Conclusion:*** *With the adductor canal block we preserved quadriceps muscle strength better than femoral nerve block and achieved good postoperative analgesia noninferior to femoral nerve block.*

Keywords: *postoperative analgesia; adductor canal block; femoral nerve block; ligamentoplasty*

Introduction

One of the most frequently performed orthopedic operations is arthroscopically assisted anterior cruciate ligament reconstruction (ACLR)[1]. Adequate postoperative pain control with an effective analgesic regiment is needed in order to do this operation as an outpatient procedure[2], but also if the patient stays overnight. So far femoral nerve block (FNB) has proven to be an effective analgesic technique for outpatient and inpatient anterior cruciate ligament reconstruction. However, this block leads to quadriceps muscle weakness[3,4] which results in functional impairment and is associated with an increased risk of falling postoperatively[5–7]. There were few attempts to reduce muscle weakening with femoral nerve block, but they have not been successful[8–10]. Adductor canal block (ACB) is predominantly a sensory block[11] and therefore saves quadriceps muscle strength and ambulation ability. That is why this block is becoming an alternative to FNB for postoperative analgesia in total knee arthroplasty[11], providing a pain relief to the knee that is comparable to FNB, while preserving the strength of the quadriceps femoris muscle[12,13]. Although both of them are knee operations, there are differences in pain between knee arthroplasty and ACLR[2,14]. Also our knowledge of the anatomy of the adductor canal that is relevant to ACLR is still limited[15]. There are few trials that include the ACB in ACLR in their reaserch[16,17], but these studies have some methodological shortcomings. Therefore, the benefits of ACB in the setting of ACLR remains unanswered.
The primary aim of this study was to examine whether ACB can preserve quadriceps motor

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strength better than the FNB. The secondary aims were measurements concerning postoperative analgesia – pain, time of the first request of additional analgesia, amount of additional analgesic requested and satisfaction score.

Methodology

This study was performed in City General Hospital „8-mi Septemvri" Skopje, Macedonia. The study was approved by the ethics hospital committee. The study was in accordance with the Consolidated Standards of Reporting Trials (CONSORT) guidelines[18,19] and the CONSORT extension for no inferiority trials[20]. It was a randomized, controlled, interventional, one side blinded study which included 80 patients, males and females, planned for ACLR operation. Using the results from an unpublished pilot study suggested that anticipated means with type α error of 0.05, enrollment ratio 1 and with a power of 85% will need a sample size of 22. To compensate for dropouts and other uncertainties we planned for the inclusion of 40 patients per group. The inclusion criteria were age 18–50 years, ASA (American Society of Anesthesiologist) 1 or 2 score and primary ACLR operation. The exclusion criteria were secondary ligamentoplasty, chronic analgesics use, allergy to local anesthetic, ketoprofen and tramadol, and contraindication for peripheral nerve block.

After the general preoperative orthopedic and anesthesiology examination was done, the patients were informed about this study and were asked to sign an informed consent if they agreed to participate. An investigator generated a list of random numbers, using an online computer randomization service (www.Randomization.com). A randomization code was used to randomize consenting study participants to either of the two study groups: ACB group or FNB group. This was put in a sealed opaque envelopes and kept with the coordinator. On the day of surgery, he handed it to the attending anesthesiologist before administering the study block to the participant. The attending anesthesiologist had no further role in the study.

The procedure started in the preoperative room where the nurse monitored basic hemodynamic parameters of the patients and inserted an i.v. line. If the patient was in the femoral nerve block group, he received a femoral nerve block preoperatively. Midazolam 1–2 mg was given as a premedication. The block was done on the patient in the supine position. The orientation marks were the inguinal ligament and the pulsation of the femoral artery. The place was cleaned with chlorhexidine and then the nerve was found with an ultrasound image with M-Turbo Sonosite ultrasound machine and linear probe 6–13 MHz. After identification of the nerve, artery, vein and two muscle fascias (fascia lata and fascia iliaca) we injected levobupivacaine 0.5% 30 ml with a Stimuplex D needle 50 mm, 22 G (B. Braun, Melsungen, Germany) in close proximity of the femoral nerve.

If the patient was in the adductor canal block group, he received block preoperatively. Midazolam 1–2 mg was given as a premedication. The block was done with the patient in the supine position. The medial aspect of the midtigh was cleaned with Chlorhexidine and then the nerve was localized with an ultrasound image with M-Turbo Sonosite ultrasound machine and linear probe 6–13 MHz. This ACB location has been found not to interfere with the innervation of the quadriceps muscle[4,21–23], sartorius muscle, the femoral artery and vein were identified. The saphenous branch of the femoral nerve is usually located within the triangular space formed by the sartorius muscle superiorly, the vastus medialis laterally, and the adductor muscles medially[24]. The ACB was performed using a 5-cm or 10-cm 22-gauge insulated needle (B. Braun Melsungen, Germany) inserted in plane with the ultrasound probe from lateral to medial until the needle tip was close to the femoral artery, and 30 ml levobupivacaine 0.5% was injected between the femoral artery and the sartorius muscle after negative aspiration every 5 ml[25].

The blinded research coordinator performed an assessment of the sensory and motor blockade before and after the block. He was not aware of which block was performed and his area of investigation (knee area and medial part of the calf) was separate of the area of the blocks (inguinal area and mid femoral area). Sensory assessment was performed every 5 min using a alcohol cold gauze applied to the sensory distribution of the saphenous nerve from medial aspect of the knee to the medial mid-calf in comparison to the nonoperative limb. It was graded on a 3-point scale, where a score of 2 was given for intact sensation, 1 for loss of sensation to pinprick, and 0 for loss of sensation to light

touch. A block was considered successful if complete loss of sensation was achieved within 30 min from the end of local anesthetic injection. If we did not have a block success after 30 min, we reported a block failure.

For measuring muscle strength, a handheld dynamometer (HHD; Lafayette Instrument, Lafayette, Indiana) was used. The HHD is considered a reliable and valid instrument[26], with standardized procedures to get valid measurements[27]. For quadriceps muscle strength evaluation, the patient was placed in a seated position with the knees flexed 60 degrees[28]. It has been recommended to fix the HHD for quadriceps evaluation[29]. A nonelastic strap was used. The strap was attached to a chair and around the subject's ankle, perpendicular to the lower leg. The HHD was placed under the strap, on the anterior surface of the tibia, 5 cm above the transmalleolar axis. Muscle strength was assessed as maximum voluntary isometric contraction (MVIC). Subjects were shown the procedure before outcome assessments. We instructed the subjects to take 2 seconds to reach maximum effort, maintain this force for 3 seconds, and then relax. A verbal command was given during the testing: „push-push-push-pause". For each assessment, the subjects performed 3 consecutive contractions, separated by a 30-second pause between each one. We used the mean value at each time point for calculations, and calculated muscle strength as percent of baseline value. The first measurement was taken before the block was applied and was used as a baseline for the after block measurements.

All patients from both groups were taken to the operating room after block assessment, where standard monitoring was applied. Patients were then administered general anesthesia with propofol 2 mg/kg i.v. and fentanyl 1 to 3 μg/kg i.v, followed by insertion of a laryngeal mask airway. Patients were mechanically ventilated using a 50:50 oxygen: air mixture with sevoflurane 1.5 to 2 vol%. Supplemental analgesia was provided as needed in the form of fentanyl 1 to 2 μg/kg i.v. if the heart rate and/or mean arterial pressure increased by 20% above the measured baseline. For postoperative nausea and vomiting prophylaxis we used ondansetron 4 mg, metoclopramide 10 mg, and ranitidine 50 mg i.v, 30 min before the end of the case and also ketoprofen 100 mg i.v.

Postoperatively, patients were taken to the post anesthesia care unit and were discharged to the ward once they met the discharge criteria. Pain was defined with a Visual Analog Scale (VAS 100-mm scale, where 0 = no pain and 100 = the worst pain). If the patient had a pain severity score 30 mm or greater at rest, patient was treated with tramadol 100 mg i.v.

MVIC was measured during knee extension of the operative limb at 6, 12, and 24 hours postoperatively as a percentage of the baseline measurement preoperatively. The analgesic outcomes include the time (hours) to first analgesic request; postoperative pain severity at rest VAS scores (millimeters) at 6, 12 and 24 h; postoperative analgesic consumption during the first 12 and second 12 (12–24) hours. Patient satisfaction with analgesia was measured on a VAS (100-mm scale, where 0 = the least satisfied and 100 = the most satisfied) at 24 h postoperatively. Incidence of postoperative neurologic symptoms (persistent numbness or paresthesia, weakness, or nonsurgical pain in the operative extremity) were measured at 7 days postoperatively.

Statistical analysis

The results obtained were statistically processed with the statistical program SPSS program version 23 (IBM SPSS, INC., Chicago, Illinois, USA) for Windows 8. The differences for the continuous variables were analyzed with the Student t test for parametric data. The categorical variables were presented as number (percentage) and compared with a Chi square test. The p value < 0.05 has been taken as statistically significant.

Results

120 patients were assessed for eligibility, of which 38 did not meet the inclusion criteria and 2 patients went home on the day of the surgery. Block success was confirmed in all participants. Patients who were enrolled had similar demographic characteristics with no clinically important differences between the groups (Table 1).

Both groups start from similar quadriceps femoris baseline strength, but the second measurement at 6 hours post block shows a great difference in

reduction of quadriceps muscle strength (Table 2). The ACB group has 21.12% reduction and the FNB group has 70.8% reduction which is a high statistical significance ($p < 0.001$). The same results appeared at 12 hours post block. As the blocks wore off, this difference disappeared at 24 hours and the results for both groups were almost similar.

Figure 2 shows the distribution of patients according to VAS during rest at 6 h, 12 h and 24 h postoperatively. In the first measurement time 6 hours postoperatively, the mean VAS for rest was 11.2 ± 6.31 mm for ACB group and 12.68 ± 9.15 mm for FNB group ($p = 0.21$). In the second measurement time 12 hours postoperatively, the mean VAS for rest was 25.5 ± 13.45 mm for ACB group and 23.88 ± 13.20 mm for FNB group ($p = 0.12$). In the third measurement time 24 hours postoperatively, the mean VAS for rest was 28.88 ± 10.09 mm for ACB group and 30.63 ± 9.37 mm for FNB group ($p = 0.21$). The patients in the adductor canal block group had a noninferior analgesia during rest, in all three measurment times, compared to the group with femoral nerve block.

There was no difference in the time when the patients were given the first rescue analgetic tramadol ($p = 0.49$) (Table 3). Also there is no difference in the total amount of rescue analgetic tramadol during the first 12 hours and the second 12 hours (12–24 h) (Table 3). In the first 12 hours there is not any difference between the groups ($p = 1$) and in the second 12 hours the persentage of patients who requested rescue analgesia medication is nearly the same, 22% ACB group and 25% FNB group (Table 4). There is not a statistical significance ($p = 0.28$) in satisfaction score, between the groups (Table 5). Both groups have similar block procedure time, it takes 3.8 min for ACB and 3.25 min for FNB. Block procedural pain is little higher in ACB, 1.875, compared to 1.45 for FNB.

There was not any incidence of falls or near falls in the first 24 hours and also, we did not see any postoperative neurologic symptoms (paresthesia, weakness, numbness or pain) at 7 days postoperative when the patients came for a checkup.

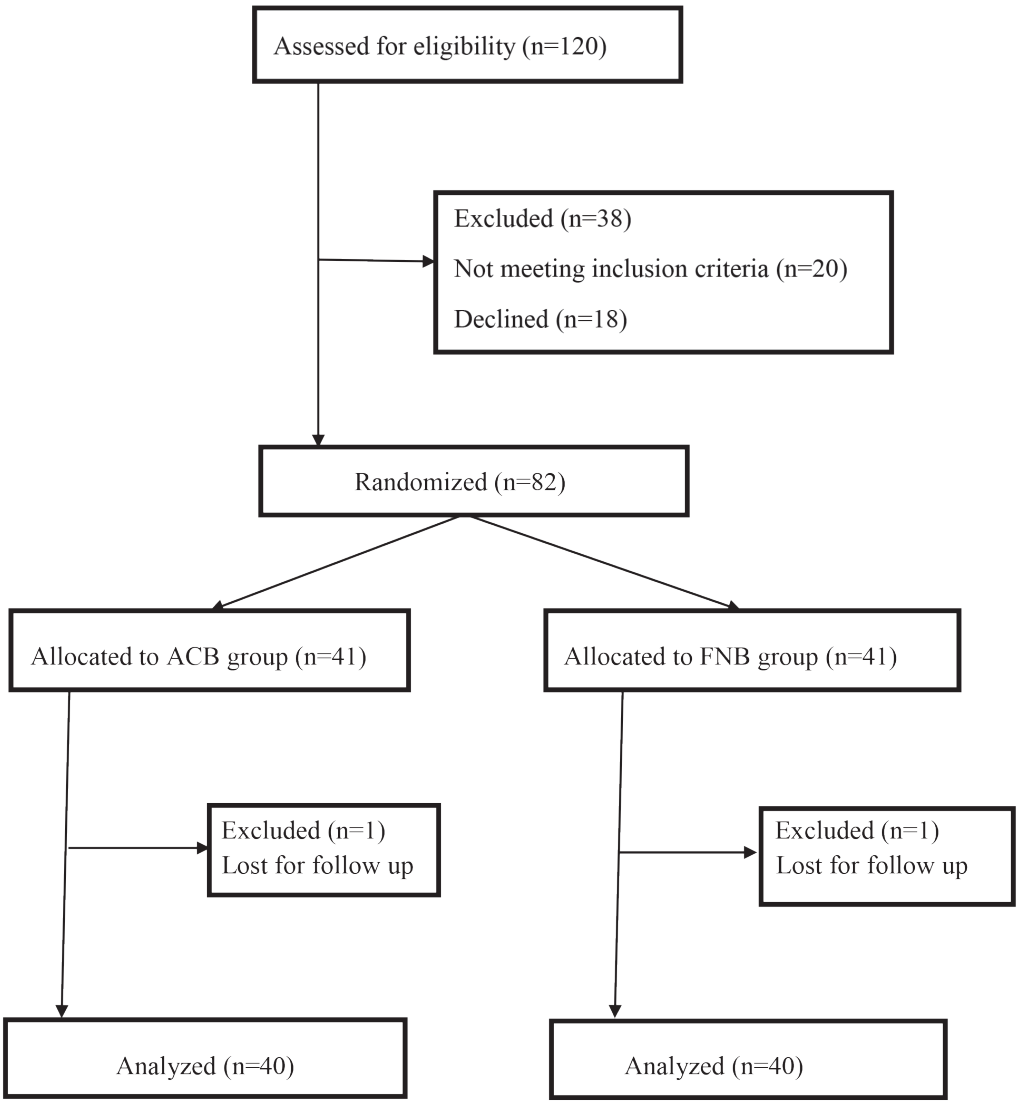
Discussion

Based on our results ACB is a better analgesic alternative than FNB, it provides postoperative analgesia as effective as FNB. Additionally, ACB preserves quadriceps muscle strength better than FNB. All the findings that address the analgesia, VAS pain score scale, first time of tramadol application and the amount of tramadol are nearly the same for both blocks, but the dynamometer results are in favor of ACB.

Three studies have previously attempted to explore the potential role of ACB in ACL settings[16,17,21]. Two trials performed the blocks after surgery under general anesthesia, but did not asses the success of the block and objective assessment of quadriceps muscle strength. In the study of Espelund et al[16]. ACB was compared to placebo and they found no analgesic benefits. However, recorded pain severity scores were unusually low and were different compared to the findings of other trials. In the second trial[17], patients in the ACB group had significantly higher VAS score, but milder quadriceps weakness than those in FNB group. Again, no post assessment of the block was done. Abdallah et al[31] showed a noninferior analgesia with the ACB compared to FNB postoperatively, but their assessment of quadriceps strength was limited to preoperative and no postoperative assessment. One study[32] showed that both blocks had a comparable postoperative analgesia after ACL reconstruction.

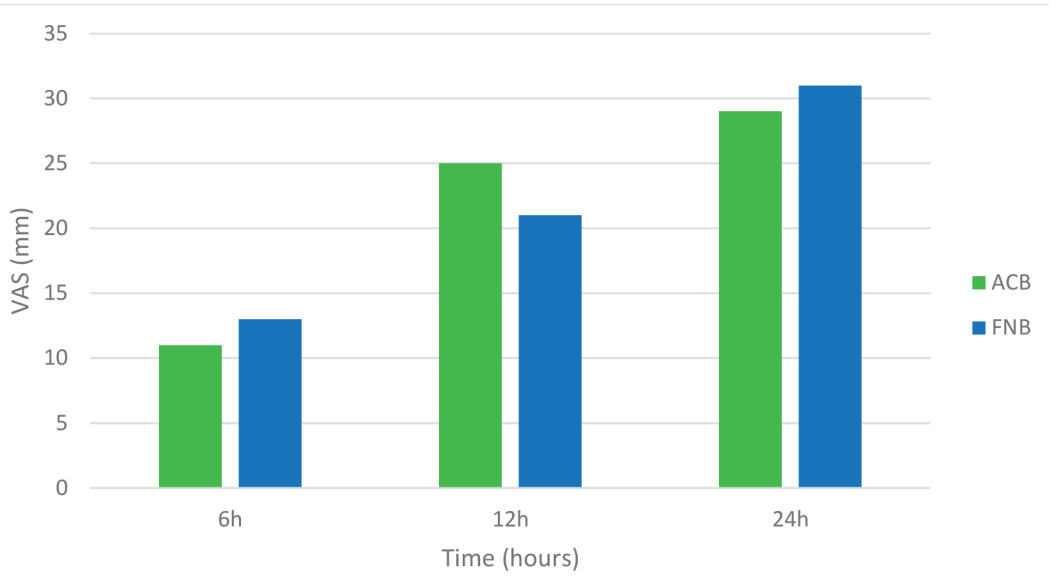
Our study has several limitations. First 30 ml of local anesthetic was applied in the adductor canal. Davis and colleagues[33] found that 30 ml of local anesthetic injected into the adductor canal spreads proximally to the anterior and posterior divisions of the femoral nerve outside the canal. Although reducing the volume for bolus injection might spare the muscle strength, we did not see a great reduction, only 21% from baseline, which is less than the studies with ACB and total knee replacement (TKR)[22]. Although they are both knee operations, the TKR is a much extensive one and effects the strength of the muscles more than ACLR does. Tramadol was used as a rescue medication as a weak opioid used routinly in our practise. Several medications are used as rescue medication for ACLR including morphine, oxycodone, and antiinflamatory drugs[34–37]. The criteria for tramadol request in this study was moderate to severe pain intensity (VAS > 30 mm)[38]. In several cases, patients had pain grater than 30 mm, but chose not to request tramadol, despite preoperative instruction that they should ask

Figure 1: Flow diagram of patient distribution



ASA – American society of anesthesiologists; ACB – Adductor canal block; FNB – Femoral nerve block

Figure 2: Distribution of pain according to VAS presented as median during rest at 6 h, 12h and 24 h postoperatively



ACB – adductor canal block; FNB – Femoral nerve block; VAS – Visual analogue scale

Table 1: Patient characteristics. Values are reported as number of subjects or mean (95% CI).

Parameters	**Adductor canal block (n = 40)**	**Femoral nerve block (n = 40)**
Age	31.5 (18–45)	33.5 (18–49)
Sex F/M	10/30	9/31
ASA I/II	35/5	32/8
Weight (kg)	81 (61–101)	78.5 (65–92)
Height (cm)	176 (163–189)	172 (163–180)
BMI (kg/m^2)	26.1 (18.5–30.1)	26.4 (19.7–29.2)
Duration of surgery (min)	113 (95–130)	114 (100–125)

F – female; M – male; ASA – American society of anesthesiologists; BMI – Body mass index

Table 2: Measurment of the quadriceps motor strength as maximal voluntary isometric contraction (MVIC) in kg-force

	ACB	**Reduction%**	**FNB**	**Reduction%**	**p value**
Baseline measurement	15.34 ± 1.74		15.38 ± 1.81		0.46
6 hours	12.1 ± 1.36	↓21.12	4.49 ± 1.01	↓70.8	< 0.001*
12 hours	12.65 ± 1.54	↓17.5	4.81 ± 1.07	↓68.72	< 0.001*
24 hours	13.37 ± 1.42	↓12.78	13.39 ± 2.06	↓12.9	0.78

ACB – adductor canal block; FNB – Femoral nerve block; *p < 0.05

Table 3: Time expressed in hours of the first given tramadol

Group	Descriptive Statistics (time of the first given tramadol)		
	mean ± SD (hours)	min – max (hours)	p value
ACB (n = 40)	15.88 ± 4.94	10–23	0.49
FNB (n = 40)	15.9 ± 4.42	7–23	

ACB – Adductor canal block; FNB – Femoral nerve block; p < 0.05

Table 4: Total amount of tramadol given in the first 12 hours and second 12 hours (12–24h)

Time of measurement		ACB (n = 40)	FNB (n = 40)	p value
First 12 hours	0 mg n = 68	34 (85%)	34 (85%)	1
	100 mg n = 12	6 (15%)	6 (15%)	
Second 12 hours (12–24 h)	0 mg n = 33	18 (45%)	15 (37.5%)	0.49
	100 mg n = 47	22 (55%)	25 (62.5%)	

ACB – Adductor canal block; FNB – Femoral nerve block; p < 0.05

Table 5: Satisfaction score

Group	Descriptive Statistics (satisfaction score)		
	mean ± SD (mm)	min – max (mm)	p-value
ACB (n = 40)	86.5 ± 12.81	50–100	0.28
FNB (n = 40)	88.12 ± 12.53	60–100	

ACB – Adductor canal block; FNB – Femoral nerve block

for it. The reasons were that pain is normal after surgery and they were afraid of opioid addiction.

Nausea and vomiting were the only side effects we recorded in this study, two episodes in pateints in FNB group and three episodes in patients in ACB group. They were all associated with tramadol administration and were easily managed. We did not had any falls due to motor paralysis, because we advised all the patients not to walk without an escort and always with the support of crutches. No patient in this study had transient or permenant neuroplegia.

The data we analyzed was for the first 24 hours, it would be interesting to follow these patients for the next few days, but also for the full recovery process. The rescue analgetic we used, interfered with the real pain score results, but we can not let the patient feel pain in order to obtain results that were not altered by analgesic use. Also the proportion of males was much higher then females, due to the sports injury of anterior cruciate ligament.

Conclusion

Adductor canal block preserved quadriceps muscle strength better than femoral nerve block, without statistically or clinically significant inferiority in pain relief. Further studies are needed to asses the effect of the blocks in the early postoperative period and in the full recovary process.

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