

Evaluation of the Adductor Canal Block for Postoperative Pain Control and Early Functional Recovery in Arthroscopic Knee Surgery: A systematic Review and Meta-analysis of Randomized Trials

^{1,2}Ashraf Elazab*, ¹Abdalla Al-zahrani, ^{1,2}Makram Radwan, ³Ahmed Salama, and ¹Ahmed Abd-elhady

¹Department of Orthopaedic Surgery, Dammam Medical Complex Hospital, Saudi Arabia

²Department of Orthopaedic Surgery, Zagazig University Hospital, College of Medicine, zagazig University, Egypt

³Department of Orthopaedic Surgery, Banha University Hospital, College of Medicine, Banha University, Egypt

Submission: November 05, 2015; **Published:** November 24, 2015

***Corresponding author:** Ashraf Elazab, Department of Orthopaedic Surgery, Dammam Medical Complex Hospital, King Khalid Street, Dammam, Eastern Province, Saudi Arabia, Tel: +966-54-618-4935; Tel: +2-050-654-2520; Emails: montocristo2003@yahoo.com; aalazab@moh.gov.sa

Abstract

Introduction: The purpose of this study was to evaluate the adductor canal block (ACB) in arthroscopic knee surgery and to evaluate its effect on postoperative pain score, opioid consumption, and quadriceps muscle power.

Methods: Randomized controlled trials (RCTs) which compared ACB with placebo or other anesthetic techniques in arthroscopic knee surgery until 30 September 2015 were identified in the databases. Ten studies were eligible according to our selection criteria. Outcomes including pain score with rest and activity, opioid consumption and quadriceps muscle power were extracted from selected studies and it were analyzed.

Results: A Total of ten RCTs with 661 patients were enrolled in this study. Systematic review and meta-analysis showed that ACB lowered the visual analogue pain score (VAS) significantly at rest and activity within 24 hours postoperatively more than placebo. However, both total opioid consumption within 24 hours postoperatively and quadriceps muscle strength showed no statistical difference between groups.

Conclusion: The ACB in arthroscopic knee surgery could achieve the goals of postoperative pain control and quadriceps muscle power preservation which are essentials for early functional recovery. However, more RCTs may be needed to confirm the efficacy of the ACB and the possibility to replace the femoral nerve block for postoperative pain control in the arthroscopic knee procedures.

Keywords: Adductor Canal Block; Saphenous nerve block; Subsartorial nerve block; Knee arthroscopy; Postoperative analgesia; Quadriceps muscle; Meta-analysis; Randomized controlled trials

Abbreviations: FNB: Femoral Nerve Block; ACB: Adductor Canal Block; VAS: Visual Analogue Scale; NRS: Numerical Rating Scale; MD: Mean Difference; ACLR: Anterior Cruciate Ligament Reconstruction

Introduction

Rehabilitation and early mobilization are essential for successful knee arthroscopic surgery. Uncontrolled pain can lead to slowed mobilization and delayed rehabilitation. However, effective postoperative pain control has been correlated with improved patient satisfaction, better short term outcomes, and decreased length of hospital stay [1-4].

Numerous analgesia techniques were introduced aiming to minimize systemic narcotic usage which could reduce the incidence of known adverse reactions including tiredness, nausea, respiratory depression, decreased intestinal motility and urinary retention [5]. Continuous epidural analgesia has been widely applied in clinical practice and it has definite effectiveness, and few systemic side effects. However, this procedure still cause hypotension, intestinal obstruction, urinary retention, motor

block, and walk limitation [6]. Femoral nerve block (FNB) was introduced, even though its analgesic effect was comparable to the epidural technique and has a lower incidence of opioid-related side effects [7,8]. However, unpleasant numbness and decreased quadriceps function frequently occur [5,9,10].

The saphenous nerve is the terminal sensory branch of the femoral nerve. It provides innervations to the skin overlying the medial, anteromedial, and posteromedial parts of the lower leg [11]. Development of ultrasound now allowed saphenous nerve block in the anteromedial thigh with very high success rates [12]. Recent studies [13-16] demonstrated the superiority of the ACB in preserving quadriceps muscle strength and thereby early mobilization compared to FNB and epidural technique. Therefore, adductor canal block (ACB) has been successfully used recently for postoperative pain control after knee surgery [3,13].

Achieving pain control and quadriceps muscle power preservation is challenging for patient satisfaction, rapid rehabilitation, and decreasing the hospital length of stay. Our aim in this study was to evaluate the effect of the ACB on postoperative pain control, opioid consumption, and quadriceps muscle power in the arthroscopic knee surgery.

Materials and Methods

Search methods

We searched the databases including PubMed, Cochrane library, Web of Science, Embase, and reference lists of included studies using the following terms: (adductor canal block, saphenous nerve block, Subsartorial nerve block, knee arthroscopy, arthroscopic knee surgery, meniscectomy, and anterior cruciate ligament). RCTs were identified until the date of last research on 30 September 2015.

Selection criteria

The inclusion criteria were RCTs which compared the analgesic effect of ACB with saline injection as a placebo in the arthroscopic knee surgery procedures. Andersen HL et al. [17] stated that ACB was equivalent to the midhigh saphenous nerve block; therefore studies compared the saphenous nerve block with placebo were included. We also added studies compared ACB with FNB in the arthroscopic knee surgery. Outcomes included pain score with rest and activity, opioid consumption and quadriceps muscle power.

The pre-specified criteria were used to select the eligible studies by two reviewers (Elazab. A, Al-zahrani. A). Any disagreement between the two reviewers about the selected

studies was resolved by consulting a third reviewer (Radwan. M).

Data extraction

Data regarding the publishing date, location of the study, patient characteristics, intervention and outcomes were extracted. The postoperative pain intensity was measured by 10 points visual analogue scale (VAS) at rest and at active knee flexion during the 1st post-operative 24 hours. When a numerical rating scale (NRS) score was used, it was converted to a VAS score. Data in other forms (i.e. median, interquartile range, and mean \pm 95% CI) were converted to mean \pm SD according to Cochrane Handbook [18]. Third outcome including postoperative opioid consumption; and fourth outcome including the quadriceps muscle strength.

Study quality

Risk of bias of included studies were assessed independently by two reviewers, with the following items: random sequence generation, allocation concealment, blinding, incomplete outcome data, selective outcome reporting and other sources of bias [18]. Disagreement was resolved by consulting a third reviewer (Table 1 & 2).

Statistical Analysis

Review Manager Software (Revman 5.3, Cochrane Collaboration, Oxford, United Kingdom) was used for the meta-analysis. The continuous variable outcomes VAS pain scores at rest within the 1st post-operative 24 hours, VAS pain scores with active flexion of the knee within the 1st post-operative 24 hours, and opioid usage within the 1st post-operative 24 hours for meta-analysis were presented as mean difference (MD) and with 95 % confidence interval (95 % CI), Heterogeneity among studies was estimated using I^2 statistic and substantial heterogeneity was represented by an I^2 value greater than 50%. In the presence of significant heterogeneity, we used a random effect model; otherwise, we used a fixed effect model. P values less than 0.05 were considered statistically significant ($P < 0.05$).

Results

Search results and Description of Studies

Among initially identified 58 articles that were searched in the databases, 33 duplicates were excluded by using endnote program and 13 citations were excluded after screening the titles and abstracts. After reading full texts, 2 citations, which did not fulfill inclusion criteria, were excluded. Ten studies with 661 patients fulfilled the inclusion criteria and were included in the analysis [1-4,12,19-23](Figure 1).

Table 1: Characteristics of the included studies.

Study	Settings	Patients no.	Anesthesia	Type of surgery	ACB group	Control group	Nerve block time
Akkaya et al. [3]	Turkey	40(20/20)	General anesthesia	Meniscectomy	Saphenous nerve block with 10 ml of 0.5% levobupivacaine	Saphenous nerve block with saline	preoperative
Chisholm et al. [12]	USA	80(39/41)	Spinal anesthesia	ACLR	Saphenous nerve block with 10 ml of 0.5% bupivacaine	Femoral nerve block with 30 ml of 0.25% bupivacaine	preoperative
El-Ahl [23]	UAE	128(64/64)	General anesthesia	ACLR	5% Saphenous nerve block with 15 ml of ropivacaine	Femoral nerve block 15 ml of ropivacaine 5%	postoperative
Espelund et al. [21]	Denmark	50(25/25)	General anesthesia	ACLR	Adductor canal block with 30 ml ropivacaine 7.5 mg/ml	Adductor canal block with 0.9% saline	postoperative
Espelund et al. [20, 22]	Denmark	72 (36/36)	General anesthesia	Minor arthroscopic knee surgery	Adductor canal block with 30 ml ropivacaine 7.5 mg/ml	Adductor canal block with 30 ml 30 ml isotonic saline	postoperative
Espelund et al. S. pain. [22]	Denmark	50(25/25)	General anesthesia	Severe pain after arthroscopic knee surgery	Adductor canal block with 30 ml ropivacaine 7.5 mg/ml	Adductor canal block with 30 ml 30 ml isotonic saline	postoperative
Hanson et al. [2]	USA	50(25/25)	General anesthesia	Medial meniscectomy	Adductor canal block with 15 mL ropivacaine 0.5%	Sham subcutaneous injection of sterile saline	Preoperative
Hsu et al. [4]	USA	68(34/34)	General anesthesia	Meniscectomy, M. repair, synovial debridement, microfracture	Infrapatellar branch of the saphenous nerve block with 10 ml 0.25% bupivacaine	Infrapatellar branch of the saphenous nerve block with 10 ml isotonic saline	Preoperative
Westergaard et al. [19]	Denmark	59(29/30)	General anesthesia	Day-case knee arthroscopy	Saphenous nerve block with ropivacaine 7.5 mg/mL	Saphenous nerve block with isotonic saline	Preoperative
Lundblad et al. [1]	Sweden	64(31/33)	General anesthesia	ACL repair	Infrapatellar nerve block with 10 ml of 0.5% levobupivacaine	sham infrapatellar nerve block with 10 ml isotonic saline	Preoperative

ACLR: Anterior Cruciate Ligament Reconstruction; ACB: Adductor Canal Block; ACL; Anterior Cruciate Ligament; M: Meniscus

Table 2: Risk of bias assessment.

Study	Random Sequence Generation	Allocation Concealment	Blinding	Incomplete Outcome Data	Selective Reporting	Other Sources of Bias
Akkaya et al. [3]	Randomization tickets	Sealed envelopes	Yes	Yes	Unclear	Unclear
Chisholm et al. [12]	Excel-compatible randomizing program	Sealed envelopes	Yes	Yes	Unclear	Unclear
El-Ahl [23]	Block randomization	Sealed envelopes	Yes	Yes	Unclear	Unclear

Espelund et al. [21]	Unclear	Unclear	Yes	Yes	Unclear	Unclear
Espelund et al. minor [20,22]	Unclear	Unclear	Yes	Yes	Unclear	Unclear
Espelund et al S. pain. [22]	Unclear	Unclear	Yes	Yes	Unclear	Unclear
Hanson et al. [2]	Unclear	Sealed envelopes	Yes	Yes	Unclear	Unclear
Hsu et al. [4]	Random-number generator	Sealed envelopes	Yes	Yes	Unclear	Unclear
Westergaard et al. [19]	Random number list	Sealed envelopes	Yes	Yes	Unclear	Unclear
Lundblad et al. [1]	Computer-generated random numbers	Sealed envelopes	Yes	Yes	Unclear	Unclear

Table 2: Risk of bias assessment (Cont.).

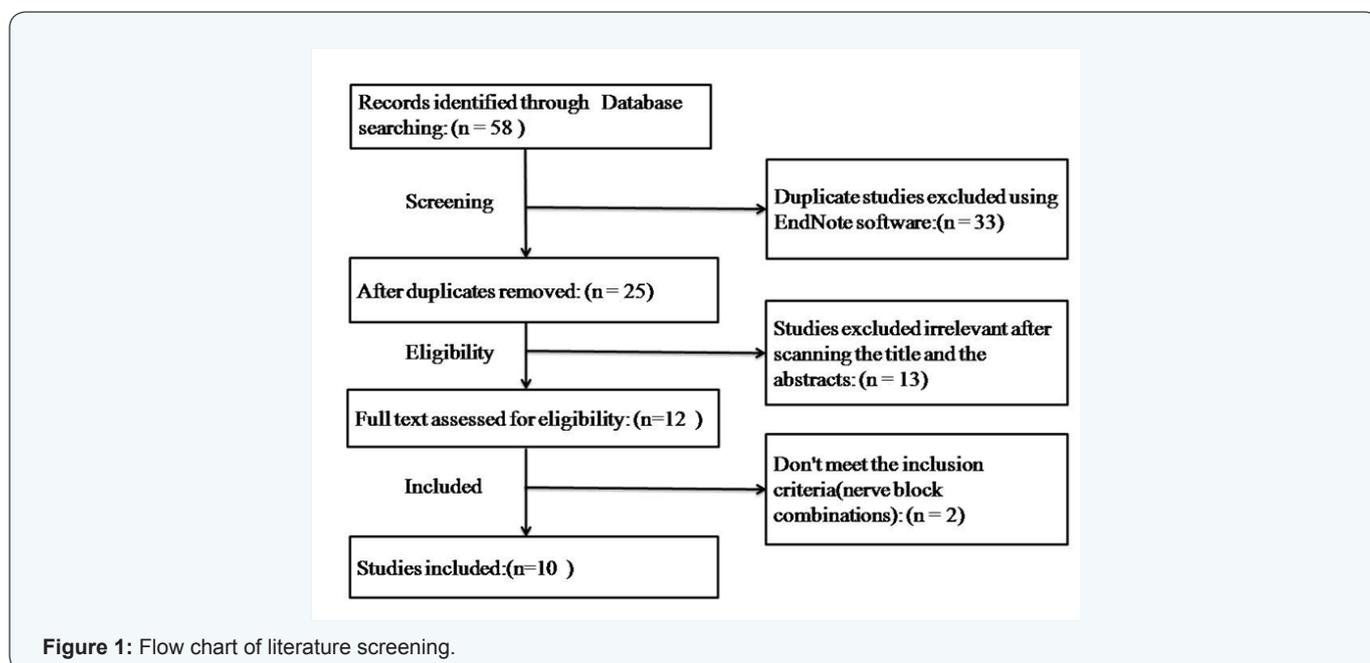


Figure 1: Flow chart of literature screening.

Table 1 summarizes the characteristics of the ten included RCTs. The studies were published between 2008 and 2015. The size of the studies ranged from 40 to 128 patients. Eight studies compared ACB, saphenous nerve block, or infrapatellar nerve block with placebo group injected with sterile saline in arthroscopic knee procedures. However, only two studies compared ACB and FNB in the arthroscopic knee surgery. The type of the injected anesthetic material varied among trials. It was ropivacaine 7.5 mg/mL in four studies, ropivacaine 0.5 mg/mL in two studies, 0.25% bupivacaine in two studies, and 0.5% levobupivacaine in two studies. The nerve block procedure was done preoperatively in six trials, and immediately postoperatively in four trials. General anesthesia was used in nine trial, however spinal anesthesia was used only in one trial. The types of surgeries were anterior cruciate ligament

reconstruction (ACL), arthroscopic assisted anterior cruciate ligament repair, meniscectomy, meniscal repair, synovial debridement, microfracture and chondroplasty.

All included studies were randomized by randomization list, or computer-generated numbers. Seven studies reported allocation concealment using sealed envelope. All trials were double blind to participants and outcome assessors.

Results of the Meta-Analysis

VAS Score with Rest: Seven studies with 393 arthroscopic knee surgeries assessed VAS score at rest within 24 hours postoperatively [1-4,19,21,22]. The combined data showed that the ACB had significantly lower pain score than the sham placebo group (Figure 2) (mean difference = -0.65; 95% confidence interval =- 1.11 to -0.18; P=0.007).

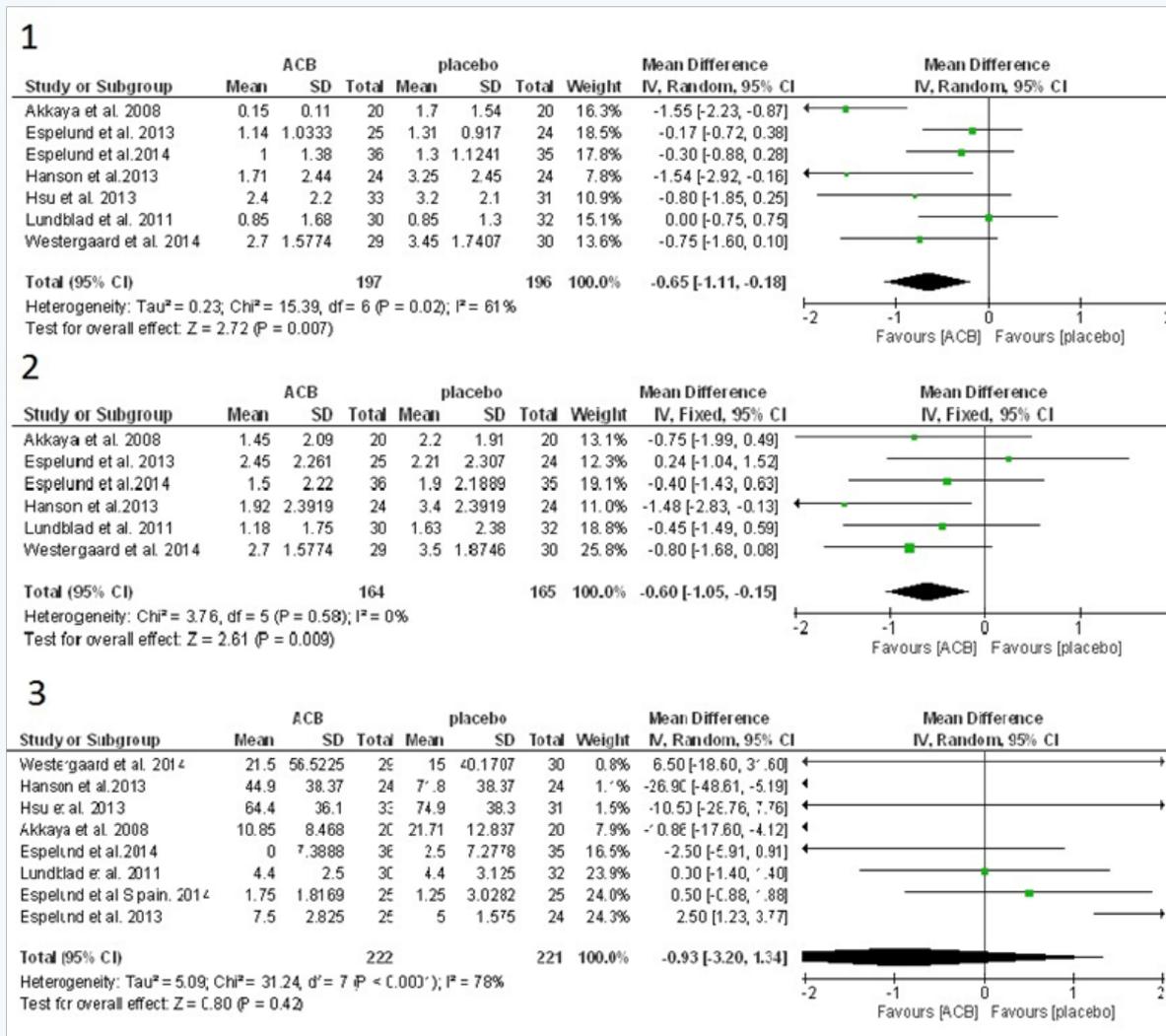


Figure 2: 1; Forest plot analysis of VAS pain score at rest within postoperative 24 hours, 2; Forest plot analysis of VAS pain score with activity within postoperative 24 hours, 3; Forest plot analysis of total opioid consumption within postoperative 24 hours.

Two studies with 168 ACLR studied the VAS score in ACB group compared to FNB group. One of these studies reported no significant difference in the VAS at rest within 24 hours postoperatively between the two groups [12]. However the other study showed that ACB had significantly higher VAS score at 24 hours postoperatively than FNB [23].

VAS Score with Activity: A total of six studies involving 329 arthroscopic knee procedures reported the results of VAS pain score with activity within 24 hours postoperatively [1-3,19,21,22]. Meta-analysis showed that ACB had also significantly lower pain score than placebo (Figure 2) (mean difference = -0.60; 95% confidence interval = -1.05 to 0.15; P=0.009).

Opioid Consumption: Eight studies with 443 patients assessed the total opioid consumption within 24 hours postoperatively [1-4,19-22]. The combined data showed no significant difference

in opioid consumption score between the ACB and the placebo group (Figure 2) (mean difference = -0.93; 95% confidence interval = -3.20 to 1.34; P=0.42).

Quadriceps muscle power

Five studies with 375 patients evaluated quadriceps muscle power [3,4,12,19,23]. RCTs that compared ACB with sterile saline injection showed no difference in the muscle power within the 1st postoperative 24 hours. Studies compared ACB and FNB reported in one study that ACB had significantly less quadriceps muscle weakness than FNB. However, quadriceps muscle power was not compared between groups in the other study.

Subgroup Analysis

Subgroup analysis was done for eight trials based on the type of arthroscopic procedures. Meta-analysis for the meniscectomy

subgroup showed that the ACB had lower VAS score with rest within 24 hours than placebo (Table 3) (mean difference = -1.55; 95% confidence interval = -2.19, 0.94; P=0.00001). In the same subgroup ACB had also lower VAS with activity within 24 hours than placebo (Table 3) (mean difference = -1.08; 95% confidence

interval = -2.00, 0.17; P=0.02). The total opioid consumption was also reduced significantly in this subgroup (Table 3) (mean difference = -15.42; 95% confidence interval = - 29.61, 1.24; P=0.03). Other parameters of the subgroup analysis were not statistically different between the ACB and the placebo group.

Table 3: Results of subgroup analysis.

Outcomes	No. of arthroscopic knee procedures				Heterogeneity	Interaction P
	No .of Included Studies	ACB	Placebo	MD or OR (95% CI)		
VAS with rest at 24 h	7 [1-4, 19, 21, 22]	197	196	-0.65 [-1.11, -0.18]	I ² = 61%, P = 0.02	0.007
Kind of surgery						
ACLR	2 [1, 21]	55	56	-0.11 [-0.55, -0.33]	I ² = 0%, P = 0.72	0.62
Minor knee arthroscopy	2 [4, 22]	69	66	0.42 [-0.93, 0.09]	I ² = 0%, P = 0.42	0.11
Meniscectomy	2 [2, 3]	44	44	-1.55 [-2.19, 0.94]	I ² = 0%, P = 0.99	0.00001
VAS with activity at 24 h	6 [1-3, 19, 21, 22]	164	165	-0.60 [-1.05, -0.15]	I ² = 0%, P = 0.58	0.009
Kind of surgery						
ACLR	2[1, 21]	55	56	-0.18 [0.98, 0.63]	I ² = 0%, P = 0.41	0.67
Meniscectomy	2[2, 3]	44	44	-1.08 [-2.00, 0.17]	I ² = 0%, P = 0.44	0.02
Opioid consumption at 24h	8[1-4, 19-22]	69	67	-0.93 [-3.2, -1.34]	I ² = 78%, P =0.0001	0.42
Kind of surgery						
ACLR	2[1, 21]	55	56	1.27[-1.18, 3.72]	I ² = 0%, P = 0.85	0.31
Minor knee arthroscopy	2[4, 22]	69	66	-2.77[-6.12, 0.58]	I ² = 0%, P = 0.40	0.11
Meniscectomy	2[2, 3]	44	44	-15.42[-29.61, 1.24]	I ² = 48%, P = 0.17	0.03

ACLR: Anterior Cruciate Ligament Reconstruction; ACB: Adductor Canal Block.

Discussion

The main findings in this study were; the VAS pain scores at rest and activity were significantly reduced with ACB than placebo within the 1st postoperative 24 hours. However combined result showed no difference between ACB and placebo in the opioid consumption within the 1st postoperative 24 hours. Quadriceps muscle strength showed also no difference between ACB and placebo group.

There are several limitations of this study. First, the quadriceps muscle strength outcome was extracted from the involved studies and summarized. However, meta-analysis could not be done due to deficient data. Secondly, the number of RCTs which compare ACB with FNB in the arthroscopic knee surgery was limited and statistical data was not enough for the comparison. Finally, different anesthetic drugs were used with different concentration in the included studies which may affect the result. However, the strength of this analysis that it compared mainly the RCTs which studied the ACB against non-block control group.

Controlled pain and preserved quadriceps muscle power are essentials for postoperative early mobilization and functional recovery post knee arthroscopic surgery. Previous studies concluded that FNB have been shown to improve postoperative pain analgesia and hospital length of stay than systemic opioid therapy post arthroscopic knee surgery [3,4,24-27]. However,

FNB had some severe side effects, such as reducing quadriceps muscle strength, delayed mobilization and being associated with the risk of falling [28,29]. These complications could be prevented with ACB as a pure sensory nerve block sparing the motor fibers of the femoral nerve and subsequently preserving the quadriceps muscle power [30-32].

Akkaya et al. [3] and Hanson et al. [2] studied the effect of saphenous nerve block on postoperative pain control post meniscectomy compared to placebo. They concluded that ACB decrease the pain score significantly at rest and activity in addition to improving patient comfort post-surgery. In these studies, opioid consumption was also significantly reduced with ACB than placebo. Hanson et al. [2] stated that all patients in both groups were able to stand in the post anesthesia care unit and no study participant subjectively mentioned leg weakness or reported falls within postoperative 24 hours. However, they didn't objectively measure the quadriceps muscle strength.

Lundblad et al. [1] compared the infrapatellar nerve block and placebo for the arthroscopy assisted ACL repair. They stated that it could improve pain and increase the number of sleep hours if it is included in a multimodal analgesic approach. Espelund et al. [21] compared the ACB and placebo for ACLR in another study. They reported that basic analgesic regimen with paracetamol, ibuprofen, and opioid were acceptable and ACB was not warranted.

Chisholm et al. [12] and El Ahl [23] compared the ACB with the FNB post ACLR. Chisholm et al. [12] stated that there were no significant difference between the two groups in pain score at rest, and opioid consumption within postoperative 24 hours. However, they were in doubt about the causes of quadriceps muscle weakness in their study and they attribute it to the FNB or the original injury, therefore, they recommend assessing quadriceps muscle over six or nine month follow up in another study. In the other study, El Ahl [23] concluded that in spite of significant preservation to the quadriceps muscle power in the ACB group than FNB group, the VAS pain score and opioid consumption was significantly higher in the ACB group.

Espelund et al. [20,22] in two different studies compared the ACB and placebo, one study in the minor arthroscopic surgery and the other for postoperative moderate and severe pain after arthroscopic knee surgery. They concluded that there were no significant analgesic effect of the ACB could be detected after minor arthroscopic knee surgery with a basic analgesic regimen. However, the ACB was highly reproducible and low risk option in treating patient with significant pain after arthroscopic knee surgery.

Hsu et al. [4] studied the effect of Infrapatellar saphenous nerve block with 10 ml 0.25% bupivacaine compared with 10 ml isotonic saline on the postoperative pain score, opioid consumption, mobility, discharge time and Lysholm knee score. They reported that no adverse effects or increased quadriceps weakness were observed following use of the nerve block. And they recorded significant improvement in early pain score and twelve-week Lysholm knee score. In another study saphenous nerve block was compared with placebo for postoperative pain control after day-case knee arthroscopy and the statistical result showed no differences in pain at rest, opioid consumption or function between groups [19].

After interpretation of the data included in the previous studies we found that the ACB was introduced as effective method for postoperative pain control and both the VAS score at rest and activity were significantly decreased. Moreover, the most attractive in this technique for the knee surgeons is the selective sensory nerve block while sparing the motor fibers. This could explain the superiority of the ACB over the FNB in preserving the quadriceps muscle power which is critical for early rehabilitation and decreasing the risk of fall post arthroscopic knee surgery.

Conclusion

The ACB in arthroscopic knee surgery could achieve the goals of postoperative pain control and quadriceps muscle power preservation which are essentials for early functional recovery. However, more RCTs may be needed to confirm the efficacy of the ACB and the possibility to replace the FNB for postoperative pain control in the arthroscopic knee procedures.

References

1. Lundblad M, Forssblad M, Eksborg S, Lönnqvist PA (2011) Ultrasound-guided infrapatellar nerve block for anterior cruciate ligament repair: a prospective, randomised, double-blind, placebo-controlled clinical trial. *Eur J Anaesthesiol* 28(7): 511-518.
2. Hanson NA, Derby RE, Auyong DB, Salinas FV, Delucca C, et al. (2013) Ultrasound-guided adductor canal block for arthroscopic medial meniscectomy: a randomized, double-blind trial. *Can J Anaesth* 60(9): 874-880.
3. Akkaya T, Ersan O, Ozkan D, Sahiner Y, Akin M, et al. (2008) Saphenous nerve block is an effective regional technique for post-menisectomy pain. *Knee Surg Sports Traumatol Arthrosc* 16(9): 855-858.
4. Hsu LP, Oh S, Nuber GW, Doty R, Kendall MC, et al. (2013) Nerve block of the infrapatellar branch of the saphenous nerve in knee arthroscopy: a prospective, double-blinded, randomized, placebo-controlled trial. *J Bone Joint Surg Am* 95(16): 1465-1472.
5. Widmer B, Lustig S, Scholes CJ, Molloy A, Leo SP, et al. (2013) Incidence and severity of complications due to femoral nerve blocks performed for knee surgery. *Knee* 20(3): 181-185.
6. Maheshwari AV, Blum YC, Shekhar L, Ranawat AS, Ranawat CS (2009) Multimodal pain management after total hip and knee arthroplasty at the Ranawat Orthopaedic Center. *Clin Orthop Relat Res* 467(6): 1418-1423.
7. Paul JE, Arya A, Hurlburt L, Cheng J, Thabane L, et al. (2010) Femoral nerve block improves analgesia outcomes after total knee arthroplasty: a meta-analysis of randomized controlled trials. *Anesthesiology* 113(5): 1144-1162.
8. Fowler SJ, Symons J, Sabato S, Myles PS (2008) Epidural analgesia compared with peripheral nerve blockade after major knee surgery: a systematic review and meta-analysis of randomized trials. *Br J Anaesth* 100(2): 154-164.
9. Sharma S, Iorio R, Specht LM, Davies-Lepie S, Healy WL (2010) Complications of femoral nerve block for total knee arthroplasty. *Clin Orthop Relat Res* 468(1): 135-140.
10. Lareau JM, Robbins CE, Talmo CT, Mehio AK, Puri L, et al. (2012) Complications of femoral nerve blockade in total knee arthroplasty and strategies to reduce patient risk. *J Arthroplasty* 27(4): 564-568.
11. Kent ML, Hackworth RJ, Riffenburgh RH, Kaesberg JL, Asseff DC, et al. (2013) A comparison of ultrasound-guided and landmark-based approaches to saphenous nerve blockade: a prospective, controlled, blinded, crossover trial. *Anesth Analg* 117(1): 265-270.
12. Chisholm MF, Bang H, Maalouf DB, Marcello D, Lotano MA, et al. (2014) Postoperative Analgesia with Saphenous Block Appears Equivalent to Femoral Nerve Block in ACL Reconstruction. *HSS J* 10(3): 245-251.
13. Jaeger P, Grevstad U, Henningsen MH, Gottschau B, Mathiesen O, et al. (2012) Effect of adductor-canal-blockade on established, severe post-operative pain after total knee arthroplasty: a randomised study. *Acta Anaesthesiol Scand* 56(8): 1013-1019.
14. Vloka JD, Hadzić A, Drobnik L, Ernest A, Reiss W, et al. (1999) Anatomical landmarks for femoral nerve block: a comparison of four needle insertion sites. *Anesth Analg* 89(6): 1467-1470.
15. Ilfeld BM, Duke KB, Donohue MC (2010) The association between lower extremity continuous peripheral nerve blocks and patient falls after knee and hip arthroplasty. *Anesth Analg* 111(6): 1552-1554.
16. Atkinson HD, Hamid I, Gupte CM, Russell RC, Handy JM (2008) Postoperative fall after the use of the 3-in-1 femoral nerve block

- for knee surgery: a report of four cases. *J Orthop Surg (Hong Kong)* 16(3): 381-384.
17. Andersen HL, Zaric D (2014) Adductor canal block or midhigh saphenous nerve block: same same but different name! *Reg Anesth Pain Med* 39(3): 256-257.
 18. Higgins JPT GS (2011) *Cochrane handbook for systematic reviews of interventions*. Version 5.1.0. 2011 updated March 2011.
 19. Westergaard B, Jensen K, Lenz K, Bendtsen TF, Vazin M, et al. (2014) A randomised controlled trial of ultrasound-guided blockade of the saphenous nerve and the posterior branch of the obturator nerve for postoperative analgesia after day-case knee arthroscopy. *Anaesthesia* 69(12): 1337-1344.
 20. Espelund M, Grevstad U, Jaeger P, Hölmich P, Kjeldsen L, et al. (2014) Adductor canal blockade for moderate to severe pain after arthroscopic knee surgery: a randomized controlled trial. *Acta Anaesthesiol Scand* 58(10): 1220-1227.
 21. Espelund M, Fomsgaard JS, Haraszuk J, Mathiesen O, Dahl JB (2013) Analgesic efficacy of ultrasound-guided adductor canal blockade after arthroscopic anterior cruciate ligament reconstruction: a randomised controlled trial. *Eur J Anaesthesiol* 30(7): 422-428.
 22. Espelund M, Fomsgaard JS, Haraszuk J, Dahl JB, Mathiesen O (2014) The efficacy of adductor canal blockade after minor arthroscopic knee surgery--a randomised controlled trial. *Acta Anaesthesiol Scand* 58(3): 273-280.
 23. El Ahl MS (2015) Femoral nerve block versus adductor canal block for postoperative pain control after anterior cruciate ligament reconstruction: A randomized controlled double blind study. *Saudi J Anaesth* 9(3): 279-282.
 24. Williams BA, Kentor ML, Vogt MT, Irrgang JJ, Bottegal MT, et al. (2006) Reduction of verbal pain scores after anterior cruciate ligament reconstruction with 2-day continuous femoral nerve block: a randomized clinical trial. *Anesthesiology* 104(2): 315-327.
 25. Dauri M, Polzoni M, Fabbi E, Sidiropoulou T, Servetti S, et al. (2003) Comparison of epidural, continuous femoral block and intraarticular analgesia after anterior cruciate ligament reconstruction. *Acta Anaesthesiol Scand* 47(1): 20-25.
 26. Wulf H, Löwe J, Gnutzmann KH, Steinfeldt T (2010) Femoral nerve block with ropivacaine or bupivacaine in day case anterior cruciate ligament reconstruction. *Acta Anaesthesiol Scand* 54(4): 414-420.
 27. Iskandar H, Benard A, Ruel-Raymond J, Cochard G, Manaud B (2003) Femoral block provides superior analgesia compared with intra-articular ropivacaine after anterior cruciate ligament reconstruction. *Reg Anesth Pain Med* 28(1): 29-32.
 28. Ackerman DB, Trousdale RT, Bieber P, Henely J, Pagnano MW, et al. (2010) Postoperative patient falls on an orthopedic inpatient unit. *J Arthroplasty* 25(1): 10-14.
 29. Muraskin SI, Conrad B, Zheng N, Morey TE, Enneking FK, et al. (2007) Falls associated with lower-extremity-nerve blocks: a pilot investigation of mechanisms. *Reg Anesth Pain Med* 32(1): 67-72.
 30. Jaeger P, Nielsen ZJ, Henningsen MH, Hilsted KL, Mathiesen O, et al. (2013) Adductor canal block versus femoral nerve block and quadriceps strength: a randomized, double-blind, placebo-controlled, crossover study in healthy volunteers. *Anesthesiology* 118(2): 409-415.
 31. Jenstrup MT, Jager P, Lund J, Fomsgaard JS, Bache S, et al. (2012) Effects of adductor-canal-blockade on pain and ambulation after total knee arthroplasty: a randomized study. *Acta Anaesthesiol Scand* 56(3): 357-364.
 32. Kwofie MK, Shastri UD, Gadsden JC, Sinha SK, Abrams JH, et al. (2013) The effects of ultrasound-guided adductor canal block versus femoral nerve block on quadriceps strength and fall risk: a blinded, randomized trial of volunteers. *Reg Anesth Pain Med* 38(4): 321-325.