Effective concentration of Ropivacaine for post-operative pain relief in Total knee replacement surgeries using ultra sound guided continuous femoral block – A randomized double blinded study

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Abstract

Introduction: Postoperative pain in total knee replacement surgeries is severe and needs intense analgesia. Of various analgesic techniques available, continuous femoral nerve block is safe and associated with minimal side effects.

Objectives: To compare the analgesic effect of various concentrations of ropivacaine using continuous femoral nerve block for post-operative pain relief in total knee replacement surgeries.

Methods: 120 patients posted for elective total knee replacement (TKR) surgeries under American Society of Anesthesiologists (ASA) physical classification I or II, under spinal anaesthesia, were randomly allocated into four groups of 30 each. Group 1, 2, 3 and 4 received ropivacaine 0.12%, 0.16%, 0.20% and 0.25% respectively at 10 mL per hour infusion, by ultrasound-guided continuous femoral nerve block. Pain relief was assessed by visual analogue scale (VAS). Analgesic requirement in the post-operative period and hemodynamic changes compared between four groups.

Results: There was no statistical difference in change in hemodynamics over time between all four groups. Analgesic requirement was significantly less and VAS score was significantly low in group 3 and group 4.

Conclusion: In this study, the minimum effective concentration of ropivacaine when used for pain relief in continuous femoral block in total knee replacement surgeries is found to be 0.20%.

Keywords: Analgesia; Knee replacement; Nerve block; Ropivacaine; Ultrasound.

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Introduction

Total Knee Replacement (TKR) is one of the most commonly performed orthopaedic procedures for the treatment of osteoarthritis of knee joint. This procedure needs intense post-operative analgesia to facilitate early mobilization to prevent complications. Different anaesthetic techniques such as parenteral opioids and continuous epidural infusion using local anaesthetics are used for post-operative analgesia in TKR surgeries.[1] Parenteral opioids even if used in patient controlled analgesia technique have the disadvantage of drowsiness, respiratory depression, nausea, vomiting, hemodynamic changes such as hypotension and delayed mobilization.[2] Continuous epidural local anaesthetic infusion though gives excellent analgesia has the adverse effects of hypotension, urinary retention, local anaesthetic toxicity, motor blockade and epidural hematoma.[3] These complications can be avoided in nerve blocks. Nerve blocks can be safely administered in patients in whom low molecular weight heparin is planned in the peri-operative period.

More recently, peripheral nerve block techniques such as ultra sound guided femoral nerve block have been used to provide satisfactory post-operative analgesia in TKR patients with minimum complications.[4] Continuous femoral blocks have the advantage of providing longer duration of pain relief when compared to single-shot block. But there is a small risk of local anaesthetic toxicity. Among the commonly used local anaesthetics, ropivacaine has the advantage of longer duration of action. Since many of the centres do not have facilities to monitor serum ropivacaine levels we designed this study to determine a minimum ropivacaine concentration that would provide a satisfactory pain relief, considering possible local anaesthetic toxicity. The aim of our study was to compare various concentrations of ropivacaine in femoral nerve block using continuous infusion for TKR surgeries. Our objective was to determine the minimum concentration that provides good analgesia without compromising hemodynamic changes and facilitating early ambulation.

Material and Methods

This study was conducted in a 1000 bedded tertiary medical college hospital from January 2014 to December 2015. In our study we used Siemens® Acuson P300 Ultra sound machine with 5 MHz curved probe for performing femoral nerve block. We preferred curved probe over the linear 12 MHz probe because of deeper placement of the femoral nerve. Braun's® 17G epidural needle and 19G catheter were

used for performing the block. Ropivacaine 0.75% was diluted with saline into four different concentrations of 0.12%, 0.16%, 0.20%, and 0.25%.

120 patients posted for elective TKR surgeries categorized in ASA physical classification I or II were randomly allocated into four groups of 30 each. Exclusion criteria included patient refusal, local site infection, coagulopathies, patients on antihypertensive drugs and beta blockers. We selected the sample size based on our aim to determine the minimum effective concentration of ropivacaine for post-operative pain relief in total knee replacement surgeries. The primary end point was demand of analgesia. We used (Statistical Analysis System) SAS version 9.0 statistical software to determine the sample size. A sample size of n=30 was arrived for a significance level of 0.05 (α=5%) and a power of 80%. Blinding was done using sealed envelope technique to prevent observer bias. During preoperative assessment patients were explained about the study procedures and Visual Analogue Scoring (VAS) system for postoperative pain evaluation.

After shifting the patient to operating room, an 18-gauge intravenous (i.v.) cannula was placed in the forearm and premedication done with 1.5 mg i.v. midazolam. Monitors such as pulse oximeter, electrocardiogram and noninvasive arterial blood pressure were placed. The patient was placed in supine position, with that side of the inguinal region exposed where the surgery was planned and the skin over the femoral triangle was disinfected with 5% povidone iodine solution and draped with sterile linen. The transducer probe was positioned parallel and inferior to femoral crease to identify the femoral artery and the femoral nerve which would be just lateral to the artery. After identifying the femoral nerve, the skin site 1 cm away from the lateral edge of the transducer was infiltrated with 3 ml of 1% lignocaine. The needle was inserted from lateral side to the medial side and advanced towards the femoral nerve under ultra sound guidance (usually 3 to 5 cm depth). After confirming the proper placement of the tip of the needle, 10 ml of 2% lignocaine with adrenaline was injected. Then the catheter was inserted to a total depth of 10 cm from the skin and the needle was removed carefully and the catheter was fixed with plaster. Success of the block was assessed with the onset of sensory block using the pinprick test after 10 minutes. Then the TKR procedure was done under sub-arachnoid block. For all the patients we used 3.2ml of 0.5% hyperbaric bupivacaine at L3-L4 space. Blinded post-graduate residents started the ropivacaine infusion (concentration depending upon the allocated group at 10 mL/hr) in the immediate post-operative period at the post-operative care unit.

Parameters such as heart rate, systolic and diastolic blood pressure, pain using VAS scoring, motor blockade using modified Bromage scale and analgesic supplementation were recorded at 4, 10, 20 and 40 hours post-operatively by a blinded qualified anaesthesiologist.

Statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) version 22.0 software for windows (SPSS Inc, Chicago, USA). Continuous variables such as change in heart rate over time were assessed with Student-Newman-Keuls test and Analysis of variance (ANOVA) tests. Change in systolic and diastolic blood pressure was assessed with ANOVA test. VAS score and analgesic supplementation was assessed using χ^2 test. A 'p' value ≤ 0.05 was considered statistically significant in all cases.

Results

We conducted this study with 120 patients divided into four groups of 30 each and used their data for statistical analysis. There were no statistically significant differences regarding mean age, sex, weight, and ASA classification in the four study groups.

Table 1: Change in mean heart rate (beats per minute) over time between four groups

Groups	Baseline	4 Hours	10 Hours	20 Hours	30 Hours
ROPIVACAINE 0.12%	69.567	76.167	74.400	71.967	74.700
ROPIVACAINE 0.16%	70.300	75.000	70.933	72.267	74.167
ROPIVACAINE 0.20%	73.200	74.367	70.300	70.533	74.667
ROPIVACAINE 0.25%	73.400	76.433	71.030	76.200	67.700

Table 2: ANOVA test for Change in mean heart rate (beats per minute) over time between four groups

	Baseline	4 Hours	10 Hours	20 Hours	30 Hours
Average Mean	71.617	75.492	71.725	72.742	72.808
Standard Deviation	6.2594	9.2854	6.1138	7.6373	9.0649
Significance	0.760	0.828	0.740	0.640	0.969

There was no statistically significant difference in change in heart rate over time between 4 study groups. ($p>0.05$) (Table 1 and Table 2).

Table 3: Change in mean systolic blood pressure (mm of Hg) over time between four groups

Groups	Baseline	4 Hours	10 Hours	20 Hours	30Hours
Ropivacaine 0.12%	124.833	127.800	126.833	121.000	124.200
Ropivacaine 0.16%	125.433	123.167	126.900	124.433	125.133
Ropivacaine 0.20%	124.867	124.267	126.567	124.700	124.100
Ropivacaine 0.25%	125.633	122.500	126.900	123.708	120.000

Table 4: ANOVA test for change in mean systolic blood pressure (mm of Hg) over time between four groups

	Baseline	4 Hours	10 Hours	20 Hours	30 Hours
Average Mean	125.192	124.433	126.642	123.708	123.358
STD. Deviation	6.6973	7.6011	7.1265	10.9486	10.2636
Signficance	.971	.627	.986	.995	.213

There was no statistically significant difference in change in systolic blood pressure over time between 4 study groups. (p>0.05) (Table 3 and Table 4).

Table 5: Change in mean diastolic blood pressure (mm of Hg) over time between four groups

Groups	Baseline	4 Hours	10 Hours	20 Hours	30 Hours
Ropivacaine 0.12%	76.100	76.000	76.533	75.733	78.467
Ropivacaine 0.16%	75.700	78.567	77.533	75.700	78.833
Ropivacaine 0.20%	77.833	77.633	77.567	75.633	77.000
Ropivacaine 0.25%	76.700	77.067	77.600	76.967	78.100

Table 6: ANOVA test for change in mean diastolic blood pressure (mm of Hg) over time between four groups

	Baseline	4 Hours	10 Hours	20 Hours	30 Hours
Average Mean	76.583	77.317	77.308	76.008	78.100
STD. Deviation	4.2969	4.8246	4.1298	4.1878	4.4484
Significance	0.220	0.168	0.753	0.610	0.385

There was no statistically significant difference in change in diastolic blood pressure over time between 4 study groups. (p>0.05) (Table 5 and Table 6).

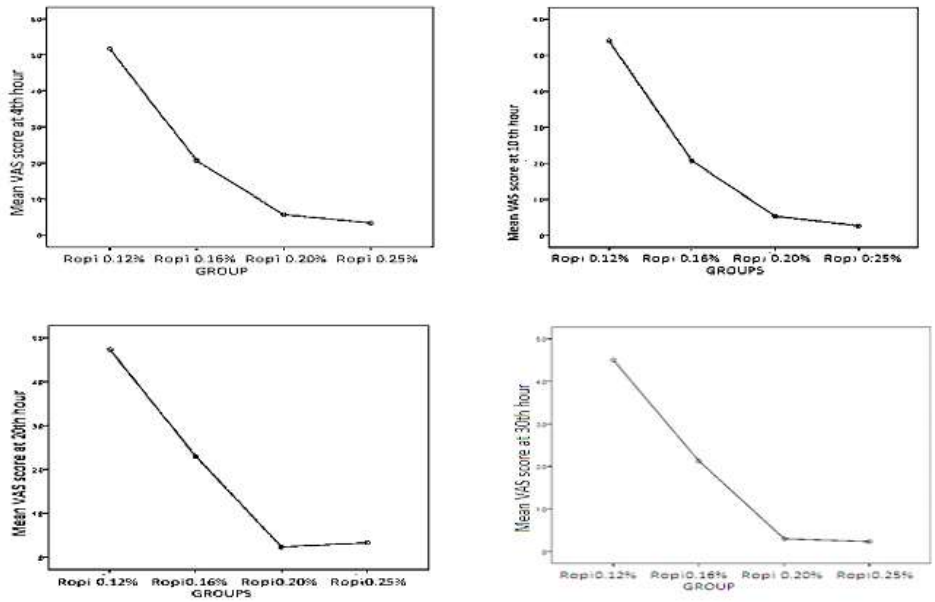

Fig. 1: Change in mean VAS score between four groups

The mean VAS score 4th, 10th, 20th, 30th hour for Ropivacaine 0.12% was 5. The mean VAS score 4th, 10th, 20th, 30th hour for Ropivacaine 0.16% was 2.5. The mean VAS score 4th, 10th, 20th, 30th hour for Ropivacaine 0.20% and 0.25% was <1 (Fig. 1).

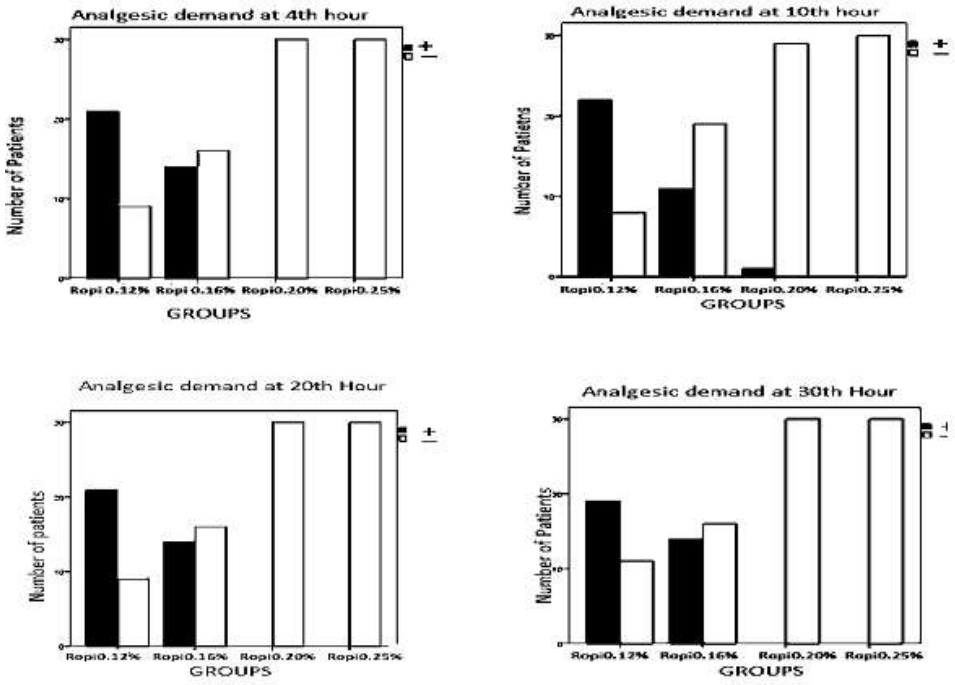

Fig. 2: Analgesic demand profile

Additional analgesic demand was significantly high in Ropivacaine 0.12% and Ropivacaine 0.16% group compared to Ropivacaine 0.20% group and Ropivacaine 0.25% group (Fig. 2). In Ropivacaine 0.25% group there was no analgesic demand at 4th, 10th, 20th, 30th hour. In Ropivacaine 0.20% group, two patients at 4th hour and one patient at 10th hour had demand for analgesia. Though Ropivacaine 0.25% group was better than Ropivacaine 0.20% in demand for analgesia there was no statistical significance among the two groups. Hence Ropivacaine 0.20% was considered as the minimal effective concentration.

There was no motor blockade noticed in all the four groups.

Discussion

TKR is associated with extensive tissue handling that causes severe post-operative pain which prevents early mobilization. This can cause various problems such as infection due to retention of collected fluid in the joint, muscle weakness due to prolonged immobility, delayed healing, pain induced complications, prolonged hospital stay, joint stiffness and deep vein thrombosis. Intravenous opioids, epidural analgesics, intrathecal opioids and Non-steroidal anti-inflammatory drugs (NSAIDS) are various pain management options available for management of post-operative pain in TKR surgeries.[1] Intravenous opioids can be given as intermittent boluses or as infusions. But a study which compared femoral nerve block with intravenous opioids found that opioids are associated with nausea, vomiting, drowsiness, constipation and respiratory depression.[2]

Studies show that epidural analgesia provides satisfactory pain relief which is useful for early mobilization of the patient.[3] But this modality of pain relief is associated with urinary retention, motor blockade, hypotension and epidural hematoma.[4] The common risk involved in epidural analgesia is formation of hematoma in epidural space because all the patients undergoing TKR should be put on low molecular weight heparin for deep vein thrombosis prophylaxis. Peripheral nerve blocks can be performed safely in these patients.[5] NSAIDS which are commonly used for management of post-operative pain in orthopaedic surgeries are not very effective in these patients.[6] Intrathecal opioids is an another option, but associated with pruritus, vomiting, and it can be given as single dose only.[7] There are some centres where intra-articular infusion of local anaesthetics are tried for knee surgeries, but carries a risk of infection.[8] Wound infiltration with local anaesthetics have been tried in some centres, which provides pain relief for short duration only.[9]

Peripheral nerve blocks provide satisfactory analgesia and enhance early mobilization of patients undergoing TKR. Peripheral nerve blocks helps in early ambulation and minimizes the time to discharge when compared to NSAIDS and intravenous opioids.[10] Studies show that there is a significant decrease in tissue and plasma cytokine levels in patients receiving peripheral nerve blocks for pain relief, which shows the anti-inflammatory effect of peripheral nerve blocks.[11]

The combination of sciatic nerve block and femoral nerve block is a preferred technique for post-operative pain relief in TKR.[6] In many centres there are objections from the surgeon for sciatic nerve block as they cannot assess peroneal nerve function in the post-operative period.[12] Cadaveric studies show that 10ml for Ropivacaine injected in proximity to femoral nerve with ultrasound guidance covers a significant segment.[13] Continuous femoral nerve block with ropivacaine provides prolonged, satisfactory analgesia and reduces the need for rescue analgesia with narcotics compared to single dose ropivacaine.[14] Continuous femoral block also helps in early mobilization and decreases the duration of hospital stay.[15]

Ultrasound guided placement of perineural catheters has got advantages over the nerve stimulator guided techniques. Peripheral nerve stimulator guided femoral nerve block produces unreliable block and the intensity of block depends on use of minimal current strength to achieve the stimulus.[16] Ultrasound helps in precise, reliable placement of catheters. It also reduces local anaesthetic requirement.[17] Ultrasound decreases number of needle punctures, needle manipulations and provide better comfort to the patient while performing the procedure.[18] One study compared in-plane and out of plane approach for localization of femoral nerve but found no difference among the two approaches.[19] Depth of catheter placement is another determinant of block. A catheter placed at 10cm depth from the skin levels provides effective block and prevents catheter migration.[20]

Ropivacaine compared with lignocaine and bupivacaine provides significant pain relief, prolonged analgesia and lesser cardio toxicity. Various studies with ropivacaine 0.3% at rate of 10ml/hr infusion have found no significant raise in plasma concentration given either through ultrasound or nerve stimulator guided techniques.[21,22,23]

Various studies have been done using single shot technique with the same concentrations but we have used continuous femoral block to achieve longer duration of analgesia. This technique was performed with ultrasound guidance for reliable placement of catheter. Ropivacaine was given at rate of 10ml/hr. VAS score used to analyze pain relief was significantly low (<1) in ropivacaine 0.20% and 0.25% group, compared to the other two groups. Demand for rescue analgesia was also significantly low in ropivacaine 0.20% and 0.25% compared to other groups. There were no statistically significant differences in VAS score and analgesic demand between Ropivacaine 0.20% and Ropivacaine 0.25%. This shows ropivacaine 0.20% and Ropivacaine 0.25% are effective drug concentrations for post-operative pain relief by continuous femoral block in TKR patients. Considering the toxicity of local anaesthetics, selecting a lower concentration would be a prudent option. Hence ropivacaine 0.20% is the minimum effective concentration compared to ropivacaine 0.25% for post-operative pain relief in TKR.

We have not monitored serum ropivacaine levels. This is the limitation of our study. We recommend future studies on this topic to use it as a sole anaesthetic technique in patients where other anaesthetic techniques are contraindicated. This technique can also be used for post trauma and chronic pain management. In future this study could be modified by addition of adjuvants like dexmedetomidine so that ropivacaine concentration can further be reduced.

Conclusion

Ropivacaine 0.20% provides safe and satisfactory post-operative pain relief in TKR surgeries without affecting hemodynamics and motor function when given as continuous femoral block.

References

1. Barrington JW, Dalury DF, Emerson RH, Hawkins RJ, Joshi GP, Stulberg BN. Improving patient outcomes through advanced pain mana gement techniques in total hipand knee arthroplasty. Am J Orthop (Belle Mead NJ) 2013;42:S1-S20.
2. Wang HJ, Zhang DZ, Li SZ. Comparing the analgesic efficacy of continuous femoral nerve blockade and continuous intravenous analgesia after total knee arthroplasty 2010;90(33):2360-2.
3. Sakai N, Inoue T, Kunugiza Y, Tomita T, Mashimo T. Continuous femoral versus epidural block for attainment of 120° knee flexion after total knee arthroplasty: a randomized controlled trial. J Arthroplasty 2013;28(5):807-14.
4. Barrington MJ, Olive D, Low K, Scott DA, Brittain J, Choong P. Continuous femoral nerve blockade or epidural analgesia after total knee replacement: a prospective randomized controlled trial. Anesth Analg 2005;101:1824–1829.
5. Anthony R, Plunkett MD, Chester C. Buckenmaier. Safety of Multiple, Simultaneous Continuous Peripheral Nerve Block Catheters in a Patient Receiving Therapeutic Low-Molecular-Weight Heparin. Pain medicine 2008;418:624-627.
6. Affonso H. Zugliani, Nubia Verçosa, José Luiz Gomes do Amaral, Louis Barrucand, Cátia Salgado, Márcia Borges Hage Karam. Control of postoperative pain following total knee arthroplasty: is it necessary to associate sciatic nerve block to femoral nerve block? Rev. Bras. Anestesiol 2007;57:34-37.
7. Olive DJ, Barrington MJ, Simone SA, Kluger R. A randomised controlled trial comparing three analgesia regimens following total knee joint replacement: continuous femoral nerve block, intrathecal morphine or both. Anaesth Intensive Care 2015;43(4):454-60.
8. Dauri M, Fabbi E, Mariani P, Faria S, Carpenedo R, Sidiropoulou T, Coniglione F, Silvi MB, Sabato AF. Continuous femoral nerve block provides superior analgesia compared with continuous intra-articular and wound infusion after anterior cruciate ligament reconstruction. Reg Anesth Pain Med 2009;34(2):95-9.
9. Ashraf A, Raut VV, Canty SJ, McLauchlan GJ. Pain control after primary total knee replacement. A prospective randomised controlled trial of local

infiltration versus single shot femoral nerve block. Knee 2013;20(5):324-7.
10. Brian M. Ilfeld, Linda T. Le, R. Scott Meyer, Edward R. Mariano, Krista Vandenborne. Ambulatory Continuous Femoral Nerve Blocks Decrease Time to Discharge Readiness after Tricompartment Total Knee Arthroplasty. A Randomized, Triple-masked, Placebo-controlled.
11. Frederic Martin, Valeria Martinez, Jean Xavier Mazoit, Didier Bouhassira, Kamel Cherif. Anti-iflammatory effect of peripheral nerve blocks after knee surgery: clinical and biologic evaluation. Anesthesiology 2008;109(3):484–490.
12. Hishiyama S, Ishiyama T, Asano N, Kotoda M, Ikemoto K, Matsukawa T. Femoral nerve block for total knee arthroplasty. Masui 2014;63(8):872-6.
13. Ishiguro S, Yokochi A, Yoshioka K, Asano N, Deguchi A, Iwasaki Y, Sudo A, Maruyama K. Technical communication: anatomy and clinical implications of ultrasound-guided selective femoral nerve block. Anesth Analg 2012;115(6):1467-70.
14. Soto Mesa D, Del Valle Ruiz V, Fayad Fayad M, Cosío Carreño F, Rodriguez, Gonzalez, Bermejo Alvárez MA. Control of postoperative pain in knee arthroplasty: single dose femoral nerve block versus continuous femoral block. Rev Esp Anestesiol Reanim 2012;59(4):204-9.
15. Eric Albrecht, Vincent Chan, Rajiv Gandhi, Arkadiy Koshkin, Ki Jinn Chin, Sylvie Robinson, Philippe Frascarolo, Richard Brull. Single-injection or Continuous Femoral Nerve Block for Total Knee Arthroplasty? Clin Orthop Relat Res 2014;472(5):1384–1393.
16. Ortiz de la Tabla González R, Martínez Navas A. Influence of femoral catheter stimulation intensity on post-surgical analgesia after total knee replacement. Rev Esp Anestesiol Reanim 2012;59(4):187-96.
17. Gandhi K, Lindenmuth DM, Hadzic A, Xu D, Patel VS, Maliakal TJ, Gadsden JC. The effect of stimulating versus conventional perineural catheters on postoperative analgesia following ultrasound-guided femoral nerve localization. J Clin Anesth 2011;23(8):626-31.
18. Fredrickson MJ, Danesh-Clough TK. Ambulatory continuous femoral analgesia for major knee surgery: a randomised study of ultrasound-guided femoral catheter placement. Anaesth Intensive Care 2009;37(5):758-66.
19. M.J. Fredrickson, T.K. Danesh-Clough. Ultrasound-guided femoral catheter placement: a randomized comparison of the in-plane and out-of-plane techniques. Anaesthesia 2013;68:382–390.
20. Zhu F, Hu Y, Zhang W. Effect of continuous femoral nerve catheter length on blockade of femoral nerve, lateral femoral cutaneous nerve and obturator nerve. Beijing Da Xue Xue Bao 2013;45(1):145-8.
21. Mouzi LK, Adams O, Cuff G, Lukasiewicz E, Champeil E, Atchabahian A. Plasma concentrations of ropivacaine following ultrasound-guided or nerve-stimulator-guided femoral nerve block: A prospective randomised study. Anaesth Crit Care Pain Med 2016;35(1):45-8.
22. Maria Bauer, Lu Wang, Olusegun K. Onibonoje, Chad Parrett, Daniel I. Sessler. Continuous Femoral Nerve Blocks: Decreasing Local Anesthetic Concentration to Minimize Quadriceps Femoris Weakness. Anesthesiology 2012;116(3):665–672.
23. Matthew T. Charous, Sarah J. Madison, J. Suresh, Nav Parkash S. Sandhu, Vanessa J. Loland. Continuous Femoral Nerve Blocks: Varying Local Anesthetic Delivery Method (Bolus versus Basal) to Minimize Quadriceps Motor Block while Maintaining Sensory Block. Anesthesiology 2011;115(4):774–781.