Different Approaches of Continuous Fascial Iliaca Compartment Block Under Ultrasound-Guidance for Hip Arthroplasty: Short axis vs long axis in-Plane Techniques

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Abstract

Continuous *Fascia iliaca* compartment block provides effective analgesia by effective blockade of the femoral and lateral femoral cutaneous (LFC) in patients undergoing hip orthopedic surgeries. We compared analgesic effect of ultrasound-guided continuous fascia iliaca compartment block using either a short-axis in-plane technique or a long-axis in-plane technique for patients undergoing hip arthroplasty. In this prospective double-blind study, twenty-six ASA- I and II patients undergoing hip orthopedic surgeries were enrolled and randomly assigned to receive continuous fascia iliaca compartment block with either a short axis in-plane or a long-axis in-plane technique. The perineural catheter was attached to an electronic infusion pump. Ropivacaine 0.2% was administered through the catheter for 48 hours (4 mL/h). The primary outcome was ropivacaine consumption within 48h in the two groups. Secondary outcomes included the procedural time, success rate of block, postoperative pain score evaluated by NRS score at rest and movement. There was no significant difference in the consumption of ropivacaine during the 48 postoperative hours ($P>0.05$). Short-axis in-plane group need less procedural time for catheterization insertion than long-axis group. Compared with the short-axis in-plane technique, long-axis in-plane continuous fascia iliaca compartment block had no ropivacaine-sparing effect on patient-controlled analgesia for hip arthroplasty.

1 Introduction

In recent years, there has been increasing interest in using ultrasound guidance for regional anesthesia^{1,2}. Ultrasound allows visualization of the nerves and the adjacent anatomical constructions.

Ultrasound transducers consist of piezoelectric crystals that emit and receive high- frequency sound waves by inter-converting electrical and mechanical energy. Linear array transducers have a high scan line density and therefore produce the best image quality. These transducers, in particular, the high-frequency broadband linear probes, have proven the most useful for nerve imaging³. Currently, we are short of evidence for the utility of

ultrasound in performing continuous fascial iliaca compartment block using the short axis or long axis techniques.

Pain administration after lower limb surgery has a significant effect on overall postoperative outcome in terms of faster organization, less postoperative nausea and vomiting. Continuous peripheral nerve blockade (CPNB) affords the possible benefits over single injection methods^{4,5}. Furthermore, the introduction of electronic pumps for the continuous infusion of local anesthetic has acceptable patients to obtain the benefits of continuous block depend on different supplies⁶. These three nerves provide the major innervation of the lower extremity involved in successful analgesia for patients undergoing lower

limb surgery. However, recent studies demonstrated that the 3-in-1 block result in anesthesia saving to the obturator nerve, thereby leading to improved displeasure among anesthesia providers and patients⁷. The fascia iliaca compartment (FIC) block is an easy and dependable method to block the femoral nerve and lateral cutaneous nerve. When performing ultrasound-guided fascia iliaca compartment block, target nerve imaging can be performed in short or long axis, which is combined with in-plane needle/catheter guidance (in-plane guidance permitting visualization of the needle tip and catheter advancement)⁸. Ropivacaine is a long-acting local anesthetic that is widely used in nerve block^{9,10}. The success rate of a nerve block relies on multiple variables^{10,11}. Increasing the local anesthetic volume or concentration generally improves block success rate^{10,11}. Furthermore, multiple nerve blocks may be required for lower limb surgery¹² leading to the frequent use of maximum recommended total doses. The risk of complications of peripheral nerve blocks in anesthetized adult patients is low¹³ and the real-time observation of nerve and related structure with the help of ultrasound may further decrease this risk. We hypothesized that ultrasound-guided different approaches to continuous fascia iliaca compartment block may have impacts on postoperative pain relief and block related side effects. To provide convincing evidence, the present prospective, randomized study was designed to compare short-axis in-plane vs. long-axis in-plane techniques of ultrasound guided continuous fascia iliaca compartment block.

1.1 Statements of problem

The two techniques have not been compared for analgesic efficacy when administered pre-operatively. This study will be designed to answer the question as to which technique provides superior analgesic efficacy, to determine the procedure characteristic by using two ultrasound-guided techniques: short-axis in-plane vs. long-axis in plane techniques.

2 Materials and Methods

2.1 Study Design

The Institutional Review Board of Tongji Hospital, affiliated to Huazhong University of Science and Technology approved this study. We enrolled patients scheduled for lower limb surgery at the Affiliated Hospital of the College of Medicine (Tongji, China). The study was prospective and interventional in nature. All the patients participating in the study were explained clearly about the purpose and nature of the study in the language they could understand. They were included in the study only after obtaining a written informed consent. Patients were randomly assigned to one of ultrasound guided fascia iliaca continuous compartment block groups: long-axis in plane or short-axis in-plane using wrapped envelopes containing group assignments based on a computer-generated randomization sequence.

2.2 Patients selection

Adults between 16-85 years scheduled for unilateral hip surgery with a continuous nerve block planned for postoperative analgesia were considered for inclusion. Twenty-six adult patients, of American Society of Anesthesiologist's (ASA) physical status score of I and II, were randomly assigned to either long-axis in-plane or short-axis in-plane (1:1 allocation, parallel trial design) group, based on a computer-generated randomization list created by an independent researcher. Patients unable to understand the study protocol or care for the infusion pump/catheter system or with any known contraindication to study medications or regional anesthesia, insulin - dependent diabetes mellitus, neuropathy of any etiology in the affected extremity, hepatic or renal failure, any additional surgical site outside the lower limb intended for catheter placement, chronic opioid use or active illicit substance abuse, pregnancy, or inability to communicate with the investigators or on potent antiplatelet, or on anticoagulants, allergy to the trial drug with hemi-diaphragmatic paralysis on contralateral side of surgery, with a psychological disorder and not willing to sign the consent were excluded from the study. A routine pre-anesthetic evaluation of each case was done after recording of the medical history. A thorough systemic examination was carried out to detect the presence of any systemic disorder. Routine and special investigations were carried out accordingly. Local examination of block site was done to exclude any sign of sepsis, previous injury or previous deformity.

2.3 Procedure

All patients were positioned supine. Standard noninvasive monitors were applied, and oxygen was administered via a facemask and the patients were given I.V fluids according to the requirement. Midazolam and fentanyl were administered IV to comfort the patient while maintaining responsiveness to verbal stimuli. The region intended for catheter dressing application was shaved; the area was sterilely prepared with povidone, and a sterile drape was applied. The ultrasound machine was readied for use with a 13–6-MHz linear array ultrasound transducer (HFL38, M-Turbo; SonoSite Inc, Bothell, WA) placed in a sterile sleeve. The inguinal ligament was recognized and divided into three equal parts between the pubic tubercle and the anterior superior iliac spine (ASIS). A short-axis (cross-section) ultrasound view of the inguinal ligament area identified the fascia iliaca, femoral nerve, and vessels. The ultrasound transducer was located along the lateral one-third of a line joining the anterior superior iliac spine (ASIS) and pubic tubercle (PT) targeting the compartment between fascia iliaca and fascia lata. Rotating the transducer 90 degrees obtained a long-axis ultrasound view (Figure 1). Transducer orientation was now parallel with the femoral nerve and vessels. The transducer was then positioned laterally to the border of the middle and lateral third of the inguinal ligament. The transducer was placed in its

previous position, and the ilium, iliacus muscle, and fascia were again identified.

Fig 1: A. long-axis image; B. Short axis image of a femoral nerve at the inguinal crease with an in-plane catheter inserted. A indicates femoral artery; arrowheads, the distal end of the catheter; and N, femoral nerve

The 22 gauge 100mm Tuohy-tip needle was inserted approximately 1–2 cm below the inguinal ligament in-plane with the transducer directed cephalad. The needle shaft and tip were easily identified with ultrasound imaging. The needle was inserted until a loss of resistance was felt as the fascia lata was passed, and further advanced until the second loss of resistance occurred when the fascia iliaca was pierced. Five milliliters of saline (0.9% sodium chloride) was injected to verify the appropriate position of the needle tip with perineural spread of the saline.

The needle was withdrawn and redirected as necessary until this end point was reached. The catheter was inserted via the sheath through the needle and advanced 3 to 5 cm beyond the needle tip anteriorly to the nerve under ultrasound visualization. All catheters were fixed to the skin with a snap-lock and covered by a transparent dressing before the local anesthetic was injected. At the end of surgery, all patients' catheters were attached to an electronic infusion pump delivering an infusion of 0.2% Ropivacaine (basal rate of 4 mL/h; patient-controlled bolus of 5 mL; and lockout interval of 30 minutes).

2.4 Outcome measurements

The Socio-demographic and surgical procedures were documented (age, sex, weight, height, BMI, ASA score, and duration of surgery). The primary outcome defined as the 0.2% ropivacaine consumption during the 48 postoperative hours. Sensory blockades of femoral nerve and lateral femoral cutaneous nerve were determined by pinprick testing, and the block quality was determined by criteria as follows: (3=normal sensation, 2= dull sensation; 1= barely perceptible; 0= no sensation, with a score equal or less than 2 considered adequate sensory blockade)^{14, 15} by a blinded research

assistant every 6 hours for up to 48 hours. A patient without sensory anesthesia at 48 hours was considered to have had catheter displacement. Motor block was also measured every 6 hours up to 48 hours by assessing the following motor functions: by muscle strength graded according to the following scale: 0; no palpable or observable muscle contraction, 1; palpable or observable contraction without motion, 2; moves without gravity loading over the full range of motion, 3; moves against gravity over the full range of motion, 4; moves against gravity and moderate resistance over the full range of motion, 5; moves against gravity and maximal resistance over the full range of motion with the flexion and extension of the knee. Adequate sensory blockade was define as muscle strength graded of 1 or less.

The secondary outcomes were postoperative pain score quantified as NRS score at Rest and on Movement, from 0 ("no pain") to 10 ("worst possible pain").

2.5 Statistical analysis

Analyses were carried out using the statistical package SPSS for Windows (V.18.0, Chicago, IL, USA). Continuous variables are presented as mean (Standard deviation, SD). Categorical variables are reported as a number of subjects (percentage). Normality of distribution was estimated with the Kolmogorov-Smirnov test. Continuous data with normal distribution were compared using the Student t test. Continuous data with non-normal distribution as well as ordinal variables were compared using the Wilcoxon-Mann-Whitney U test. Comparisons of categorical variables were based on W2 test or Fisher exact test as appropriate.

3 Results

3.1 Socio-demographics and surgical procedures

The total number of patients who have undergone surgery and been observed in this study were 26, with 13(50%) patients from the short-axis and 13(50%) from the long-axis. With regards to gender, almost 54% are females and the remaining 46% are males (Table 1). There was no statistical significance between the groups in demographic variables and surgical procedures.

3.2 Procedural time of catheter placement and hemodynamic changes

The difference in procedural time including time for wearing gloves and disinfection, time for ultrasound scanning, time required for catheterization, catheter depth and hemodynamic changes in systolic blood pressure and diastolic blood pressure between the short-axis and long-axis groups were compared (Table 2). As expected, there was no statistically significant difference between the short-axis and long-axis groups. Time required for ultrasound scanning and catheterization in the short-axis group is marginally reduced than in the long-axis group. Similarly, no significant difference was observed in hemodynamic changes between the two groups, except for systolic blood pressure in the first 5 minutes ($p=0.029$).

Table 1: Socio-demographics and surgical procedures related parameters (n = 26)

Variable	Short-Axis (n = 13)	Long-Axis (n = 13)	P
Gender			
Male	5 (38.5)	7 (53.8)	0.429
Female	8 (61.5)	6 (46.2)	
Age,yrs	55.6 (13.54)	59.0 (18.78)	0.272
Weight,	61.0 (10.07)	62.0 (9.31)	0.281
Height	160.0 (6.03)	166.0(9.21)	0.053
BMI	25.1 (3.56)	23.5 (3.70)	0.071
Intra-operative drugs			
Propofol	183.4 (88.37)	164.6 (139.20)	0.148
Sufentanil	17.6 (11.47)	16.9 (7.51)	0.057
Remifental	235.3 (347.38)	123.0(213.82)	0.835
Surgery time	217.5 (103.60)	211.0 (92.40)	0.434

Data are presented as the Mean (Standard deviation) except for Gender that is presented as number (%). $P < 0.05$ compared with The Short-Axis and Long-Axis

3.3 Sensory and Motor Blockade at Measured Time Points

The sensory and motor blocks were similar in the two groups, femoral and lateral femoral cutaneous nerves blockade were similarly maintained in the two groups, while muscle strength graded was 84% and 83% in short-axis group and long-axis group respectively until 6 hours postoperative then started to decrease similarly in the two groups (Table 3).

3.4 Cumulative Ropivacaine Consumption

The use of 0.2% ropivacaine in 48 hours was analyzed, and there were no statistically significant differences between two groups at any time point (Figure 2).

Fig 2: Ropivacaine, 0.2%, was infused up to 48 hours at 4 mL/h in both group. Culmative use of ropivacaine (ml) was recorded, mean (standard deviation) values are illustrated.

There were no statistically significant differences between treatments at any time point

Table 2: Procedural time of catheter placement and hemodynamic changes (n = 1)

Variable	Short-Axis	Long-Axis	P
Ultrasound Time	Mean (SD)	Mean (SD)	
Wear gloves- disinfection	71.6 (13.1)	77.2 (15.7)	0.104
Ultrasound Imaging Time	88.0 (17.6)	114.1(8.0)	0.082
Catheterization Time	117.5(13.6)	133.2(21.5)	0.091
Catheter depth	7.07(1.03)	9.53(1.05)	0.174

Systolic blood pressure

5 min	130.0 (25.4)	123.0 (19.9)	0.029
10 min	125.6 (18.4)	115 (17.8)	0.078
15 min	124 (19.9)	116.6 (18.5)	0.190
20 min	129.0 (21.3)	119.0 (15.5)	0.115
25 min	122.0 (23.0)	118.0 (15.2)	0.053
30 min	113.0 (15.0)	118.0(14.0)	0.091

Diastolic blood pressure

5 min	78.0 (10.2)	72.0 (13.0)	0.210
10 min	79.3 (15.0)	67.4 (10.0)	0.117
15 min	68.0 (10.3)	67.2 (9.0)	0.089
20 min	72.0 (11.0)	69.0 (8.3)	0.190
25 min	68.0 (10.0)	66.0 (8.0)	0.191
30 min	66.4 (9.0)	65.0 (6.0)	0.132

Data are presented as the Mean, (Standard deviation). $P < 0.05$ compared with The Short-Axis and Long-Axis

3.5 Numeric Rating Scale at different time interval

Figure 3, here was no significant changes noted in the numeric rating scale at rest after procedure ($P > .05$, Figure 3). There were also no significant differences in pain scores noted on numeric rating scale at the movement (Figure 4).

4 Discussion

Hip fracture is painful, but the evidence on pain management after hip fracture was surprisingly sparse. Pain management in Tongji hospital is based upon the use of systemic analgesia according to local protocols. Several approaches exist for managing postoperative pain after hip arthroplasty. The aims of each remain the same: to minimize pain while avoiding the side

effects of excess administration of analgesics and not delaying the rehabilitation.

Fig 3: (Rest) NRS pain scores 0, 6, 12, 18, 24,30,36,42 and 48 hours after FIC block performance, (NRS score, 0 = absolute no pain, 10 = worst possible pain). NRS (0-10) = indicates numeric rating scale

Table 3: Adequate Sensory and Motor Blockade at Measured Time Points in two groups.

Time (hours) after block	Short-Axis	Long-Axis
Femoral nerve	(n %)	(n %)
0 Hour	13(100)	13(100)
6 Hours	13(100)	13(100)
12 Hours	13(100)	13(100)
24 Hours	11 (82)	11 (79)
48 Hours	9 (69)	9 (65)
Lateral Cutaneous Femoral Nerve		
0 Hour	13(100)	13(100)
6 Hours	13(100)	13(100)
12 Hours	13(100)	13(100)
24 Hours	11 (82)	11 (79)
48 Hours	9 (75)	9 (74)
muscle strength graded		
0 Hour	12 (84)	12 (83)
6 Hours	11 (82)	12 (83)
12 Hours	10 (78)	10 (75)
24 Hours	10 (72)	10 (68)
48 Hours	9 (69)	8(66)

Values are presented as number (percentages), No significant difference between the two groups

Fig 4: (Movement) NRS pain scores 0, 6, 12, 18, 24,30,36,42 and 48 hours after FIC block performance, (NRS score, 0 = absolute no pain, 10 = worst possible pain). NRS (0-10) = indicates numeric rating scale

This study shows possible benefits effect of ultrasound-guided continuous fascia iliaca compartment block using either a short-axis in-plane technique or a long-axis in-plane technique for pain management in patients undergoing hip arthroplasty. Thus, by means of adding an ultrasound guided fascia iliaca compartment block to the standard protocol, the intravenous anesthesia use can be decreased thereby lowering the risk of important side-effects.

This study is prospective, randomized clinical trial to compare ropivacaine consumption during the 48 postoperative hours as the primary outcome for the short-axis in-plane technique versus long-axis in-plane ultrasound-guided continuous fascial iliaca compartment. Our data demonstrated that a short-axis in-plane technique require less time to complete sensory blockade compared with the long-axis in-plane approach.

For ultrasound-guided continuous fascia iliaca compartment block, a short-axis in-plane technique results in a small decrease in the procedural time to complete catheter placement compared to the long-axis in-plane approach.

The pain management of hip replacement patients, in postoperatively, there was no significant differences noted in the numeric rating scale at rest after operation ($P > .05$, Figure 3) and also were no significant differences in pain scores noted on numeric rating scale at the movement. (Figure 4). The distribution of sensory and motor block obtained by ultrasound-guided using a short-axis in-plane technique or a long-axis in-plane technique was similar after the loading dose. The obturator nerve has been reported cannot be blocked by this technique, so we did not test it in our study. During the study, the block quality started to decrease particularly at 24 hours after surgery. This can be explained by the lower volume of the local anesthetic given as infusion than the loading dose. This is in agreement with the result of other study¹⁶.

We consider this difference might achieve statistical significance if the sample size was approximately 100 per group because of the large SD noted in the sample. Performance of the study with 100 subjects per group would prove to be difficult because of time constraints; however, we were satisfied with the analgesic effects reported in two groups. We are also happy to see that the short-axis and long-axis groups are comparable in sensory block and motor block. Furthermore, all subjects were satisfied with the postoperative analgesia. When queried, only 1 patient reported the favorite for intravenous analgesia.

The results support the findings of Fournier *et al.*¹⁷ that the average length of time to first analgesic request was nearly 492 minutes when the 3-in-1 block was used in combination with general anesthesia. The 3-in-1 block has frequently been the peripheral nerve block of choice for lower-extremity surgery and was introduced by Winnie *et al.*¹⁸. Its main benefit continues to be the ability to block the femoral, LFC, but spare of obturator nerves. Although this method appeared to be effective, some studies propose that it can be technically difficult in the indicators of inexperienced, recently trained anesthesia providers. Prior studies have shown a success rate of achieving blockade as low as 20%, which has been related to its difficulty in placement^{19,20}.

In our study, we report two minor complications (hypothermia, hypotension). There has been only one patient reporting the complication after the block. We used single bolus injection of 0.2% ropivacaine. Ropivacaine produces good sensory block with less motor block which is very useful in initial ambulation in the postoperative period and the cardiotoxic adverse effects are minimal compared to bupivacaine. This has been proved by a trial on therapeutic use of ropivacaine in regional anesthesia done by Markham *et al.*²⁰.

Elizabeth Dulaney-Cripe *et al.*²¹. Established the benefits of a continuous fascia iliaca compartment block positioned post-operatively when combined with a comprehensive pain protocol as measured by pain score, opioid consumption, and hospital length of stay. Many other studies have demonstrated the morphine sparing effect of FICB in lower limb surgery²².

This indicates that the FICB with a single bolus of 0.2 % ropivacaine is very effective in providing considerable pain relief in common of the patients in the first 0-6 hours. Vital parameters were monitored for every 5 minutes at regular intervals during catheterization. All the parameters were within suitable range implying the block did not produce any significant hemodynamic changes.

In summary, ultrasound-guided continuous fascia iliaca compartment block, using a short-axis in-plane technique may have a reduced procedural time and was easier to perform than the long-axis in-plane group. Long-axis in-plane technique did not offer new clinical advantages compared to the previously validated short-axis in-plane technique.

5 Conclusion

With this study, we conclude that there is no significant difference in ropivacaine consumption during 48 postoperative hours for lower limb surgery patients between the short-axis in-plane group and long-axis in-plane group of continuous fascia iliaca compartment block. However, the short-axis in-plane group spend less procedural time and was easier to perform than the long-axis in-plane group.

More multicenter trials of the two techniques in a large sample size are supposed to be done in the future.

6 Conflict of Interest

There are no conflicts of interest.

7 Author's contributions

AAB and MW conducting study, interpreted data and draft the manuscript. Both authors approved the paper for publication.

8 References

1. Marhofer P, Greher M, Kapral S. Ultrasound guidance in regional anaesthesia. *Br J Anaesth*. 2005; 94: 7–17.
2. Grau T, Leipold RW, Conradi R, Martin E, Motsch J. Efficacy of ultrasound imaging in obstetric epidural anesthesia. *J Clin Anesth* 2002; 14: 169–75.
3. Peterson MK, Millar FA, Sheppard DG. Ultrasound-guided nerve blocks. *Br J Anaesth* 2002; 88:621–624.
4. Van Norman GA, Jackson S, Rosenbaum SH, Palmer SK: *Clinical Ethics in Anesthesiology: A Case-Based Textbook*. Cambridge Medicine, 2011.
5. Singelyn FJ, Deyaert M, Joris D. Effects of intravenous patient-controlled analgesia with morphine, continuous epidural analgesia, and continuous three-in-one block on postoperative pain and knee rehabilitation after unilateral total knee arthroplasty. *Anesth Analg*. 1998; 87:88–92.
6. Capdevila X, Barthelet Y, Biboulet P. Effects of perioperative analgesic technique on the surgical outcome and duration of rehabilitation after major knee surgery. *Anesthesiology*. 1999; 91:8–15.
7. Chelly JE, Delaunay L, Williams B, Borghi B. Outpatient lower extremity infusions. *Best Pract Res Clin Anaesthesiol*. 2002; 16: 311–20.
8. Winnie AP, Ramamurthy S, Durrani Z. The inguinal paravascular technic of lumbar plexus anesthesia: the "3-in-1 block." *Anesth Analg*. 1973; 52(6):989-996.
9. Ilfeld BM, Fredrickson MJ, Mariano ER. Ultrasound-guided perineural catheter insertion: three approaches but few illuminating data. *Reg Anesth Pain Med*. 2010; 35:123–126.
10. Bouaziz H, Bondar A, Jochum D. Regional anesthesia practice for total knee arthroplasty: French national

- survey – 2008. *Annales Franc raises d'Anesthesie et de Reanimation*. 2010; 29: 440–51.
11. Eledjam JJ, Cuvillon P, Capdevila X. Postoperative analgesia by femoral nerve block with ropivacaine 0.2% after major knee surgery: continuous versus patient-controlled techniques. *Reg Anesth Pain Med*. 2002; 27: 604–11.
 12. Vandepitte C, Gautier P, Xu D, Salviz EA, Hadzic A. Effective volume of ropivacaine 0.75% through a catheter required for inter scalene brachial plexus blockade. *Anesthesiology*. 2013; 118: 863–7.
 13. Taha AM, Abd-Elmaksoud AM. Lidocaine use in ultrasound guided femoral nerve block: what is the minimum effective anesthetic concentration (MEAC90)? *Br J Anaesth*. 2013; 110: 1040–4.
 14. Giaufre E, Dalens B, Gombert A. Epidemiology and morbidity of regional anesthesia in children: a one-year prospective survey of the French-Language Society of Pediatric Anesthesiologists. *Anesth Analg*. 1996; 83:904–12.
 15. Dalens B, Vanneuville G, Tanguy A. Comparison of the fascia iliaca compartment block with the 3-in-1 block in children. *Anesth Analg*. 1989; 69:705–13.
 16. Gray AT. *Atlas of Ultrasound-Guided Regional Anesthesia*, 1st edn. Philadelphia, PA: Saunders Elsevier, 2010; 29–32.
 17. Fournier R, Van Gessel E, Gaggero G, Boccovi S, Forster A, Gamulin Z. Postoperative analgesia with 3-in-1 femoral nerve block after prosthetic hip surgery. *Can J Anesth*. 1998; 46(1):34-38.
 18. Winnie AP, Ramamurthy S, Durrani Z. The inguinal paravascular technic of lumbar plexus anesthesia: the “3-in-1 block.” *Anesth Analg*. 1973; 52(6):989-996.
 19. Fournier R, Van Gessel E, Gaggero G, Boccovi S, Forster A, Gamulin Z. Postoperative analgesia with 3-in-1 femoral nerve block after prosthetic hip surgery. *Can J Anesth*. 1998; 46(1):34-38.
 20. Markham A, Faulds D. Ropivacaine. *Drugs*. 2012; 31; 52(3):429–49.
 21. Dulaney-Cripe E, Hadaway S, Bauman R, Trame C, Smith C, Sillaman B, et al. A continuous infusion fascia iliaca compartment block in hip fracture patients: a pilot study. *J Clin Med Res*. 2012; 4 (1):45.
 22. Dupre LJ. Three-in-one block or femoral nerve block: what should be done and how [French]? *Ann Fr Anesth Reanim*. 1996; 15(7):1099-1101.