Archives of Anesthesiology and Critical Care (Summer 2024); 10(3): 239-246.

Available online at http://aacc.tums.ac.ir

Research Article

Comparison of Analgesia Produced by Preoperative Ultrasound-Guided Femoral Nerve Blocks and Postoperative Intravenous Administration of Opioids in Patients Undergoing Hip Replacement Surgery

Moloud Zolfaqari[1], Mehrdad Mokaram Dori[1], Seyed Hossein Khademi[1], Mehryar Taghavi Gilani[2], Maliheh Ziaee[3]*, Tayyebe Ghanei[4]

[1]*Department of Anesthesiology, School of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran.*

[2]*Lung Diseases Research Center, Mashhad University of Medical Sciences, Mashhad, Iran.*

[3]*Department of Community Medicine, School of Medicine, Social Determinants of Health Research Center, Gonabad University of Medical Sciences, Gonabad, Iran.*

[4]*Department of Anesthesiology, Mashhad University of Medical Science, Mashhad, Iran.*

ARTICLE INFO

Article history:
Received 25 June 2023
Revised 16 July 2023
Accepted 29 July 2023

Keywords:
Hip joint;
Analgesia;
Nerve block;
Opioid;
Femur;
Morphine;
Ultrasound;
Pain

ABSTRACT

Background: Perioperative pain management can improve surgery results and patient outcomes. Moreover, multimodal methods for pain control have been advised so this study was conducted to assess the beneficial impact of preoperative ultrasound-guided femoral nerve blocks in hip replacement surgery.
Methods: This study is a double-blinded clinical trial including 60 individuals who were candidates for joint replacement surgery. The intervention group (n = 30) received a femoral nerve block prior to general anesthesia.
Results: After surgery, patients received morphine, Apotel, and morphine + Apotel, all of which were administered at lower doses in the intervention group (femoral nerve block) than in the control group. Pain intensity in first hour (P= 0.01), 4 hours (P= 0.003), 8 hours (P= 0.01), 12 hours (P= 0.001), and 24 hours (P= 0.01) after surgery and average pain 4 hours (P= 0.01), 8 hours (P = 0.01), 12 hours (P = 0.02), and 24 hours (P= 0.01) after surgery was significantly less in the intervention group (femoral nerve block) than in the control group.
Conclusion: The findings of our investigation demonstrated the efficacy of ultrasound-guided femoral nerve blocks in the improvement of pain control following hip replacement surgery.

Introduction

The gold standard for treating severe osteoarthritis in people who have not responded to conservative therapy is the total hip replacement [1]. Additionally, congenital abnormalities, trauma, Paget's disease, femoral head osteonecrosis, SLE, ankylosing spondylitis, and rheumatoid arthritis may be indications for this surgery [2]. Ninety percent of patients who are adequately selected for this procedure have total pain relief and considerable improvement in function [3-4]. As a result, this procedure has garnered the interest of several academics and clinicians in recent years [5]. Each year, roughly 170,000 people in the United States and nearly 300,000 people globally receive total hip replacement

The authors declare no conflicts of interest.
*Corresponding author.
E-mail address: malihehziaee@gmail.com

surgery [6-7]. Wiles conducted the procedure for the first time in 1938 in London. McKee and Farrar completed their work in the 1950s. Finally, Charnley's activities in 1960, which were based on the biomechanical and functional principles of the hip joint, led to the development of a new standard arthroplasty technique that is still used in many facilities today [8].

Given the critical nature of postoperative pain control, which can result in both short-term (such as reducing pain associated with surgery and speeding recovery) and long-term (such as reducing chronic pain and improving quality of life) benefits [9], analgesics and narcotics are frequently used to alleviate postoperative pain. Opioids may cause respiratory depression, nausea and vomiting, pruritus, and urine retention [10-12]. Due to the difficulties above, several studies have shown that a femoral nerve block may be an efficient strategy to prevent postoperative discomfort and morbidity [10]. Nerve block analgesia is a short-term process that typically lasts between a few hours and several days. It is conducted by injecting local anesthetics, corticosteroids, and other medicines into or near the nerve network [13]. Additionally, it provides great analgesia following surgery, leading to less opioid consumption and fewer adverse effects [14].

The femoral nerve block is one of the most straightforward methods available and is ideal for anterior thigh surgery and postoperative pain control [14]. The advantages of the blockade, such as ultrasound-guided femoral nerve block, include improved nerve localization, less spent time, decreased demanding dose for local anesthetic, increased visibility of how and where local anesthetic is supplied, and decreased risk of local anesthetic toxicity, a faster and more complete onset of nerve block, a longer duration of sensory and motor nerve block, fewer complications compared to other methods of analgesia like continuous infusion or intermittent administration of opioids, and increased patient satisfaction [15]. Aziz et al. concluded in 2009 that the ultrasound-induced nerve block promotes analgesia to begin earlier and last longer [16]. Munirama et al. (2015) discovered that the rate of pain alleviation was larger with ultrasound-guided nerve block than with nerve stimulator alone, and the rate of vascular damage was lower with ultrasound guidance [17]. Joana Zulian et al. (2019) compared different doses of ropivacaine (0.25% or 0.375%) for femoral nerve block and subarachnoid injection of morphine (100 micrograms) for postoperative pain control of anterior cruciate ligament surgery and showed no difference in analgesic efficacy among three groups [18]. Philippe Biboulet 1, Didier Morau, Pierre Aubaset al. (2003) investigated VAS scores and morphine consumption after total hip arthroplasty surgery with three postoperative pain management methods of femoral nerve block, psoas compartment nerve block (PCB), and patient control analgesia (PCA) with morphine and found less morphine consumption in PCB group in first 4 hours but no difference in VAS scores and morphine consumption between three groups after 4 hours [19]. Given the scarcity of research on preoperative ultrasound-guided femoral nerve blocks across the world and in our nation and recent advancements in ultrasonography technology for administering nerve blocks, the purpose of this study was to assess the beneficial impact of preoperative ultrasound-guided femoral nerve blocks in hip replacement surgery.

Objective of the study: This study aimed to compare the analgesia provided by preoperative ultrasound-guided femoral nerve block and postoperative intravenous administration of opioids in patients undergoing hip replacement surgery.

Methods

The present study was a block-randomized and double-blind clinical trial. We conducted a parallel-group, superiority trial in a referral center. This study was registered in the registry of clinical trials (http://www.irct.ir)IRCT number: IRCT20150826023772N2.

It was conducted based on the guidelines of the Declaration of Helsinki and its study method was approved by the Ethical Committee of Mashhad University of Medical Sciences (code: IR.MUMS.MEDICAL.REC.1399.610). All participants signed a written informed consent approved in advance by the Ethical Committee.

Patients referred to Imam Reza Hospital in Mashhad between July 2020 and July 2021 who were candidates for hip replacement surgery were included in the present study if they had an ASA class 1 or 2 and provided informed consent to participate in the project. Patients were also given the option to withdraw from the study if they so desired. The exclusion criteria were hemodynamic instability, a history of local anesthetic allergy, shock, any unpredictable event during surgery that may last surgery time more than 150 minutes and the emergence or diagnosis of a new condition such as multiple sclerosis. While the sample size for the study was calculated using the independent sample t-test and the values provided in the "Pre-operative Femoral Nerve Block in Hip Arthroscopic Surgery" study [20], the sample size was obtained a total of 27 and accounting for 10% dropout, the sample size in the present study was considered 30.

Patients were randomly assigned to intervention or control groups using www.randomization.com's random number table. One of the study team members printed the letters A (intervention group) and B (control group) and placed them inside the envelope. The envelopes were sealed, and their contents were hidden. Then, each patient opened an envelope and was assigned to the intervention or control group.

Our primary outcome was a comparison of pain intensity using the NRS between intervention and control groups. Also, the secondary outcome was the assessment of pain intensity in any group after taking the intervention.

40 people were selected for the case group, of which 10 were excluded due to dissatisfaction with the continuation of the study (Figure1).

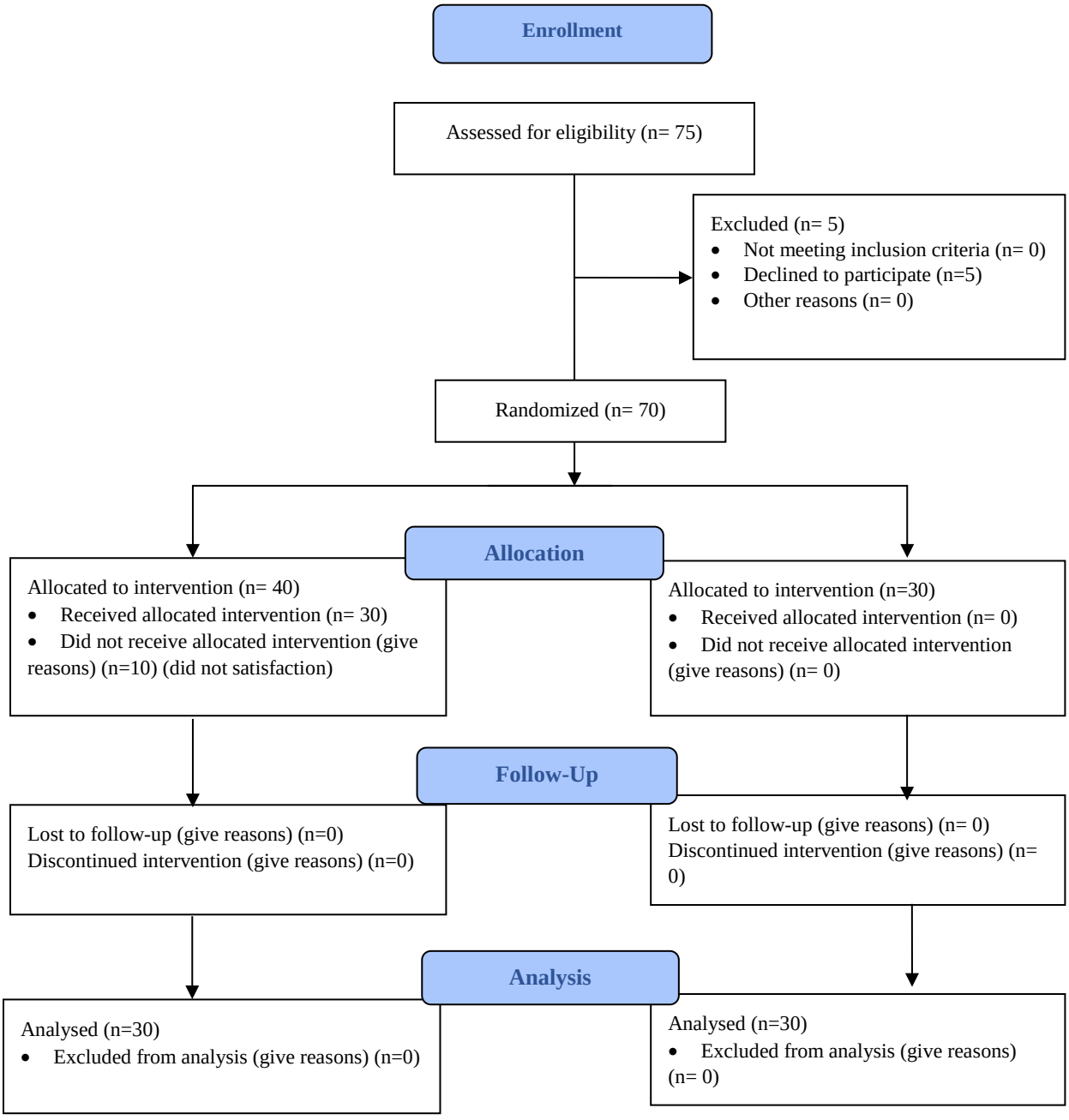

Figure 1- CONSORT flow chart

The specified hip surgery team of the Imam-Reza hospital performed the hip replacement surgeries always in less than 150 minutes, in the case of unexpected events or surgery that lasted more, the case was excluded from the study. The femoral nerve block was performed with a 22G nerve stimulator needle (B-BRUN) attached to a nerve stimulator machine (B-BURUN) and the needling was guided by a Sonosite Edge II ultrasound machine with a linear transducer (5-12 Hz). After observing the femoral nerve inplane needling was conducted towards the nerve and after observation of quadriceps muscle contracture with 0.5 mA 11 ml of a solution contained 5

ml of 0.5% Marcaine with 5 ml of 2% lidocaine, and 50 micrograms of fentanyl were injected. Successful perineural infiltration of the local anesthetic mixture was confirmed with ultrasound guidance. After ensuring effective femoral nerve block with wet cotton in the anterior thigh skin for group patients, both groups received general anesthesia with sequential injections of propofol 2 mg/kg, fentanyl 3 µg/kg body weight, and atracurium 0.5 mg/kg body weight. Then, intubation and mechanical ventilation were conducted using an appropriate endotracheal tube and controlled ventilation with a 5 ml/ kg tidal volume with 50% N2O in O2. Anesthesia was maintained with continuous infusion of Propofol 6 mg /kg/ h and fentanyl 1 µg / kg with atracurium 0.2 mg/kg body weight every half an hour. Patients in both groups were observed as usual throughout the procedure (ECG, blood pressure, arterial blood oxygen percentage, body temperature, and capnography during general anesthesia).

Pain intensity was assessed by patients based on a scale of 0 to 10. Pain intensity classification was included: mild: 1 to 4, moderate: 5 to 6 and severe: 7 to 10.

All patients were assessed for pain intensity using the NRS at the first hour, 4, 8, 12, and 24 hours following surgery by an observer who was uninformed of the previous type of analgesia. In the event of an NRS greater than 3 in either of the groups, morphine 0.05 mg per kg was injected intravenously and repeated every 4 hours, and paracetamol 1 g was injected intravenously every 6 hours, and the number of injections and drug prescriptions were recorded.

Finally, the data were evaluated statistically using SPSS 24. Due to the normal distribution of the data in the two groups, the t-test was performed to compare them. The chi-square and Fisher's exact tests were also performed to compare grouped data. Repeated measure ANOVA was performed to compare pain intensity means in any group at consecutive stages. A significance threshold of 0.05 was used in all tests. The study groups were unknown to the patients and analysts.

To ascertain high-quality reports in clinical trial studies, the study was conducted following the CONSORT checklist.

Results

Sixty individuals were investigated in this study (30 in the intervention group (femoral nerve block and 30 in the control group). The sex, mean age of the participants and Preoperative mean NRS were not significantly different between the two groups (Table 1).

Patients in both groups had the same protocol of analgesia during surgery of fentanyl 1 µg/kg every 30 minutes and 50% N20 in O2. Patients received injectable medications following surgery if the NRS was reported as more than 3, including morphine 0.05 mg/kg every 4 h and Paracetamol (Apotel) 1g IV infusion in 20 minutes every 6 hours. Analgesic drugs consumed were lower in the intervention group (femoral nerve block) than in the control group.

The Chi-square test revealed that patients' pain intensity was significantly less in the intervention group (femoral nerve block) than in the control group in all consecutive stages after surgery (Table 2).

The t-test revealed that the mean pain experienced by patients in the first hour after surgery was less in the intervention group than in the control group, although this difference was not statistically significant (P = 0.5). However, the intervention group's mean pain was significantly less in the intervention group (femoral nerve block) than in the control group in 4 hours (P = 0.01), 8 hours (P = 0.01), 12 hours (P = 0.02), and 24 hours (P = 0.01) after surgery (Table 3).

The repeated measures ANOVA test revealed that the pain score in consecutive stages (1 to 24 hours) was measured individually in the intervention group (femoral nerve block and GA) and the control group (general anesthesia). The results indicated a significant difference between the mean pain score of patients at different periods in the intervention group (P = 0.01). Comparing mean pain scores revealed that the greatest amount of pain occurred four hours after surgery, and the least amount of pain occurred 24 hours after surgery. However, there was no statistically significant difference in patients' mean pain scores at different periods in the control group (P = 0.4) (Figure2 and 3).

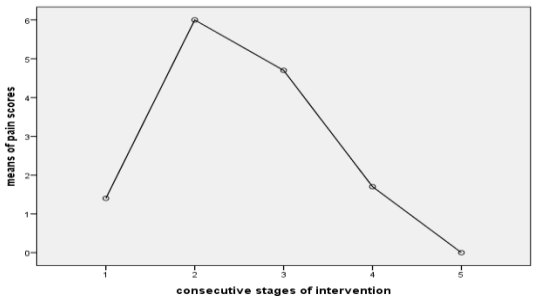

Figure2- mean of pain scores in intervention group at consecutive stages

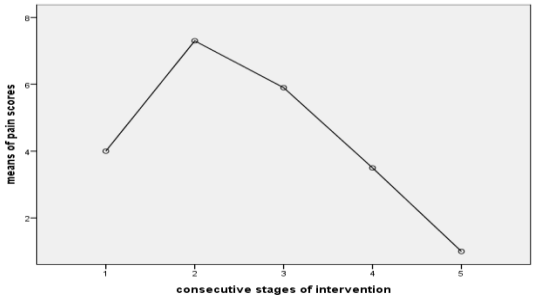

Figure3- mean of pain scores in the control group at consecutive stages

Table1- characteristics of participants

Characteristics	Classification	Intervention group	Control group	P value
Age (M±SD)		46.66±17.85	48.60±19.46	0.06
Sex (N (%))	female	14 (46.7)	10 933.3)	0.21
	male	16 (53.3)	20 (66.7)	
Preparation of pain intensity (M±SD)		2	2.5	0.3

(M±SD): mean± standard deviation
N (%): number (percent)

Table 2-The frequency and comparison of pain severity after surgery in study groups

Pain severity		No pain Frequency (%)	Mild pain Frequency (%)	Moderate pain Frequency (%)	Severe pain Frequency (%)	Total Frequency (%)	P value¥
1 Hour	intervention	16 (100.0)	14 (40.0)	0 (0.0)	0 (0.0)	30 (50.0)	
	Control	0 (0.0)	21 (60.0)	8 (100.0)	1 (100.0)	30 (50.0)	0.01
	Total	16 (100.0)	35 (100.0)	8 (100.0)	1 (100.0)	60 (100.0)	
4 Hour	intervention	-	2 (100.0)	26 (60.5)	2 (13.3)	30 (50.0)	
	Control	-	0 (0.0)	17 (39.5)	13 (86.7)	30 (50.0)	0.003
	Total	-	2 (100.0)	43 (100.0)	15 (100.0)	60 (100.0)	
8 Hour	intervention	3 (100.0)	8 (88.9)	18 (40.0)	1 (33.3)	30 (50.0)	
	Control	0 (0.0)	1 (11.1)	27 (60.0)	2 (66.7)	30 (50.0)	0.01
	Total	3 (100.0)	9 (100.0)	45 (100.0)	3 (100.0)	60 (100.0)	
12	intervention	15 (88.2)	13 (39.4)	2 (20.0)	-	30 (50.0)	
Hour	Control	2 (11.8)	20 (60.6)	8 (80.0)	-	30 (50.0)	0.001
	Total	17 (100.0)	33 (100.0)	10 (100.0)	-	60 (100.0)	
24	intervention	30 (61.2)	0 (0.0)	-	-	30 (50.0)	
Hour	Control	19 (38.8)	11 (100.0)	-	-	30 (50.0)	0.01
	Total	49 (100.0)	11 (100.0)	-	-	(100.0)	

¥: Fisher's exact test or chi-square test

Table 3- The frequency and comparison of mean postoperative pain severity after surgery in study groups

Pain	Groups	Mean	Standard deviation	P value*
1 Hour	intervention	1.40	1.52	0.5
	Control	4.00	1.64	
4 Hour	intervention	6.00	1.11	0.01
	Control	7.30	1.51	
8 Hour	intervention	4.70	2.18	0.01
	Control	5.90	0.96	
12 Hour	intervention	1.70	1.87	0.02
	Control	3.50	1.59	
24 Hour	intervention	0.00	0.00	0.01
	Control	1.00	0.14	

*: T-test

Table 4- The frequency and comparison of administered drugs in the study groups

Administered drugs		Intervention Frequency (%)	Control Frequency (%)	P value*
1 Hour	No drugs	27 (90.0)	12 (40.0)	<0.001
	Morphine	1 (3.3)	4 (13.3)	
	Apotel	2 (6.7)	14 (46.7)	
4 Hour	No drugs	1 (3.3)	-	0.55
	Morphine	26 (86.7)	28 (93.3)	
	Apotel	1 (3.3)	-	
	Morphine and apotel	2 (6.7)	2 (6.7)	
8 Hour	No drugs	8 (26.7)	-	0.009
	Morphine	20 (66.7)	24 (80.0)	

	Apotel	2 (6.7)	3 (10.0)	
	Morphine and Apotel	-	3 (10.0)	
12 Hour	No drugs	19 (63.3)	3 (10.0)	<0.001
	Morphine	11 (36.7)	19 (63.3)	
	Apotel	-	8 (26.7)	
24 Hour	No drugs	30 (100.0)	23 (76.7)	0.005
	Apotel	-	7 (23.3)	

*: chi-square test

Discussion

The consensus of preventive analgesia is based on the pathophysiologic consequences of pain like central sensitization and stress response. Proactive pain management revealed a more successful pain control strategy than reactive pain management. In reactive pain management like PRN orders, the painkillers are prescribed after a patient complains, in this case, the catastrophic domino of the hypothalamus- pituitary-adrenal axis activation and hormonal release can already happen and the patient may be involved with stress response consequences like deep vein thrombosis, graft failure, hyperglycemia and ischemia. Moreover, mismanagement or under treatment of pain delivers intense noxious input to the spinal cord and can facilitate the pain conduction pathways to induce “pain hypersensitivity” and hyper excitability (central sensitization) [21]. Preventing central sensitization with intensive multimodal analgesic interventions could theoretically reduce the intensity or even eliminate acute postoperative pain and hyperalgesia and chronic pain after surgery [21]. The current study demonstrated that a femoral nerve block accompanied by the analgesic regime of the general anesthesia as a multimodal analgesic regime successfully improved average pain reported and reduced analgesic consumption following hip replacement surgery in group A patients. There was not any obvious motor weakness in the two groups after surgery that can be explained by the half-life duration of the local anesthetics when administered during block before surgery and should be metabolized to the lower concentration necessary for motor blocking in recovery and admission period.

Also, the same analgesics were prescribed during general anesthesia for two groups which consisted of fentanyl every half an hour and 50% inhalation of N2O that both have a short half-life and in the limited time of the surgery of fewer than 150 minutes, cumulative effects of the analgesics were not mattered of fact for postoperative analgesia in both groups.

To corroborate our findings, we may refer to Mokaram-dori et al. (2016), who indicated that ultrasound-guided femoral nerve block is accompanied by a high success rate of nerve block, a faster onset of effects, and a longer duration of analgesia [22]. According to the results of a meta-analysis conducted by Kuchalik et al. (2017), peripheral nerve block considerably lowers postoperative pain. Additionally, there was evidence of improved patient satisfaction, less postoperative disorientation, and a shorter hospital stay [23]. Vandebroek et al. discovered in 2013 that patients receiving peripheral nerve block had considerably decreased pain levels at rest and during movement [24]. According to Sites et al. (2004) [25] and Nelson (2003) [26], a femoral nerve block is a straightforward procedure for achieving postoperative analgesia that is associated with few complications and low systemic side effects. Our investigation corroborates the efficacy of femoral nerve block in lowering pain in patients following surgery. However, our study did not investigate patient satisfaction or problems associated with a femoral nerve block, which might be the focus of future research in our nation. Minimizing the severity of patients' postoperative pain has some benefits, including the ability to begin rehabilitation programs earlier and more successfully and to leave the hospital sooner, hence boosting patient satisfaction.

However, in light of the purpose of our study, which was to compare the analgesia provided by femoral nerve block versus postoperative intravenous opioid injection in the management of a patient's pain, it should be noted that few studies have been conducted to examine the role of femoral nerve block in reducing postoperative pain and the need for analgesics [25-30]. In this context, Li et al. (2021) [31] and Wu et al. (2021) [32] indicated in their investigations that the femoral nerve block improves analgesia and decreases opioid consumption following surgery, hence improving recovery. Kadic et al. A clinical investigation indicated that femoral nerve block is an effective means of reducing morphine usage and allowing for early recuperation; however, it does not provide a substantial functional improvement over morphine use [29]. Beaudoin et al. performed femoral nerve blocking on 13 patients with hip fractures in 2010 and discovered that this approach was safe and helpful and a viable alternative to opioid usage [30]. In a 1998 double-blind clinical research, Allen et al. concluded that peripheral nerve block is a highly feasible option for analgesia following knee replacement surgery. Additionally, they discovered that this technique reduced opioid use by 50–67% when compared to the control group [27].

Regarding the research completed in our country in this field, we can also refer to Rahimzadeh et al. (2015), who reported that the femoral nerve block resulted in more

satisfaction, and a greater reduction in pain [33], which is consistent with our findings.

Limitation and future direction

Given the paucity of research and clinical data in this area and the limitations of our investigation, more studies with bigger sample numbers and longer follow-up intervals are advised in the future.

Conclusion

Reduced pain following surgery, particularly painful surgeries such as hip replacement, is critical for both patients and health and insurance systems, as well as hospitals; it reduces many of the patients' complications, shortens the length of hospital stay and treatment costs, and ultimately increases patient satisfaction, decreases postoperative pain time, and allows patients to return to normal activities more rapidly. Given that femoral nerve block is one of the most effective methods of pain control following lower limb surgery, and given the recent advances in ultrasonography technique for performing nerve blocks, as well as the results of our study, it appears that preoperative ultrasound-guided femoral nerve block, due to its sufficient efficiency and effectiveness, as a part of multimodal analgesia regime is a suitable modality for pain management after hip replacement surgery.

Acknowledgments

This research was financially supported by Mashhad University of Medical Sciences Vice Chancellor for Research. We would like to express our gratitude to the deputy and Imam Reza (AS) Hospital in Mashhad for their assistance.

References

[1] Borrero S, Kwoh CK, Sartorius J, Ibrahim SA. Brief report: Gender and total knee/hip arthroplasty utilization rate in the VA system. J Gen Intern Med. 2006; 21 Suppl 3:S54-7.

[2] Keisu KS, Orozco F, Sharkey PF, Hozack WJ, Rothman RH, McGuigan FX. Primary cementless total hip arthroplasty in oc togenarians. Two to eleven-year follow-up. J Bone Joint Surg Am. 2001; 83-A(3):359-63

[3] Lachiewicz PF, Messick P. Precoated femoral component in primary hybrid total hip arthroplasty: results at a mean 10-year follow-up. J Arthroplasty. 2003; 18(1):1-5.

[4] Meding JB, Ritter MA, Keating EM, Faris PM, Edmondson K. A comparison of collared and collarless femoral components in primary cemented total hip arthroplasty: a randomized clinical trial. J Arthroplasty. 1999; 14(2):123-30

[5] Uo MH, Gilbert NF, Parvizi J. What's new in total hip arthroplasty? J Bone Joint Surg Am. 2007; 89(8):1874-85.

[6] Siopack JS, Jergesen HE. Total hip arthroplasty. West J Med. 1995; 162(3):243-9.

[7] Zhan C, Kaczmarek R, Loyo-Berrios N, Sangl J, Bright RA. Incidence and short-term outcomes of primary and revision hip replacement in the United States. J Bone Joint Surg Am. 2007; 89(3):526-33.

[8] Harris WH, Maloney WJ. Hybrid total hip arthroplasty. Clin or Orthop Relat Res. 1989; (249):21-9.

[9] Robert W. Acute Postoperative Pain.in: Miller R.D. Miller's Anesthesia. 7th ed. California; Elsevier. 2010:2757-71, 1652-3, 2757-2760.

[10] Sites BD, Beach M, Gallagher JD, Jarrett RA, Sparks MB, Lundberg CJ. A single injection ultrasound–assisted femoral nerve block provides side effect-sparing analgesia when compared with intrathecal morphine in patients undergoing total knee arthroplasty. Anesth Analg. 2004; 99(5): 1539-43.

[11] Capdevila X, Barthelet Y, Biboulet P, Ryckwaert Y, Rubenovitch J, d'Athis F. Effects of perioperative analgesic technique on the surgical outcome and duration of rehabilitation after major knee surgery. Anesthesiology. 1999; 91(1):8-15.

[12] Chelly JE, Greger J, Gebhard R, Coupe K, Clyburn TA, Buckle R, Criswell A. Continuous femoral blocks improve recovery and outcome of patients undergoing total knee arthroplasty. J Arthroplasty. 2001; 16(4):436-45.

[13] Prabhakar H, Rath S, Kalaivani M, Bhanderi N. Adrenaline with lidocaine for digital nerve blocks. Cochrane Database Syst Rev. 2015; 2015(3):CD010645.

[14] Abrahams M, Aziz M, Fu R, Horn J-L. Ultrasound guidance compared with electrical neurostimulation for peripheral nerve block: a systematic review and meta-analysis of randomized controlled trials. Br J Anaesth. 2009; 102(3):408.

[15] Marhofer P, Chan VW. Ultrasound-guided regional anesthesia: current concepts and future trends. Anesth Analg. 2007; 104: 1265-9.

[16] Aziz MF, Abrahams MS, Horn JL. Ultrasound guidance compared with electrical neurostimulation for peripheral nerve block. Br J Anaesth. 2009; 102(3):408-17.

[17] Munirama G, McLeod A. systematic review and meta-analysis of ultrasound versus electrical stimulation for peripheral nerve location and blockade. Anesthesia. 2015; 10(6):1111.

[18] Fiorentin JZ, Martins AV, Cañola JM, Gutierrez LC, Perches F, Sakae TM, et al. Comparison between subarachnoid morphine and femoral nerve block for analgesia after knee ligament reconstruction: a randomized clinical trial. Revista Brasileira de Anestesiologia. 2021; 70:613-9.

[19] Biboulet P, Morau D, Aubas P, Bringuier-Branchereau S, Capdevila X. Postoperative

analgesia after total-hip arthroplasty: comparison of intravenous patient-controlled analgesia with morphine and single injection of femoral nerve or psoas compartment block. A prospective, randomized, double-blind study. Reg Anesth Pain Med. 2004; 29(2):102-9.

[20] Wang X, Sun Y, Wang L, Hao X. Femoral nerve block versus fascia iliaca block for pain control in total knee and hip arthroplasty; A meta-analysis from randomized controlled trials. Medicine (Baltimore). 2017; 96(27): e7382.

[21] Michael A. Gropper, Ronald D Miller, Miller's Anesthesia, 9th edition, 2020 Elsevier,ch:81 P2617, ch 24:P 701-2, 704

[22] Mokaram-dori M, Rezaei H, Abadi MK. Femoral nerve block by nerve stimulator with or without ultrasonography guide for postoperative pain management of isolated femoral shaft fracture. Anesthesiology and Pain. 2016; 6(4):26-32.

[23] Kuchalik J, Magnuson A, Lundin A, Gupta G. Local infiltration analgesia or femoral nerve block for postoperative pain management in a patient undergoing total hip arthroplasty. A randomized, double-blind study. Scand J Pain. 2017; 16:223-230.

[24] Vandebroek A, Vertommen M, Huyghe M. Ultrasound-guided femoral nerve block and lateral femoral cutaneous nerve block for postoperative pain control after primary hip arthroplasty. Acta Anaesthesiol Belg. 2014; 65(1):39-44.

[25] Sites BD, Beach ML, Chinn CD, Redborg KE, Gallagher JD. A comparison of sensory and motor loss after a femoral nerve block was conducted with ultrasound versus ultrasound and nerve stimulation. Reg Anesth Pain Med. 2009; 34(5):508-13.

[26] Nielsen KC, Klein SM, Steele SM. Femoral Nerve Blocks. Tech Reg Anesth Pain Manage. 2003; 7(1):8-17.

[27] Allen HW, Liu SS, Ware PD, Nairn CS, Owens BD. Peripheral nerve blocks improve analgesia after total knee replacement surgery. Anesth Analg. 1998; 87(1):93-7.

[28] Szczukowski MJ Jr, Hines JA, Snell JA, Sisca TS. Femoral nerve block for total knee arthroplasty patients: a method to control postoperative pain. J Arthroplasty. 2004; 19(6):720-5.

[29] Kadic L, Boonstra MC, Malefijt DW, Lako SJ, Egmond J, Driessen JJ. Continuous femoral nerve block after total knee arthroplasty? Acta Anaesthesiol Scand. 2009; 53(7):914-20.

[30] Beaudoin FL, Nagdev A, Merchant RC, Becker BM. Ultrasound-guided femoral nerve blocks in elderly patients with hip fractures. Am J Emerg Med. 2010; 28(1):76-81.

[31] Li J, Dai F, Ayala KE, Zhou B, Schonberger RB, Sharma A. Transmuscular Quadratus Lumborum and Lateral Femoral Cutaneous Nerve Block in Total Hip Arthroplasty. Clin J Pain. 2021; 37(5):366-371.

[32] Wu Y, Hu J, Xu M, Yang J. A Commentary on "Transmuscular Quadratus Lumborum and Lateral Femoral Cutaneous Nerve Block in Total Hip Arthroplasty. Clin J Pain. 2021; 37(10):788.

[33] Rahimzadeh P, Imani F, Feiz H, Khaladbarin A, Abbasi A. Interventional study of ultrasound-guided femoral nerve block in adductor canal and comparison with the classical method in relieving pain after elective knee surgery. Anesthesiology and Pain. 2015; 6(3):1-8.