ORIGINAL ARTICLE

THE EFFECTS OF REGIONAL ANESTHESIA TECHNIQUES USED IN INTERTROCHANTERIC FEMUR FRACTURE SURGERY ON HEMODYNAMIC AND CARDIAC FUNCTIONS IN GERIATRIC PATIENTS

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Abstract

Introduction: In the geriatric patient group, various regional anesthesia methods can be used for anesthesia in intertrochanteric femur fracture, which is frequently encountered. This study aimed to evaluate the echocardiographic effects of various regional anesthesia techniques applied in intertrochanteric femur fracture surgeries.

Materials and Method: This prospective, observational study included 64 patients aged 60–100 years, classified as American Society of Anesthesiologists score I–IV risk group, who were scheduled to undergo intertrochanteric femur fracture surgery. Patients were divided into Group SA (n=32): spinal anesthesia, and Group LP+SP (n=30): lumbar and sacral plexus block. The primary outcome measure was the ejection fraction measured by the modified Simpson method; the secondary outcome measures were ejection fraction measurement by the fractional shortening method, mitral and aortic valve Doppler measurement results, intraoperative blood pressure monitoring, amounts of intravenously administered fluids, entropy values.

Results: In the intragroup evaluation, when the baseline ejection fraction values were compared with the ejection fraction values at the 20th minute after the procedure, a statistically significant decrease was observed in both groups ($p<0.05$). In the intergroup evaluation, a statistically significant difference was found in ejection fraction measurement values at the 20th minute after the procedure, with lower values observed in the spinal anesthesia group ($p<0.05$).

Conclusion: The results of this study indicate that spinal anesthesia has a greater impact on the cardiovascular system compared to lumbar and sacral plexus block.

Keywords: Geriatrics; Anesthesia, Spinal; Frailty; Echocardiography.

INTRODUCTION

Intertrochanteric femur fracture (IFF) surgery is a frequently performed procedure, especially in elderly patients. The high prevalence of comorbidities may increase mortality and morbidity rates (1). The determination of the anesthesia method depends on various medical factors such as the patient's age, existing diseases, type of surgery, and the risks of anesthesia application. Spinal anesthesia is the most widely preferred regional anesthesia method in adult orthopedic lower extremity surgeries (2). Spinal anesthesia results in differences in stroke volume, heart rate, cardiac output, vascular resistance, and arterial blood pressure. The most common complication associated with spinal anesthesia is hypotension. With inhibition of the sympathetic system, systemic vascular resistance and cardiac output decrease; if bradycardia is added to this, hypotension may occur. These changes associated with spinal anesthesia may pose challenges in perioperative management, particularly in elderly and frail patients. Lumbar plexus block and combined parasacral sciatic nerve block can also be used to provide anesthesia in lower extremity surgeries. Previous studies have indicated that the combination of lumbar plexus and parasacral sciatic nerve blocks provides anesthesia associated with minimal hemodynamic fluctuations and a reduced influence on the cardiovascular system when compared with general or neuraxial anesthesia techniques (3-5). On the other hand, postoperative mortality is also important for these patients. There are studies showing that mortality is influenced by the anesthesia method, as well as studies indicating that it is independent of the anesthesia method (6,7).

The hypothesis of our study was that spinal anesthesia administered in IFF surgeries reduces ejection fraction (EF) to a greater extent compared to peripheral block applications. The aim of this study was to assess, via echocardiography, the cardiac effects of spinal anesthesia and lumbosacral plexus block employed in IFF surgery, with particular focus on their influence on hemodynamic parameters.

MATERIALS AND METHOD

This prospective observational study was conducted between October 2020 and October 2022, approved by the institutional ethics committee (2011-KAEK-25 2020/10-03), and registered in the clinical trials database (NCT04975386). Subsequently, 64 patients scheduled to undergo IFF surgery were evaluated for eligibility.

Patients aged 60–100 years, classified as categories I–IV according to the ASA Physical Status Classification, and scheduled for treatment with intramedullary nails were included in the study. All patients received detailed information regarding the procedure, and written informed consent was obtained prior to participation. The exclusion criteria included allergy to local anesthetics or other medications used, bleeding disorders, mental disorders, and a body mass index greater than 30.

The choice of anesthesia was determined based on the patient's clinical presentation, existing comorbidities, and the clinical preference of the attending anesthesiologist, without researcher intervention. Echocardiographic measurements were performed by an anesthesiologist experienced in the technique. To minimize observer bias, the physician conducting the measurements was blinded to the anesthesia technique administered. Furthermore, this individual was not involved in the administration of anesthesia or the clinical decision-making processes. Pre-procedural echocardiographic evaluations were used to establish baseline cardiac functions and to facilitate the comparison of post-procedural changes.

The study population was divided into two groups: the SA group (n=32), who received lumbar spinal anesthesia, and the LP+SP group (n=32), who underwent combined lumbar and sacral plexus block anesthesia.

Anesthesia Management:

The anesthesia method was decided by the anesthesiologist in charge, regardless of



echocardiographic findings. Echocardiographic evaluations, however, were performed by a different anesthesiologist, independent of the chosen anesthesia method, and were administered by the same physician for all patients.

In the operating room, intravenous access was established using an 18–20 G intravenous catheter, and routine monitoring, including ECG, non-invasive blood pressure, and peripheral oxygen saturation, was performed. After the patients' foreheads were cleaned and dried, entropy probes were applied. Following an explanation of the procedure and patient positioning, initial measurements were obtained with the echocardiography device. For premedication, 1 mg intravenous midazolam and 25 µg fentanyl were administered.

Application of Spinal Anesthesia:

Patients were placed in the lateral decubitus position with the operative side facing downward, and the skin was disinfected under aseptic conditions. At the appropriate intervertebral level, unilateral spinal anesthesia was administered using a 25G Quincke needle to access the subarachnoid space, followed by the injection of 13 mg of hyperbaric bupivacaine solution. The sensory block level was assessed with the pin-prick method. After achieving the T10 level and establishing motor block (approximately 20 minutes), echocardiographic measurements were repeated; subsequently, the patient was positioned in the lateral decubitus position with the operative side uppermost, and the surgical procedure was initiated.

Lumbar Plexus and Sciatic Nerve Block Application:

Following monitoring, patients were positioned with the operative side uppermost, the lower leg extended straight, and the upper leg slightly flexed. A neurostimulator device was connected. After preparation of the operative area, a convex ultrasound probe (2–3 MHz, Esaote Mylab 30) was prepared in sterile conditions. The probe was placed below the iliac crest, and with a subcostal approach using the shamrock technique, a 20-G, 15-cm peripheral nerve block needle was advanced to the lumbar plexus. The accuracy of lumbar plexus localization was confirmed by the neurostimulator. Once verified, a total of 20–30 ml of a mixture containing 7.5 ml bupivacaine at 0.5% concentration, 7.5 ml lidocaine, and 5 ml isotonic solution was injected. Subsequently, under ultrasound guidance, a parasacral approach was used to access the sacral plexus, and following localization confirmation with the neurostimulator, 15 ml of the same mixture was administered to perform the sacral plexus block (8). After the motor block was established (approximately 20 minutes), echocardiographic measurements were repeated; subsequently, the patient was positioned in the lateral decubitus position with the operative side uppermost and handed over to the surgical team.

Transthoracic Echocardiography

Following explanation of the procedure and proper patient positioning (left lateral decubitus), apical two-, three-, and four-chamber echocardiographic images were acquired. Following manual tracing of the endocardial borders, cardiac chamber volumes and ejection fractions were computed using the Biplane Simpson method implemented in the echocardiographic system's software. Fractional shortening was determined by obtaining systolic and diastolic diameter measurements using 2D-echocardiography and M-mode. Left ventricular diastolic function was evaluated by recording peak E and peak A velocities using the Doppler mode.

Outcome Measures:

The primary outcome measure was the ejection fraction (EF) value measured by the modified Simpson method; the secondary outcome measures were EF measurement by the fractional shortening method, mitral and aortic valve Doppler measurement results, intraoperative blood pressure monitoring, amounts of intravenously administered fluids, and entropy values.

Statistical Analysis:

Data analysis was performed using the IBM SPSS 23.0 statistical package program (IBM Corp., Armonk, NY, USA). While evaluating the study data, in addition to descriptive statistical methods (frequency, percentage, mean, standard deviation, median, min-max), the Chi-Square (χ^2) test was used for the comparison of qualitative data. The suitability of the data for normal distribution was evaluated using the Kolmogorov-Smirnov and Shapiro-Wilk tests. When normal distribution was not observed, the Mann-Whitney U test was used for comparisons between the affected and unaffected sides.

Values with a probability (p) less than α=0.05 were considered significant and indicated a difference between the groups, whereas values greater than this were considered not significant and indicated no difference between the groups.

Power Analysis:

In our pilot study involving 10 patients, the EF value was found to be 50% ± 9% 20 minutes after lumbar plexus block, and it was predicted that the EF value might be 15% lower in patients undergoing spinal anesthesia. When the EF value in the spinal anesthesia group was accepted as 42.5%, the required minimum sample size for each group was determined as 27 subjects, calculated with reference to power of 0.85 and a confidence interval of 0.95 (the G*Power program was used for sample size calculation). Considering possible complications, it was planned to include two groups of 32 patients each, with a total of 64 patients in the study.

RESULTS

At the end of the study, statistical analysis was performed on the results of a total of 62 patients, including 32 in the spinal anesthesia group and 30 in the LP+SP group. In the LP+SP group, one patient was excluded due to entropy monitor malfunction, and another was excluded because of a change in the anesthesia technique resulting from a surgical complication. When demographic data between the groups were compared, no statistically significant difference was detected (p>0.05). (Table 1) An examination of the patient characteristics and intraoperative data presented in Table 1 revealed no statistically significant differences between the SA and LP+SP groups regarding the total volume of crystalloid fluids administered, the requirement for ephedrine following the onset of hypotension, or the estimated blood loss (p > 0.05).

Table 1. Comparison of Demographic Characteristics of Patients

		LP+SP (n:30)	SA (n:32)	p
Age (years)		66 (95-45)	65 (90-50)	0.429
BMI (kg/m^2)		22.2±1.6	23±1.9	0.786
Gender	M/F	15 (%50) /15(%50)	14 (%46) /16(%54)	0.860
Medications given during the operation				
Fentanil (µg)		66.9 (100-50)	63.7(100-0)	0.980
Ketafol (mg)		1.7 (0-30)	1.9 (0-40)	0.071
Midazolam (mg)		1 (0-3)	1 (0-2)	0.801
Intravenous fluid (mL)		983 (1500-500)	1008 (1500-500)	0.691
Intraoperative bleeding (mL)		272.3 ± 135.6	250.3 ± 72.9	0.223
Side (Right/Left)		19 (%85.7)/6(%14.3)	21(%85.7)/4(%14.3)	0.880
Ephedrine		3 (%10)	5 (%15)	0.721



When echocardiographic results were evaluated, no statistically significant difference was found between preoperative EF, E/A ratio, and FS values ($p<0.05$). (Table 2) At the 20th minute after the procedure, a statistically significant difference was detected in EF values, with the spinal anesthesia group showing lower values ($p<0.001$). (Table 2) When the percentage change values of EF calculated before the procedure and at the 20th minute after the procedure were compared, a statistically significant difference was again detected, with lower values in the spinal anesthesia group ($p<0.001$). (Table 2) In the intragroup evaluation, EF values in both groups were found to be statistically significantly lower when compared between baseline and the 20th minute after the procedure ($p<0.001$). (Table 2) In the intergroup evaluation, no statistically significant difference was detected in the E/A ratio and FS values at the 20th minute after the procedure. (Table 2) In the intragroup comparison of E/A ratio and FS values, the postoperative E/A ratio in the spinal anesthesia group was found to be statistically significantly lower ($p<0.001$). (Table 2)

Comparison of hemodynamic parameters between the groups revealed that systolic, diastolic, and mean arterial pressures at 5, 10, 15, 20, and 25 minutes post-procedure were significantly lower in the spinal anesthesia group compared to the lumbar plexus group ($p<0.001$). (Table 3) Entropy values measured during the operation were similar in both groups.

Table 2. Comparison of EF, E/A Ratio and FS Values Between Groups

	LP +SP (n:30)	SA (n:32)	p
EF (preoperative)	56.8(65-50)	58 (60-50)	0.337
EF (20 min)	53.5(60-46)	51 (62-42)	**0.001**
p	**0.001**	**0.001**	
EF % variation	-5.6(-14.8-5.6)	-11.8(-20.7-6)	**0.001**
E/A (preoperative)	0.85(1.8-0.53)	0.74(1-0.53)	0.141
E/A (20 min)	0.81(1.7-058)	0.7 (0.86-0.55)	0.610
p	0.064	**0.007**	
FS (preoperative)	37.1(42-30)	36.1(45-30)	0.244
FS (20 min)	37.7(45-28)	35.3(41-28)	0.004
p	0.650	0.180	

Table 3. Comparison of SBP, DBP and MAP Values Between Groups

	SBP			DBP			MAP		
	LP+SP(n:30)	SA(n:32)	p	LP+SP(n:30)	SA(n:32)	p	LP+SP(n:30)	SA(n:32)	p
Preoperative	133.7	130.9	0.157	78.9	77.8	0.485	112.8	106.5	0.108
Post-procedure	132.6	133.7	0.134	70.7	63.7	0.062	96.9	86.6	0.128
5 min	132.1	112.6	**0.004**	68.0	57.2	**0.010**	94.6	78.9	**0.002**
10 min	128.3	102.1	**0.000**	69.0	58.6	**0.022**	94.5	76.8	**0.008**
15 min	127.6	108.3	**0.001**	68.0	55.8	**0.003**	92.0	76.0	**0.002**
20 min	128.3	111.6	**0.006**	67.6	55.5	**0.012**	90.8	76.1	**0.009**
25 min	125.3	109.3	**0.004**	65.9	60.0	**0.015**	88.4	74.6	**0.003**
30 min	129.6	125.3	0.123	63.4	59.8	0.181	88.4	76.1	**0.009**
35 min	123.2	129.6	0.328	63.1	62.1	0.816	89.4	79.9	0.065
40 min	125.4	123.2	0.465	63.6	63.5	0.705	87.3	83.0	0.430
45 min	121.8	125.4	0.226	66.0	63.2	0.314	89.9	83.7	0.281
50 min	123.1	121.8	0.353	62.2	59.9	0.568	87.4	80.4	0.118
55 min	125.8	123.1	0.190	63.6	61.9	0.260	88.9	82.8	0.205
60 min	125.4	123.2	0,465	65.3	61.5	0.108	90.8	84.0	0.143

DISCUSSION

This study, designed to evaluate the echocardiographic effects of various regional anesthesia techniques employed in intertrochanteric femur fracture surgeries, demonstrated a statistically significant reduction in ejection fraction (EF) values at 20 minutes post-procedure compared to baseline in both the LP+SP block and spinal anesthesia groups. Moreover, intergroup analysis at the 20th minute showed a statistically significant difference, with the spinal anesthesia group exhibiting lower EF values.

Echocardiography allows both qualitative and quantitative measurement of systolic functions. Visual assessment of global and regional function based on echocardiographic images, quantitative evaluation of ventricular volume and ejection fraction (EF) by endocardial border tracing, and determination of Doppler systolic phase indices are valuable clinical tools (9). Both spinal anesthesia and peripheral block techniques are used for lower extremity surgical procedures. One of the common complications of spinal anesthesia is hypotension, and the effects of this condition on cardiac functions have been investigated in various studies. In a study by Donati et al., Donati et al. showed that unilateral subarachnoid anesthesia with 0.5% hyperbaric bupivacaine caused significant hemodynamic changes, including decreases in blood pressure, cardiac output, and ejection fraction, resulting in reduced left ventricular function (10). Another study comparing two different age groups after low-dose spinal anesthesia reported decreases in stroke volume, left ventricular end-diastolic volume, and cardiac index in both groups (11). They reported that cardiovascular changes were more pronounced in elderly patients and were associated with hypotension. Therefore, alternative regional anesthesia techniques have recently been adopted to mitigate the hemodynamic effects associated with spinal anesthesia. In a study by Fanelli et al., comparing unilateral spinal anesthesia with sciatic and femoral nerve blocks in lower extremity surgery, the cardiac index decreased by 15–20% in the spinal anesthesia group. Furthermore, at 10 and 15 minutes, the cardiac index was significantly lower in the spinal anesthesia group compared with the sciatic–femoral block group. They concluded that unilateral spinal anesthesia affects cardiovascular homeostasis more than a combined sciatic-femoral nerve block (5).

Although lumbar plexus and sciatic nerve blocks provide adequate surgical anesthesia by blocking the entire lower extremity, they theoretically cause some hemodynamic changes due to sympathetic nerve blockade in that region (hemisympathectomy) (11,12). In another study conducted by Canakci et al. involving patients undergoing total knee arthroscopy, those who received unilateral spinal anesthesia were compared with those who received lumbar and sciatic blocks. Intraoperative mean arterial pressure values were found to be higher in the LP+SP block group than in the spinal anesthesia group (13). In another study with a design similar to ours, hypotension after spinal anesthesia was observed in 38% and 27% of patients in the LP+SP group. Although these rates were not statistically significant, the spinal anesthesia group was found to require more ephedrine (14).

In the results of our study, EF values in both the spinal anesthesia group and the LP+SP block group were lower at the 20th minute after the procedure compared to baseline values. The percentage decrease was calculated to be greater in the spinal anesthesia group, where concomitant arterial blood pressure values were also lower. Unlike the literature, the need for vasopressor drugs did not differ between groups (14).

Two different considerations are prominent in the management of regional anesthesia in geriatric patients. These include hypotension due to vasodilation and cardiac diastolic dysfunction associated with aging. Hypotension during spinal anesthesia is primarily the result of a reduction in

systemic vascular resistance caused by blockade of preganglionic sympathetic fibers (15). Following spinal anesthesia, sympathetic blockade causes vasodilation in the arterial and venous systems, resulting in venous pooling in the periphery, decreased venous return to the heart, relative hypovolemia, and hypotension (16). This may explain the decrease in ejection fraction.

The E/A ratio, which can be used as an indicator of diastolic dysfunction, was observed to be lower in the spinal anesthesia group in our study. With aging, progressive fibrosis causes a reduction in venous capacitance. This condition disrupts the expected protective compensatory mechanism against volume changes in the venous system and may lead to diastolic dysfunction. The E/A ratio was found to be below 1 in 87% of elderly patients. The finding of low EF with FS measured within normal limits confirms this hypothesis (17,18).

This study has both limitations and strengths in certain areas. The prospective, observer-blind design may have reduced potential bias by ensuring that echocardiographic measurements were independent of anesthesia technique. Taking measurements before surgical incision may eliminate confounding factors such as bleeding, occult blood loss, or volume changes due to surgical manipulation. Additionally, the evaluation of geriatric patients may provide specific information about cardiac responses in a clinically sensitive group.

Limitations:

Our study has several limitations. First, detailed numerical echocardiographic parameters, such as left ventricular volumes and diastolic flow velocities, were not recorded. Second, the 20-minute follow-up window precluded the assessment of long-term postoperative outcomes and cardiac effects during later surgical stages. However, this timing allowed us to isolate the direct physiological effects of the anesthesia techniques by eliminating confounding factors such as surgical manipulation and hemorrhage. Finally, the lack of an objective scoring system to assess patient frailty and the reliance of the power analysis on a limited pilot study are additional limitations. Future research incorporating continuous intraoperative monitoring and long-term follow-up will provide deeper insights into this field.

CONCLUSIONS

As a result, it was determined that the cardiovascular effects of spinal anesthesia exceeded those of lumbar and sacral plexus block. Hypotension due to vasodilation was a controllable outcome. Lumbar and sacral plexus block may be considered an alternative method for patients undergoing hip surgery who are at high risk and cannot tolerate hemodynamic instability. In addition, the detection of diastolic dysfunction using transthoracic echocardiography may be utilized for selecting of the anesthesia method and as a non-invasive tool for hemodynamic monitoring. Given the observed decrease in ejection fraction (EF) even in patients with normal baseline function, preoperative echocardiography can be a valuable tool for selecting the appropriate anesthesia method, especially in high-risk patients with limited cardiac reserve.

REFERENCES

1. Davis FM, Woolner DF, Frampton C et al. Prospective, multi-centre trial of mortality following general or spinal anaesthesia for hip fracture surgery in the elderly. Br J Anaesth 1987;59(9):1080-8. (DOI:10.1093/bja/59.9.1080)
2. Auroy Y, Benhamou D, Bargues L et al. Major complications of regional anesthesia in France: The SOS Regional Anesthesia Hotline Service. Anesthesiology 2002;97(5):1274-80. (DOI:10.1097/00000542-200211000-00034)
3. Naja Z, el Hassan MJ, Khatib H et al. Combined sciatic-paravertebral nerve block vs. general anaesthesia for fractured hip of the elderly. Middle East J Anaesthesiol 2000;15(5):559-68.

4. Ho AM, Karmakar MK. Combined paravertebral lumbar plexus and parasacral sciatic nerve block for reduction of hip fracture in a patient with severe aortic stenosis. Can J Anaesth 2002;49(9):946-50. (DOI:10.1007/BF03016880)
5. Fanelli G, Casati A, Aldegheri G et al. Cardiovascular effects of two different regional anaesthetic techniques for unilateral leg surgery. Acta Anaesthesiol Scand 1998;42(1):80-4. (DOI:10.1111/j.1399-6576.1998.tb05084.x)
6. Vail EA, Feng R, Sieber F et al. Long-term Outcomes with Spinal versus General Anesthesia for Hip Fracture Surgery: A Randomized Trial. Anesthesiology 2024;140(3):375-386. (DOI:10.1097/ALN.0000000000004807)
7. Rodkey DL, Pezzi A, Hymes R. Effects of Spinal Anesthesia in Geriatric Hip Fracture: A Propensity-Matched Study. J Orthop Trauma 2022;36(5):234-238. (DOI:10.1097/BOT.0000000000002273)
8. Bendtsen TF, Lönnqvist PA, Jepsen KV et al. Preliminary results of a new ultrasound-guided approach to block the sacral plexus: the parasacral parallel shift. Br J Anaesth 2011;107(2):278-80. (DOI:10.1093/bja/aer216)
9. Lang RM, Bierig M, Devereux RB et al. Recommendations for chamber quantification: a report from the American Society of Echocardiography's Guidelines and Standards Committee. J Am Soc Echocardiogr 2005;18(12):1440-63. (DOI:10.1016/j.echo.2005.10.005)
10. Donati A, Mercuri G, Iuorio S et al. Haemodynamic modifications after unilateral subarachnoid anaesthesia evaluated with transthoracic echocardiography. Minerva Anestesiol 2005;71(3):75-81.
11. Lairez O, Ferré F, Portet N et al. Cardiovascular effects of low-dose spinal anaesthesia as a function of age: An observational study using echocardiography. Anaesth Crit Care Pain Med 2015;34(5):271-6. (DOI:10.1016/j.accpm.2015.02.007)
12. de Leeuw MA, Slagt C, Hoeksema M et al. Hemodynamic changes during a combined psoas compartment-sciatic nerve block for elective orthopedic surgery. Anesth Analg 2011;112(3):719-24. (DOI:10.1213/ANE.0b013e318206bc30)
13. Canakci E, Unal D, Guzel Y. The Effect of Unilateral Spinal Anaesthesia and Psoas Compartment with Sciatic Block on the Postoperative Pain Management in Total Knee Artroplastic Surgery. Pain Res Manag 2017;2017:4127424. (DOI:10.1155/2017/4127424)
14. de Visme V, Picart F, Le Jouan R et al. Combined lumbar and sacral plexus block compared with plain bupivacaine spinal anesthesia for hip fractures in the elderly. Reg Anesth Pain Med 2000;25(2):158-62. (DOI:10.1053/rapm.2000.0250158)
15. McCrae AF, Wildsmith JA. Prevention and treatment of hypotension during central neural block. Br J Anaesth 1993;70(6):672-80. (DOI:10.1093/bja/70.6.672)
16. Critchley LA, Short TG, Gin T. Hypotension during subarachnoid anaesthesia: haemodynamic analysis of three treatments. Br J Anaesth 1994;72(2):151-5. (DOI:10.1093/bja/72.2.151)
17. Jeong EM, Dudley SC Jr. Diastolic dysfunction. Circ J 2015;79(3):470-7. (DOI:10.1253/circj.CJ-15-0064)
18. Dugo C, Rigolli M, Rossi A et al. Assessment and impact of diastolic function by echocardiography in elderly patients. J Geriatr Cardiol 2016;13(3):252-60. (DOI:10.11909/j.issn.1671-5411.2016.03.008)