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Unilateral Spinal Anesthesia in Hip Fracture Surgery for Geriatric Patients With High Cardiovascular Risk due to Aortic Stenosis is Safe and Effective

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Abstract

Introduction: Aortic stenosis is a cause of mortality or morbidity. It complicates the selection and management of anesthetic procedures. The aim of this study was to evaluate the efficacy, hemodynamic effects and postoperative outcome of unilateral spinal anesthesia in geriatric patients with hip fractures with moderate or severe aortic stenosis. **Material and Method:** A retrospective observational study was conducted on geriatric high-risk patients with cardiac conditions who underwent surgery for hip fractures under unilateral spinal anesthesia with low-dose hyperbaric bupivacaine. The study period spanned from January 2018 to December 2021. The inclusion criteria were individuals with moderate to severe aortic stenosis, as defined by the American Heart Association Criteria. Data on demographic information, cardiac pathologies, hemodynamic data, data on motor and sensory block, perioperative complications, and mortality rates at 30th and 180th days were collected. **Results:** Mortality rates at the 30th day and 180th day were 8.9% (n:4) and 24.4% (n:11), respectively. T6 level was predominantly obtained level of anesthesia (44.4%). Motor and sensory block formation times averaged 7.6 and 4.8 minutes, respectively. Surgical procedures were performed mostly within 1 hour (66.7%), and complications were rare (11.1% hypotension). Initial analgesic effect showed a rapid resolution, with 64.4% of patients requiring analgesic within the first hour postoperatively. **Conclusion:** In elderly patients with moderate to severe aortic stenosis scheduled for hip fracture surgery, we posit that unilateral spinal anesthesia with ultra-low dose is safe and effective option.

Keywords

aortic stenosis, unilateral spinal anesthesia, geriatric anesthesia, hip surgery, low-dose bupivacaine, regional anesthesia

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Introduction

The evolution of preventive medicine, enhanced diagnostic and treatment modalities, coupled with a declining birth rate, has contributed to the contemporary rise in the elderly population.[1] Hip fractures, primarily occurring after simple falls in elderly patients, represent a significant cause of both mortality and morbidity. This injury often necessitates hospitalization and surgical intervention; therefore it had an impact on the overall quality of life.[2,3] The in-hospital mortality rate in geriatric patients with hip fractures varies between 2% to 14%.[4]

The early mortality rate, defined as the 30-day mortality rate post-surgery, ranges from 8% to 13%, with the mortality rate in the first and sixth months reported at around 25%. Additionally, the sixth-month morbidity rate is reported at around 70%.[2,5-7] Patients with high frailty encounter challenges in anesthesia selection and management due to physical impairment and comorbidities.[8]

Aortic stenosis, prevalent in 2-9% of elderly patients, constitutes a significant factor contributing to perioperative mortality and morbidity performed for noncardiac causes.[9,10] High-risk categorization encompasses severe aortic stenosis, delineated by an aortic valve area of ≤ 1 cm^2, and moderate aortic stenosis, defined as a valve area of 1-1.5 cm2.[11-14] Notably, for non-cardiac surgeries, patients with severe aortic stenosis exhibit a nonfatal myocardial infarction rate of 31%, while those with moderate aortic stenosis exhibit an 11% rate.[10]

In geriatric patients with hip fractures, where the abrupt decrease in systemic vascular resistance and hypotension due to sympathetic blockade after spinal anesthesia may be poorly tolerated, general anesthesia is often the preferred choice. Furthermore, it is advisable to employ close perioperative hemodynamic monitoring, including invasive artery monitoring.[15,16] While spinal anesthesia was historically considered relatively contraindicated in this patient population, several reports indicate successful application with very low doses of local anesthetic in severe aortic stenosis cases. However, the absence of large-scale studies poses a limitation in evaluating the broader applicability of this approach.[17-19]

Unilateral spinal anesthesia involves administering the local anesthetic drug at a significantly low dose and rate, with the patient maintained in the lateral decubitus position for approximately 10-15 minutes to facilitate regional block on one side. This targeted approach, limiting motor and sensory block to the necessary anesthesia area, results in decreased incidence of side effects such as hemodynamic instability and enhance a faster recovery of the block.[20,21] Despite reported series demonstrating the superiority of unilateral spinal anesthesia over general anesthesia and peripheral blocks in geriatric patients, its efficacy in individuals with aortic stenosis has yet to be explored. In this retrospective study, our objective was to assess the efficacy and safety of unilateral spinal anesthesia applied for hip fracture surgery in geriatric population with moderate or severe aortic stenosis. For this purpose, we analyzed anesthesia-related intraoperative variables and short-to mid-term mortality rates.

Material and Methods

This study was conducted as retrospective case series covering January 2018 to December 2021. Ethical approval was obtained from Ege University School of Medicine Local Ethics Committee. Inclusion criteria were determined based on our indications for performing unilateral spinal anesthesia. These criteria included: cases diagnosed with moderate or severe aortic stenosis confirmed by echocardiography, cases with ASA physical status IV, and cases aged 65 and over. Exclusion criteria were determined by the presence of conditions that constitute a contraindication to spinal anesthesia. Exclusion criteria comprised individuals with ASA physical status III and below, those on antithrombotic therapy with impaired coagulation parameters, individuals with infections at the intervention site, those who had undergone previous surgical interventions in the targeted area, individuals with severe spinal deformities, neurological diseases, uncooperative patients, those with peripheral nerve diseases, and patients with known allergies to local anesthetic drugs. Additionally, patients below the age of 65 and those with incomplete medical records were also excluded.

Demographic data, including age, gender, body mass index (BMI) and comorbidities, were recorded, along with cardiac pathologies contributing to their high-risk status. Intraoperative monitoring parameters included electrocardiography (ECG), heart rate (HR), non-invasive systolic arterial pressure (SAB), diastolic arterial pressure (DAB), mean arterial pressure (MAP), and peripheral oxygen saturation (spO2). Blood pressure monitoring was performed by non-invasive upper arm cuff, both for intraoperative and postoperative period. Time between intrathecal injection to inability to sense pinprick at T10 level were documented as duration of sensory block occurrence. Time between injection to paralysis were documented as duration of motor block occurrence. Initial level of sensory block were noted either as T4, T6, T8 or T10. Need for blood transfusion of each were also noted.

Additional intraoperative need for anesthetics, vasopressors, and analgesics after initial dose of bupivacaine were noted, as well as intraoperative and postoperative complications. Hypotension was defined as a blood pressure below 90/60 mmHg. The use of vasopressors was indicated on a case-specific basis, considering the persistence of hypotension. Duration of hospital stay and postoperative intensive care requirements were also noted.

Additionally, 30-day and 180-day mortality rate was assessed. In addition to descriptive analyses, we conducted a comparative analysis specifically focusing on cases where mortality occurred within the 6-month period. Mortality status for each patient was obtained through an electronic patient files.

The statistical analysis was conducted utilizing the SPSS 24 software (Statistical Package for the Social Sciences Inc., Chicago, IL, USA). The data is expressed as mean ± standard deviation (SD), median (M), and the range between minimum and maximum values. The Mann-Whitney U test was employed for continuous variables, while the Chi-square test was applied for categorical variables. The significance level for all tests was set at $P < 0.05$.

Patient Management

We employ a semi-urgent approach for the treatment of geriatric hip fractures. For cases aged 65 and above with a history of cardiac disease or indications of cardiac issues during preoperative evaluation, cardiology consultation is sought. Efforts are dedicated to optimizing the treatment of cardiac conditions in the preoperative period. Unilateral spinal anesthesia is administered to patients deemed to be at high cardiac risk (ASA-IV), provided that coagulation parameters are intact and there are no contraindications to spinal anesthesia, such as impaired coagulation parameters, infection at the application site, advanced spinal deformity, neurological disease, peripheral nerve disease, local anesthetic allergy, and uncooperative behavior. During the specified study period, all geriatric patients meeting the inclusion criteria received this approach. The only exceptions were patients with contraindications to spinal anesthesia. Blood pressure monitoring were taken with upper arm cuff at 5-minute intervals both for intraoperative and postoperative period. Before administering spinal anesthesia, ketamine at a dose of 0.25 mg/kg was given for analgesia, along with midazolam at a dose of 0.02 mcg/kg for sedation, prior to positioning the patient. Then, the patient is positioned laterally, and their chin was tucked to cheir chest to possible extent. After cleaning the area using povidone-iodine, and hyperbaric bupivacaine is administered at a dose of 6.5-7.5 mg using 22/25-gauge quincke needle utilizing median approach. Level of spinal injection was either L3/4 or L4/5. Subsequently, the patient's position is maintained until the establishment of the block. The establishment of the block was confirmed using the pinprick test. Afterwards, patients were positioned in supine position for surgery. All included patients were operated in supine position. For intramedullary nails, the procedure is performed on a traction table in the supine position. For partial hip replacements, the anterolateral approach is utilized in the supine position.

Patients

Among the 553 elderly patients who underwent surgical treatment for hip fracture in study period, 45 cases with moderate (33 patients) and severe (12 patients) aortic stenosis (AS) were identified as high-risk individuals concerning their cardiac problems. Average age 82.2 (SD ± 8.6) years, with 22 of them (44%) being 85 years or older. There were 17 (37.8%) males and 28 (62.2%) females. Mean BMI was 26.2 (SD ± 4.3) (Table 1).

The predominant level of spinal block observed was usually T6 (44.4%), with 26.7% of patients experiencing the block at T8 level, 13.3% at T4 level, and 15.6% at T10 level. Regarding motor and sensory block formation times, the average motor block formation time was 7.56 minutes, while the sensory block formation time averaged at 4.84 minutes. The majority of surgical procedures had an operation time between 0-1 hour (66.7%), with the remaining 33.3% of patients undergoing operations lasting 1-2 hours.

73.3% of patients exhibited moderate aortic stenosis, while 26.7% presented with severe aortic stenosis. Among patients with systemic comorbidities, the majority (61.4%) had extravalvular pathology. Approximately half of the patients (42.2%) did not had any other systemic disease aside from the valve condition. However, in 15 patients (33.3%), an additional disease other than the valve was identified, and in 11 patients (24.4%), more than one systemic disease other than the valve was detected.

Results

No patient required conversion to general anesthesia. No patients required postoperative admission to the intensive care unit. All patients were transferred to the inpatient service in stable condition after their follow-up in the postoperative recovery room.

Regarding changes in intraoperative variables, baseline values for systolic blood pressure was 151.1 mmHg (SD ± 27.9) while it was 130.5 mmHg (SD ± 27.0) for 10^{th} minute, and 124.8 (SD ± 25.4) for 30^{th} minute. Mean baseline value for diastolic blood pressure was 74.4 mmHg (SD ± 18.8) while it was 63.7 mmHg (SD ± 18.4) in 10^{th} minute and 58.5 mmHg (SD ± 13.5) for 30^{th} minute. Base mean value for heart rate was 90 bpm (SD ± 16.5), while it was 88.2 bpm (SD ± 15.9) at 10^{th} minute and 84.7 bpm (SD ± 16.1) for 30^{th} minute. Mean baseline SpO_2 was 94.2% (SD ± 3.5) while it was 96.0% (SD ± 2.8) in 10^{th} minute and 97.4% (SD ± 2.9) in 30^{th} minute (Table 2). The average time for the onset of motor block was 7.6 minutes (SD ± 3.0), with resolution occurring at 59.7 minutes (SD ±

Table 1. Demographic Characteristics.

		Mean	SD
Age		82.2	±8.6
BMI		26.2	±4.3
		n	%
Gender	Male	17	37.8
	Female	28	62.2
Underlying valvular disease	Isolated aortic stenosis	17	38.6
	Additional valve disease	27	61.4
Individuals with comorbidities other than valve disease	Hypertension	34	75.5
	Diabetes mellitus	18	40.0
	Coronary artery disease	16	35.5
	Congestive heart failure	16	35.5
	Arrythmia	8	17.7
Degree of aortic stenosis	Mild	33	73.3
	Severe	12	26.7
Need for blood transfusion	No	35	77.8
	Yes	10	22.2
Applied procedure	Partial hip replacement	20	44.4
	Intramedullary nail	25	55.6
Degree of aortic stenosis and ejection fraction	Mild AS, EF Normal	11	24.4
	Severe AS, EF, Normal	1	2.2
	Mild As, EF 41-50%	16	35.6
	Mild AS, EF 31-40%	3	6.7
	Mild AS, EF <30%	3	6.7
	Severe AS, EF 41-50%	2	4.4
	Severe AS, EF 31-40%	2	4.4
	Severe AS, EF <30%	7	15.6

Values are presented in numbers (n) and percentages (%). EF: Ejection Fraction. AS: Aortic Stenosis.

Table 2. Intraoperative Hemodynamic Variables.

		Mean	SD
sBP	1st minute	151.1	±27.9
	10th minute	130.5	±27.0
	30th minute	124.8	±25.4
dBP	1st minute	74.4	±18.8
	10th minute	63.7	±18.4
	30th minute	58.5	±13.5
HR	1st minute	90.0	±16.5
	10th minute	88.2	±15.9
	30th minute	84.7	±16.1
SpO_2	1st minute	94.2	±3.5
	10th minute	96.0	±2.8
	30th minute	97.4	±2.9

1st min values indicate baseline measurement obtained prior to application of unilateral spinal anesthesia. 10th min values indicates values obtained 10 minutes after baseline values. 30th min values indicates values obtained 30 minutes after baseline values Values are presented in Mean, Standard deviation (SD) and Median HR: Hearth rate sBP: Sistolic Blood Pressure dBP: Diastolic Blood Pressure.

27.1). For sensory block, these durations were 4.8 minutes (SD ± 2.7) for onset and 76.1 minutes (SD ± 25.4) for resolution.

In terms of complications, the majority of patients (88.9%) did not experience any complications, while hypotension was only the intraoperative complication and detected in 5 cases (11.2%). Same patients developed necessity for vasopressor agents. Notably, 64.4% of the initial postoperative analgesic requirements occurred within the first hour, 31.1% within 1-2 hours, and only 4.4% within 2-3 hours. This pattern suggests a rapid resolution of the block in patients, necessitating analgesia primarily within the first hour (Table 3). No patient had postoperative complications related to anesthesia.

30-day mortality rate was determined to be 8.9%. Notably, the 180-day mortality rate stands at 24.4%, indicating an increase in mortality beyond the first month (Table 4).

Comparing various factors including gender, ASA score, thoracic block level, postoperative first analgesic requirement time, presence of complications, inotrope/vasopressor need, operation time, presence of additional valve pathology, degree of aortic stenosis, type of surgical procedure, and the need for blood transfusion; there was no statistically significant relationship was found between mortality rates in any group ($P > 0.05$).

Discussion

This study aimed to investigate outcomes of unilateral spinal anesthesia, employing low doses of local anesthetic, in cases with high cardiac risk due to aortic stenosis. Based on our findings, we have deduced that the utilization of unilateral spinal anesthesia with low doses of local anesthetic is a safe approach in this group. Furthermore, our findings suggest that its implementation does not exacerbate mortality. It is noteworthy that this study is one of the most extensive series of unilateral spinal anesthesia using low doses of local anesthetic in geriatric hip fracture cases with high cardiac risk due to aortic stenosis.

In their investigation of the hemodynamic effects of unilateral spinal on elderly patients with a preoperative ASA score of III/IV undergoing surgery for hip fractures and deemed high risk, Chohan et al. utilized a very low dose (approximately 1.8 mL) of 0.5% hyperbaric bupivacaine to assess the sympathetic effects of US. The authors noted that this approach reduced side effects

Table 3. Data on Intraoperative Variables.

		n	%
Block level (Initial)	T4	6	13.3
	T6	20	44.4
	T8	12	26.7
	T10	7	15.6
Intraoperative hypotension	No	40	88.9
	Yes	5	11.1
Intraoperative need for vasopressor agents	No	40	88.9
	Yes	5	11.1
Duration of operation	0-1 hour	30	66.7
	1-2 hour	15	33.3
Time needed for postoperative analgesic	0-1 hour	29	64.4
	1-2 hour	14	31.1
	2-3 hour	2	4.4
Applied procedure	Partial hip replacement	20	44.4
	Intramedullary nail	25	55.6

Values are presented in numbers (n) and percentages (%). T: Thoracal.

Table 4. Mortality Rates.

		N	%
Mortality	30-day mortality	4	8.9
	180-day mortality	11	24.4

associated with the blockade, with hypotension primarily observed within the first 5 minutes of the operation.[22] Similarly, Ozturk et al. conducted a unilateral spinal study in 40 patients with geriatric femur fractures using low-dose hyperbaric bupivacaine (7.5-10 mg), observing hypotension in 10 patients, which was controlled with 5 mg epinephrine.[23] In our series, hypotension occurred in only 5 patients, and a response was achieved through fluid therapy or a single-dose bolus of noradrenaline. Hemodynamic stability was maintained throughout the procedure, obviating the need for postoperative inotropes or intensive care, and no in-hospital mortality occurred. The notably lower incidence of hypotension in our study, compared to others, is attributed to the use of a lower dose of unilateral spinal and the short duration of spinal anesthesia's effects. Additionally, similar to two other studies, our research indicated a temporary loss of motor power, typically confined to the operation duration. Our data comparing baseline and 30-minute values for HR, sBP, dBP, mBP, and SpO_2 suggests the safety of the applied technique, as evidenced by the need for vasopressors in only 5 patients, which could be managed without continuous vasopressor administration. Although there were significant changes when comparing the values before and after anesthesia, the mean values remained within safe limits. In our series, the patients to whom we applied unilateral spinal anesthesia were fragile and had comorbidities. There may be an opinion that arterial blood pressure monitoring could be beneficial in this group, where comorbidities such as congestive heart failure and arrhythmia are common. However, the fact that most of the surgeries generally took less than an hour (66.6%), that hypotension that required inotropes was only in 11.2% of the patients, and that we did not require continuous inotropes in the patients who developed hypotension, supported our decision to avoid this invasive procedure. Nonetheless, we believe that invasive monitoring can be used based on case-specific indications. A future comparative study on this subject would provide more definitive conclusions.

In a comprehensive cohort study encompassing 6896 cases, Castronuovo et al. investigated early, mid, and late-term mortality in elderly patients undergoing hip surgery. Their findings revealed a 30-day mortality rate of 7%, a 6-month mortality rate of 18%, and a 2-year mortality rate of 30%.[24] Keswani et al., in a study focusing on patients with moderately severe aortic stenosis and hip fracture, reported a 30-day mortality rate of 14.7%, a 1-year mortality rate of 46.8%, and a 30-day serious or minor complication rate of 74%.[11] Adunsky et al. observed an in-hospital mortality rate of 6.45%, a 1-year mortality rate of 17.7%, and a major complication rate of 8% in patients with simple and moderate aortic stenosis.[25] In our study, the 30-day mortality rate was determined to be 8.9%, with a corresponding 30-day morbidity rate of 6.7%. Both the 180-day mortality and morbidity rate were recorded at 15.6%, mirroring the data obtained by Castrunovo et al. in geriatric patients without aortic stenosis.

The timing of surgery in geriatric patients with hip fractures and concurrent aortic stenosis represents a highly pertinent and contentious issue, requiring a delicate balance between the urgency of fracture treatment and the associated risk posed by the underlying cardiac condition. The prevailing consensus emphasizes the necessity for expedited surgical intervention.[26] The American Academy of Orthopedic Surgeons guidelines recommend operating on these patients within the initial 48 hours.[27] Nevertheless, surgeries for patients with aortic stenosis may encounter postponement due to various factors such as comorbidities, electrolyte imbalances, ongoing medical treatments, and preallocation of intensive care units for potential postoperative requirements. A study by Maheswari et al., encompassing 720 patients, underscored a direct relationship between surgical timing and 1-year mortality. The authors associated each 10-hour delay from admission to surgery with a 5% higher 1-year mortality rate, advocating for urgent treatment.[28] However, it's crucial to note the retrospective nature and the ten-year span covered by the study, as acknowledged by the

authors themselves. In contrast, the comprehensive analysis by Khan et al., compiling 52 studies with 291,413 patients, found no significant correlation between the time until surgery and mortality. The study concluded that only early surgery contributed to a reduction in the length of hospital stay. Our principle of performing surgery promptly after a comprehensive preoperative evaluation aligns with this approach.[29]

In a study by Rostagno et al., involving 66 patients, the average time until the operation was reported as 2.6 ± 3 days, with an in-hospital mortality rate of 10%.[30] McBrien et al. reported an average time until operation of 5.5 days in their study of 66 patients. They observed an increasing tendency towards general anesthesia with the severity of aortic stenosis but found no significant correlation between the severity of aortic stenosis and increasing 30-day or 1-year mortality rates (5.1% and 25.7%).[31] In our study, the timing of surgery exhibited variability, ranging from 3 to 10 days. This variability is influenced by several factors, including the severity of aortic stenosis, with more severe cases requiring additional preoperative optimization. The presence of other comorbid conditions, such as heart failure, kidney failure, and respiratory problems, also exerted a significant impact. While efforts to optimize preoperative decompensated conditions and prepare the patient for the procedure may have extended the time frame, and cardiology consultations may contribute to this delay.[32] On the other hand, challenges inherent to hospital operations, operating room schedules could contribute to the postponement of surgery in these high-risk patients. Future studies focused on the possible effects of delays in surgeries caused by cardiology consultations could provide valuable insights into this multifaceted issue.

The decision to proceed with surgery and selecting optimal approach in this patient population necessitates careful consideration and a multidisciplinary approach involving collaboration among cardiologists, orthopedic surgeons and anesthesiologists. This collaborative effort is vital for comprehensively evaluating the patient's condition and making informed decisions. In light of preliminary data on matter, further research would hold importance to ascertain the efficacy and safety of unilateral spinal anesthesia in this specific patient cohort. Moreover, patient specific characteristics and comorbidities should be taken into account when contemplating the use of unilateral spinal anesthesia.

The retrospective nature of our study constitutes a significant limitation. Furthermore, the exclusion of patients who opted out of surgery due to high risk introduces another shortcoming. Another limitation of our study was the absence of a control group, which might helped drawing more solid conclusions. Additionally, the power of the data obtained was not supported by a power analysis. Another limitation was the potential selection bias stemming from eligibility criteria that relied on preoperative cardiac assessment, as there could be patients with aortic stenosis who did not receive preoperative consultation. Additionally, the relatively low number of patients in our study is noteworthy. However, the infrequency of encountering geriatric patients with moderate or severe aortic stenosis and low surveillance, owing to the natural course of the disease, contributes to the challenge of recruiting larger cohorts. Consequently, there is a need for prospective studies encompassing a greater number of patients to validate our findings and elucidate the long-term outcomes of low-dose unilateral spinal anesthesia in this specific population.

Conclusion

Geriatric patients with moderate to severe aortic stenosis slated for hip-fracture surgery necessitate a comprehensive evaluation prior to the operation. We posit that unilateral spinal anesthesia administered with a very low dose of local anesthetic stands as a safe and effective option and could be utilized in selected cases as an alternative to other techniques in for this specific patient group, provided they are carefully prepared for the operation under optimal conditions and timing. Future comparative studies will provide valuable insights and contribute significantly to the existing body of literature.

Declarations

This study received no funding. There is no commercial relationship with third parties in any terms. There is no conflict of interest to declare. All procedures were conducted in accordance with the Helsinki Declaration-2013. Informed consent was obtained from all subjects or their legal guardian. Raw dataset for that study is available from corresponding author on reasonable request.

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Author Contributions

ZÇ and AV wrote the paper. KKÖ and OA performed data acquisition. SK, NÖ, KA and NS edited the paper and supervised the study.

Declaration of Conflicting Interests

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