Risk Factors for Intraoperative Hypotension in Elderly Patients Undergoing Fast Track Hip Fracture Surgery under Spinal Anesthesia: A Retrospective Observational Study

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ABSTRACT

Objective: Fast-track hip fracture surgery is urgent. Time-limited preoperative optimization increase the risk of perioperative cardiovascular issues, affecting postoperative outcomes. This study aimed to identify risk factors for intraoperative hypotension in elderly patients undergoing fast-track hip fracture surgery with spinal anesthesia.

Materials and Methods: This retrospective observational analysis was conducted at a university-based hospital. Medical records from 2018 to 2022 were examined to compare variables associated with intraoperative hypotension. Multivariate logistic regression analysis was used to determine the risk variables for intraoperative hypotension.

Results: The incidence of intraoperative hypotension was 50.1%. Significant factors associated with intraoperative hypotension included a history of previous stroke (adjusted odds ratio [OR]: 2.41; 95% confidence interval [CI]: 1.38–4.21, P = 0.002), a preoperative baseline SBP below 100 mmHg (adjusted OR: 2.34; 95% CI: 1.34–4.08, P = 0.003), a preoperative urine output less than 0.5 ml/kg/h (adjusted OR: 2.74; 95% CI: 1.07–6.96, P = 0.034), undergoing an intramedullary nail procedure (adjusted OR: 2.64; 95% CI: 1.85–3.77, P < 0.001). Conversely, protective factors included receiving preoperative blood transfusions (adjusted OR: 0.43; 95% CI: 0.24–0.77, P = 0.004) and receiving a spinal bupivacaine dose of 7.5 mg or above (adjusted OR: 0.59; 95% CI: 0.36–0.95, P = 0.033).

Conclusion: Modifiable factors include ensuring adequate preoperative intravascular volume to optimize urine output and blood pressure, and correcting anemia. Prioritizing these measures for at-risk patients can help prevent complicated hospital stays.

Abbreviations: SBP = systolic blood pressure, OR = odds ratio, CI = confidence interval

Keywords: Fast-track hip fracture; intraoperative; hypotension; risk factors; spinal anesthesia (Siriraj Med J 2024; 76: 454-464)

INTRODUCTION

Hip fractures are a major cause of death and morbidity in elderly patients. Early surgical intervention for hip fractures can reduce mortality, morbidity, and postoperative complications. Recent studies, combined with the recommendations of the National Institute for Health and Care Excellence (NICE), advocate for performing surgery either immediately upon admission or on the following day.[1-3] The "Hip Fracture Fast Track" protocol was developed by a multidisciplinary team of specialists to enhance patient care.[4] This protocol addresses important issues, such as cardiovascular compromise,

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electrolyte imbalances, deep vein thrombosis (DVT) risk assessment, perioperative pain management, and potential postoperative complications, such as myocardial infarction, stroke, delirium, pulmonary embolism,and urinary tract infections (UTIs).[5] Optimizing these aspects is important for reducing mortality, morbidity, and hospital stays.

The fast-track hip fracture is an urgent operation. Time-limited preoperative optimization, particularly in elderly patients, increases the likelihood of substantial perioperative cardiovascular problems, which are related to postoperative outcomes. Moreover, patients with hip fractures who experience frequent low blood pressure during the intraoperative period are at increased risk for significant postoperative cardiovascular complications, which are significantly associated with postoperative mortality.[6,7]

The choice between general anesthesia and neuraxial techniques depends on the patient's medical conditions and involves discussing risks and benefits with the patient and family. Recent studies found no significant difference in 30-day mortality rates between general and regional anesthesia, though regional anesthesia is associated with shorter hospital stays and lower in-hospital mortality.[8,9] Neuraxial anesthesia is often preferred unless contraindicated, such as in cases of coagulopathy. Factors associated with hypotension after spinal anesthesia in various surgeries include a history of hypertension, low baseline systolic blood pressure, older age, female gender, and high-level spinal anesthesia above T5.[10-14]

Patient-related and surgical factors influence the incidence of perioperative hypotension. Extracapsular hip fractures have a higher bleeding risk compared to intracapsular fractures.[15] The type of surgical procedure also impacts blood loss, with intramedullary nailing causing more hidden blood loss than extramedullary fixation.[16-19] However, few studies have specifically examined the risk factors for intraoperative hypotension in hip fracture surgery under spinal anesthesia. This study aims to identify these risk factors in patients undergoing fast-track hip surgery with spinal anesthesia as a primary outcome, contributing to improved perioperative care and long-term consequences.

Common early complications following hip fractures include cardiovascular events, respiratory complications, venous thromboembolism (VTE), delirium, pressure ulcers, and infections. The incidence of postoperative complications in these patients is nearly 50%[20], resulting in increased medical expenses due to the high morbidity rates. Furthermore, intraoperative hypotension is a significant risk factor for postoperative cardiovascular complications and long-term complications, such as postoperative cognitive dysfunction (POCD)[6,7,21], which contributes to a decline in overall health. Consequently, the purpose of this paper is also to identify early postoperative complications in patients presented with intraoperative hypotension compared to those without hypotension. This objective also emphasizes the importance of preoperative optimization to mitigate postoperative adverse outcomes.

MATERIALS AND METHODS

Study design

This single center retrospective observational study was conducted at Siriraj hospital, a university-based tertiary referral center in Thailand, and approved by the Siriraj Institutional Review Board (COA no. Si 056/2022). The medical records was examined from 2018 to 2022.

Participants

Elderly patients aged 65 years or older in the Acute Geriatric Hip Fracture: Fast Track program (within 48 hours) who underwent hip surgery under spinal anesthesia were enrolled. Exclusion criteria included preoperative hypotension, multiple injuries, failed spinal anesthesia, and incomplete medical records.

Data collection

Data were collected as part of the Acute Geriatric Hip Fracture: Fast Track project. Patients' medical records were reviewed. Three investigators extracted the data, with the fourth investigator randomly checking every 20th patient to ensure the accuracy and consistency of the data.

Collected preoperative demographic data included gender, age, body weight, height, comorbidities, American Society of Anesthesiologists (ASA) classification, drug history, premedication with antihypertensive drugs, baseline blood pressure, preoperative hemoglobin (Hb) and hematocrit (Hct) (pre-transfusion), blood urea nitrogen (BUN), creatinine, estimated glomerular filtration rate (eGFR), urine specific gravity, preoperative amount of urine output per kilogram per hour (ml/kg/h), amount of intravenous fluid received, preoperative blood transfusion, and time from admission to surgery.

Intraoperative data included the type of anesthesia, type of surgery, operation duration, dose of local anesthetic for spinal anesthesia, total propofol used, blood component transfusion, total intraoperative crystalloid and colloid, episodes of hypotension, inotrope/vasopressor use, total vasopressor dose, estimated blood loss, and urine output. Postoperative data included 30-day mortality, postoperative complications (hypotension, cardiac and respiratory complications, stroke, delirium, acute renal failure, UTIs, pressure sores), ICU admissions, length of ICU, and length of hospital stay.

Outcome measurement

Intraoperative hypotension was defined as a SBP of 90 mmHg or lower, a decrease in mean arterial pressure (MAP) of more than 30% from the baseline[22], or the intraoperative administration of cumulative doses of norepinephrine equal to or greater than 11 mcg or ephedrine exceeding 12 mg following spinal anesthesia, as outlined in the study by Chinachoti et al.[10] The latter definition was adopted based on the observation of their study[10] of an average ephedrine and norepinephrine administration of 12 mg and 11 mcg, respectively, to a hypotension group. Because of the lack of real-time computerized records at our hospital, manually recorded vital signs may not have accurately captured all hypotension incidents. Therefore, we incorporated this definition into our criteria for intraoperative hypotension. The presence of postoperative delirium was determined daily by geriatricians using the Confusion Assessment Method for the Intensive Care Unit (CAM-ICU).

Sample size calculation

Based on previous studies[10,14], we hypothesized that approximately eight risk factors are associated with intraoperative hypotension during hip fracture surgery under spinal anesthesia. These include age, an ASA classification of three or higher, coexisting medical conditions, such as hypertension, the number of antihypertensive drugs used as premedication, preoperative baseline SBP, preoperative intravascular volume status, including the amount of intravenous fluid administered and urine output before surgery, the type of operation (intramedullary vs. nonintramedullary nail), and the dose of local anesthetic drug.

For multivariate analysis, multiple logistic regression was used, adhering to the rule that requires at least 20 cases per independent variable. Consequently, the minimum outcome events required were 160 patients. Anticipating that the incidence of intraoperative hypotension following spinal anesthesia would be approximately 30%[10], the total number of cases needed was determined to be 533. Anticipating the potential for approximately 20% incomplete medical records in a retrospective study, we adjusted the sample size to 666 cases.

Statistical analysis

Depending on the normality of distribution, continuous data were presented as the mean, standard deviation (SD), median, and interquartile range (IQR) and analyzed using either an independent Student's t-test or the Mann–Whitney U-test. Categorical variables were reported as frequency and percentage and compared using the Chi-square or Fisher's exact tests. Variables with a P value of 0.20 or less in the univariate analysis were included in the multivariate logistic regression using a forward stepwise analysis. Associated factors are presented as crude odds ratios (OR), adjusted OR, and 95% confidence intervals (CI). Multivariate analysis was conducted via logistic regression. Statistical analysis was performed using SPSS version 18.0 software (IBM Corp, Armonk, NY).

RESULTS

From 2018 to 2022, 940 individuals in the Hip Fracture Fast Track project underwent fast-track hip surgery. Of these patients, 258 underwent surgery with general anesthesia, 14 were below the age of 65, and two had two surgeries for their hip fractures. Consequently, 666 patients were included in this study (Fig 1). The Acute Geriatric Hip Fracture: Fast Track program reported a mean waiting time from admission to surgery of 41.4 ± 37.0 hours for the entire group. Intraoperative hypotension was observed in 334 of 666 patients, which represented 50.1%.

The preoperative demographics of the patients were comparable between the groups (Table 1). The age distribution revealed a significantly higher proportion of intraoperative hypotension in patients aged 80 years or older compared to those without hypotension. However, there were no significant differences in gender distribution. The prevalence of comorbidities varied between the two groups. For instance, the group with intraoperative hypotension had a significantly higher proportion of patients with chronic kidney disease, cerebrovascular disease, and cognitive impairment, while other comorbidities showed no significant differences.

Baseline SBP was significantly lower in the hypotensive group compared with that in the non-hypotensive group; however, other preoperative tests did not show significant differences, except for the Hct: Hb ratio and eGFR. The incidence of intraoperative hypotension in patients who received preoperative blood transfusion was lower compared with that in the non-hypotensive group. Of note, a higher incidence of preoperative urine output less than 0.5 ml/kg/h was observed in the hypotension group.

Regarding intraoperative characteristics (Table 2), the type of surgery varied significantly in the intramedullary nail procedure in the hypotension group. In contrast, bone

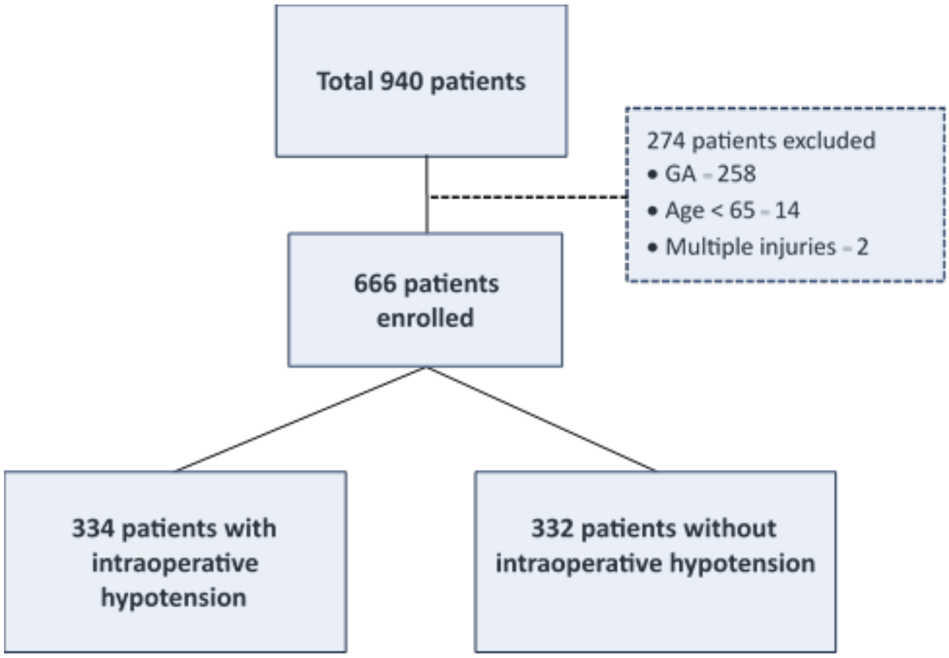

Fig 1. Study flow of patient selection including enrollment, inclusion, and exclusion criteria.

TABLE 1. Preoperative characteristics

Variables	Intraoperative Hypotension (n=334)	Nonintraoperative Hypotension (n=332)	P value
Age			0.016*
65–79 years	105 (31.4%)	134 (40.3%)	
≥ 80 years	229 (68.5%)	198 (59.6%)	
Female	258 (77.2%)	259 (78.0%)	0.81
Body mass index (kg/m²)	23 ± 4.2	22 ± 4.3	0.39
Comorbidities			
Hypertension	268 (80.2%)	250 (75.3%)	0.13
Type 2 diabetes mellitus	109 (32.6%)	120 (36.1%)	0.34
Dyslipidemia	198 (59.3%)	197 (59.3%)	0.99
Chronic kidney disease (eGFR < 60)	109 (32.6%)	82 (24.7%)	0.024*
End-stage renal disease	6 (1.8%)	4 (1.2%)	0.75
Coronary artery disease	40 (12.0%)	25 (7.5%)	0.053
Arrhythmia	22 (6.6%)	18 (5.4%)	0.53
Peripheral arterial disease	7 (2.1%)	5 (1.5%)	0.57
Previous stroke	57 (17.1%)	26 (7.8%)	<0.001*
Cognitive impairment	59 (17.7%)	40 (12.0%)	0.042*
Hypothyroidism	14 (4.2%)	18 (5.4%)	0.46
Cancer	42 (12.6%)	28 (8.4%)	0.081

TABLE 1. Preoperative characteristics (Continue)

Variables	Intraoperative Hypotension (n=334)	Nonintraoperative Hypotension (n=332)	P value
ASA classification			0.14
I–II	167 (50.0%)	185 (55.7%)	
III–IV	167 (50.0%)	147 (44.3%)	
Activities of Daily Living (ADL) dependence	21 (6.3%)	19 (5.7%)	0.76
Antihypertensive drugs			
CCB	166 (49.7%)	164 (49.4%)	0.94
Beta-blocker	95 (28.4%)	84 (25.3%)	0.36
ACEI/ARB	109 (32.6%)	100 (30.1%)	0.48
Vasodilator	31 (9.3%)	33 (9.9%)	0.77
Alpha-blocker	22 (6.6%)	22 (6.6%)	0.98
Diuretic	39 (11.7%)	38 (11.4%)	0.93
Numbers of antihypertensive drugs given on the day of surgery			0.52
none	170 (50.9%)	181 (54.5%)	
1 drug	128 (38.9%)	113 (34.0%)	
≥ 2 drugs	36 (10.8%)	38 (11.4%)	
Antiplatelet/Anticoagulants			
Aspirin	102 (30.5%)	92 (27.7%)	0.42
Clopidogrel	4 (1.2%)	5 (1.5%)	0.75
Others	7 (2.1%)	6 (1.8%)	0.79
Warfarin	12 (3.6%)	8 (2.4%)	0.37
DOAC	1 (0.3%)	0 (0.0%)	1.00
LMWH	15 (4.5%)	19 (5.7%)	0.47
Baseline SBP (mmHg)	114 ± 18	123 ± 19	<0.001*
Preoperative testing			
Hemoglobin (g/dl)	11.21 ± 1.80	11.39 ± 1.85	0.21
Hematocrit (%)	33.91 ± 4.96	34.24 ± 5.33	0.42
Hct/Hb ratio	3.04 ± 0.19	3.01 ± 0.16	0.09
BUN/Cr ratio	20.18 ± 8.92	20.56 ± 8.79	0.58
eGFR (ml/min/1.73m^2)	62.05 ± 24.31	65.11 ± 24.21	0.11
IV fluid pre-op (ml/h)	80 (60–80)	80 (60–80)	0.58
Pre-op blood transfusion given	33 (9.9%)	46 (13.9%)	0.11
Pre-op urine output <0.5 ml/kg/h	20 (6.8%)	7 (2.5%)	0.016*

Data are presented as mean ± standard deviation (SD), number (%), or median (Interquartile range, IQR)
Abbreviations: ASA = American Society of Anesthesiologists, eGFR = estimated glomerular filtration rate, CCB = Calcium Channel Blocker, ACEI = Angiotensin-converting enzyme inhibitor, ARB = Angiotensin II receptor blocker, DAPT = Dual antiplatelet, LMWH = Low Molecular Weight Heparin, SBP = Systolic blood pressure, Hct = Hematocrit, Hb = Hemoglobin, BUN = Blood urea nitrogen, Cr = Creatinine, ml = milliliters, kg = kilograms
*P value < 0.05 was considered statistically significant.

TABLE 2. Intraoperative characteristics

Variables	Intraoperative Hypotension (n=334)	No intraoperative Hypotension (n=332)	P value
Duration of waiting time for admission and surgery (h)	38 (22–45)	37 (19–46)	0.34
The type of Surgery			
Intramedullary nail	202 (60.5%)	128 (38.6%)	<0.001*
Cemented used	20 (6.0%)	29 (8.7%)	0.017*
Operation time (min)	137 (±34)	138 (±32)	0.57
Bupivacaine for spinal block			0.001*
<7.5 mg	65 (19.7%)	36 (10.9%)	
≥7.5 mg	265 (80.3%)	292 (89.0%)	
Propofol for sedation (mg)	70 (0–140)	40 (0–142)	0.061
Crystalloid (ml)	825 (600–1100)	700 (500–900)	<0.001*
Blood transfusion	63 (18.9%)	41 (12.3%)	0.021*
Blood transfusion (ml) †	273 (257–296)	287 (256–306)	0.41
Colloid	12 (3.6%)	6 (1.8%)	0.16
Estimate blood loss (ml)	200 (100–250)	200 (100–300)	0.88
Urine output (ml/kg/h)	1.28 (0.75-2.22)	1.41 (0.91–2.20)	0.08
Vasopressor			
Ephedrine (mg)	6 (0–18)	0 (0–0)	<0.001*
Norepinephrine (mcg)	20 (4–40)	0 (0–0)	<0.001*

Data are presented as the mean ± standard deviation (SD), number (%), or median (Interquartile range, IQR)
mcg = micrograms
*P value < 0.05 was considered statistically significant.
† Blood transfusion volume was calculated from the patients who received intraoperative blood transfusion.

cement was used less frequently in the hypotension group. There was a significant difference in the administration of bupivacaine for the spinal block. A lower dose (< 7.5 mg) was more commonly used in the hypotension group. In addition, patients who experienced intraoperative hypotension received significantly more crystalloids and were more likely to require blood transfusions during surgery. In the hypotension group, the median dose of ephedrine was 6 mg and 20 mcg for norepinephrine.

We compared the patients with and without intraoperative hypotension. Univariate analysis identified significant variables (P ≤ 0.20) associated with intraoperative hypotension, including age, ASA classification ≥ 3, underlying disease of hypertension, chronic kidney disease ≥ Stage 3, history of coronary artery disease, history of cerebrovascular diseases, cognitive impairment, history of cancer, decreased baseline mean SBP, increased preoperative Hct:Hb ratio, decreased eGFR, blood transfusion administered before surgery, and preoperative urine output below 0.5 mL/kg/h.

Based on a multivariate logistic regression analysis, all variables with P-values of 0.20 or less were included. The analysis identified six independent risk factors for intraoperative hypotension (Table 3), including a history of previous stroke, a preoperative baseline SBP below 100 mmHg, a preoperative urine output below 0.5 ml/kg/h, the administration of a preoperative blood transfusion, undergoing an intramedullary nail procedure, and receiving a spinal anesthetic drug dose of 7.5 mg or above.

Preoperative factors such as a history of previous stroke, a preoperative SBP below 100 mmHg, and urine output less than 0.5 ml/kg/h were strongly associated with

TABLE 3. Risk factors associated with intraoperative hypotension

Variables	Adjusted OR (95% CI)	P value
Previous stroke	2.41 (1.38–4.21)	0.002*
Preoperative SBP < 100 mmHg	2.34 (1.34–4.08)	0.003*
Received pre-op. blood transfusion	0.43 (0.24–0.77)	0.004*
Pre-op urine output < 0.5 ml/kg/h	2.74 (1.07–6.96)	0.034*
The type of Surgery: Intramedullary vs. No intramedullary nail	2.64 (1.85–3.77)	<0.001*
Spinal anesthesia with bupivacaine ≥7.5 mg	0.59 (0.36–0.95)	0.033*

Data are presented as crude and adjusted odds ratios (OR) (95% confidence interval [CI]).
*P value < 0.05 was considered statistically significant.

an increased risk of intraoperative hypotension. Conversely, preoperative blood transfusions were linked to a reduced incidence of this condition. Regarding intraoperative factors, intramedullary nail surgery significantly increased the risk of intraoperative hypotension. However, administering bupivacaine doses 7.5 mg or above for spinal anesthesia was associated with a lower incidence of intraoperative hypotension.

According to postoperative outcomes (Table 4), patients who experienced intraoperative hypotension had a significantly higher rate of postoperative hypotension, ICU admissions after surgery, length of hospital stays, postoperative UTIs, and postoperative delirium.

DISCUSSION

Several factors were significantly associated with intraoperative hypotension including a history of previous stroke, preoperative systolic blood pressure below 100 mmHg, urine output less than 0.5 ml/kg/h, administration of preoperative blood transfusions, undergoing an intramedullary nail procedure, and receiving a spinal anesthetic drug dose 7.5 mg or above. Patients experiencing intraoperative hypotension were observed to have higher rates of postoperative complications compared to those in the non-hypotension group. These complications included persistent hypotension, ICU admission after surgery, prolonged hospital stays, UTIs, and delirium. We observed a 50.1% incidence of hypotension, aligning with other findings reporting a range from 30% to 68%, likely reflecting variations in diagnostic criteria of hypotension or sample sizes.[10,14,22] We defined intraoperative hypotension using specific criteria that included the average intraoperative use of vasoactive agents, addressing the limitations of manual anesthetic record-keeping at our center. The criteria were a SBP of 90 mmHg or lower, or a MAP decrease of more than 30% from baseline, with the administration of vasoactive agents at the anesthesiologist's discretion. The reliable recording of vasopressor use in our records supports the inclusion in our hypotension criteria. No significant correlation was observed between intraoperative hypotension and factors, such as age, ASA classification, premedication with antihypertensive drugs, or anesthesia level, which were different from previous studies.[14] This lack of correlation may be attributed to variations in hypotension criteria and sample size across studies.

Our study identified significant correlations between intraoperative hypotension and both non-modifiable risk factors, such as a history of stroke and intramedullary nail procedures, and modifiable risk factors, including preoperative SBP below 100 mmHg, urine output less than 0.5 ml/kg/h, preoperative blood transfusions, and the dosage of bupivacaine in spinal anesthesia. Regarding the non-modifiable risk factors, recent studies have not conclusively established a clear association between prior stroke and the incidence of intraoperative hypotension. However, some research suggests that impairments in the sympathetic nervous system and baroreceptor function, which may be altered following a stroke, can contribute to increased risk of intraoperative cardiovascular instability.[23,24] These insights support our hypothesis that patients with a history of stroke are at elevated risk of developing intraoperative hypotension during surgery. From our study, intramedullary fixation influences intraoperative hypotension. As blood loss is a major complication associated with the intramedullary nail

TABLE 4. Postoperative outcomes.

Variables	Intraoperative Hypotension (n=334)	No intraoperative Hypotension (n=332)	P value
Duration in PACU (min)	90 (70–120)	85 (65–120)	0.46
Postoperative hypotension	34 (10.2%)	15 (4.5%)	0.005*
Postoperative delirium	88 (26.3%)	58 (17.5%)	0.006*
ICU admission	46 (13.8%)	27 (8.1%)	0.02*
Length of ICU stay (day)	2 (1–2)	2 (1–2)	0.83
Length of hospital stay (day)	10 (7–13)	9 (7–12)	0.038*
Complications			
MI	7 (2.1%)	4 (1.2%)	0.37
Stroke	3 (0.9%)	2 (0.6%)	1.00
CHF/Pulmonary edema	16 (4.8%)	17 (5.1%)	0.84
Acute pulmonary embolism	6 (1.8%)	1 (0.3%)	0.12
Respiratory infection/Atelectasis	27 (8.1%)	30 (9.0%)	0.66
Acute renal failure/AKI	14 (4.2%)	9 (2.7%)	0.30
UTI	104 (31.1%)	73 (22.0%)	0.008*
DVT	5 (1.5%)	1 (0.3%)	0.22
Sepsis	6 (1.8%)	5 (1.5%)	0.77
Pressure sore	4 (1.2%)	2 (0.6%)	0.69
30-day mortality rate	5 (1.5%)	2 (0.6%)	0.45

Data are presented as number (%) or median (Interquartile range, IQR).
Abbreviations: PACU = Post-anesthesia care unit, ICU = intensive care unit, MI = Myocardial infarction, CHF = Congestive heart failure, AKI = Acute kidney injury, UTI = Urinary tract infection, DVT = Deep vein thrombosis.
*P value < 0.05 was considered statistically significant.

procedure,[16,17] previous studies have indicated that intramedullary fixation incurs greater hidden blood loss compared to extramedullary fixation or the use of a locking compression plate.[18,19] Consequently, we propose that the augmented hidden blood loss seen in the intramedullary nail procedure could lead to perioperative under-resuscitation, thereby increasing the risk of intraoperative hypotension.

Regarding the modifiable risk factors which potentially ralated to preoperative hypovolemia, a preoperative SBP below 100 mmHg correlates with intraoperative hypotension, confirming earlier studies that identified low preoperative blood pressure as a significant predictor for hypotension following spinal anesthesia.[12,13] Additionally, our study noted a unique correlation between a preoperative urine output less than 0.5 ml/kg/h and intraoperative hypotension, a link not widely demonstrated elsewhere. Agerskov et al.[25] observed that 36% of hip fracture patients were fluid-responsive preoperatively, while 26% displayed signs of hypovolemia. Based on these findings, a preoperative urine output, indicative of oliguria[26], reflects inadequate intravascular volume, possibly due to unrecognized blood loss, poor fluid intake, or insufficient preoperative resuscitation. These findings underscore the critical role of optimizing both preoperative macrocirculation and microcirculation in managing risks associated with anesthesia-related hypotension.

Conversely, our study identified a modifiable protective factor against intraoperative hypotension during hip surgery. Patients who received preoperative blood transfusions exhibited a reduced risk of intraoperative hypotension. This finding is consistent with Swetech et al.[12], who associated anemia with hypotension following spinal anesthesia. Furthermore, Land et al.[27] demonstrated that a preoperative transfusion protocol for patients with Hb levels below 7 g/dl undergoing elective joint arthroplasty led to decreased intraoperative hypotension. Hip fracture patients frequently arrive at the hospital dehydrated, a condition resulting from chronic issues, the initial trauma, or restricted access to fluids while immobile.[28] Our results suggest that preoperative volume resuscitation, guided by baseline SBP, urine output, and blood transfusions in at-risk patients, could enhance intravascular volume optimization, thereby stabilizing hemodynamic profiles during surgery.

Another protective factor identified was the dosage of local anesthetic used during surgery. Patients receiving more than 7.5 mg of bupivacaine for spinal anesthesia exhibited more stable blood pressure compared to those receiving less, contrasting with other studies that reported a low-dose spinal anesthesia (less than 7.5 mg of bupivacaine) is associated with reduced vasopressor use.[29] Additionally, no hypotension was found in patients administered 7.5 mg of isobaric bupivacaine, versus 15 mg.[30] The differences in findings may relate to our anesthesiologists' careful consideration of bupivacaine dosage, especially in patients with multiple comorbidities or frailty who are typically given doses under 7.5 mg. These patients often present with additional risk factors for developing intraoperative hypotension, such as advanced age or inadequate intravascular volume, suggesting the need for further subgroup analysis to explore these results.

Our study revealed that patients experiencing intraoperative hypotension had significantly higher incidences of postoperative hypotension, ICU admissions, prolonged hospital stays, delirium, and UTIs compared to those without intraoperative hypotension. We defined postoperative hypotension as previously described, often necessitating fluid resuscitation or vasopressors following surgery. Specifically, postoperative hypotension occurred in 10.2% of patients with intraoperative hypotension. In contrast, another study reported a 23.8% incidence of postoperative hypotension.[31] Furthermore, our findings indicate a significantly higher incidence of postoperative ICU admissions in patients who experienced intraoperative hypotension, aligning with previous studies.[6,32] However, several confounding factors may influence the likelihood of postoperative ICU admission, including comorbidities, an ASA classification of three or higher, and a high risk of postoperative pulmonary complications. Previous study detailed the implementation of a protocol for screening hip fracture patients for postoperative ICU admission, identifying significant predictors such as anticoagulant use, emergency department respiratory rate, injury severity score, number of comorbidities, and chronic obstructive pulmonary disease.[33] These results underscore the complexity of factors leading to ICU admissions following hip fracture surgery.

Current studies[34,35] have found no evidence of an association between intraoperative hypotension and the length of hospital stay; however, our study demonstrated that patients in the hypotension group had significantly longer hospital stays compared with those in the non-hypotensive group. This finding is consistent with Tassoudis et al.[36], who reported that the duration of intraoperative hypotension may delay the hospital discharge of patients undergoing major abdominal surgery.

Regarding postoperative complications, delirium is a common issue frequently associated with patients with hip fractures. Wang CG et al.[37] reported an overall incidence of postoperative delirium following hip fracture surgery of 19.2%. Similarly, our study demonstrated a correlation between postoperative delirium and intraoperative hypotension. Corresponding with previous systematic reviews[38,39], they noted that blood pressure lability, including intra- and post-surgical hypotension, and a lower MAP of 80 mmHg were significantly associated with an increased risk of postoperative delirium. Additionally, UTIs are another significant complication related to intraoperative hypotension during hip fracture surgery, with previous studies reporting a 3-12% incidence in geriatric hip fracture patients.[40,41] Our study found a higher rate of postoperative UTIs in patients with intraoperative hypotension. One study identified extended NPO (nil per os) times post-surgery as an independent risk factor for UTIs,[41] suggesting that prolonged NPO may lead to dehydration or under-resuscitation, contributing to the higher incidence of UTIs in these patients.

These outcomes and complications resulting from intraoperative hypotension during hip surgery underscore the importance of maintaining stable hemodynamics. By ensuring adequate preoperative and intraoperative resuscitation, this could mitigate the risk of these postoperative complications and reduce morbidity in patients with hip fractures.

Limitations

This study had several limitations. First, it is a single-center retrospective study, which may lead to variations in certain variables compared with previous studies. Second, the findings are based on a retrospective review of patient records. There may be instances of incomplete or inaccurate data, particularly in the intraoperative hemodynamic profiles manually recorded by anesthesia providers. Finally, the criteria for hypotension included the use of vasopressors for the reasons discussed earlier. Despite these limitations, our study had notable strengths. This is the second study to identify risk factors for intraoperative hypotension in elderly patients undergoing hip fracture surgery with spinal anesthesia. With a larger sample size, our study identified additional potential risk factors related to intraoperative hypotension, including previous stroke, preoperative blood transfusion, urine output less than 0.5 ml/kg/h, and intramedullary procedure. In future studies, randomized controlled trials, systematic reviews, or meta-analyses are recommended to identify more modifiable risk factors, such as blood transfusion management and fluid resuscitation optimization.

CONCLUSION

In this study, we examined modifiable risk factors, including preoperative SBP, preoperative blood transfusion, and preoperative urine output. A protocol should be established for screening at-risk patients to enhance preoperative optimization and preparation. This approach may also ensure heightened vigilance during the intraoperative period, thereby preventing adverse outcomes. In addition, we identified unfavorable postoperative outcomes, including increased incidences of postoperative hypotension, delirium, ICU admissions, UTIs, and prolonged hospital stays. Thus, the role of a multidisciplinary team of physicians is important to provide comprehensive care for these patients.

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Author Contributions

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Declaration of Conflicting Interests

The authors declare no conflicts of interest.

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