Incidence, Risk-factors, and Outcomes of Intraoperative Hypotension Following Spinal Anesthesia in Hip Fracture Surgery: A Retrospective Study from Thailand

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ABSTRACT

Objective: Hip fractures are a major health problem in older individuals. Surgical repair is the recommended treatment. Intraoperative hypotension (IOH) due to spinal anesthesia is common and may be associated with unfavorable outcomes. This study aimed to identify the incidence, risk factors, and outcomes of IOH in patients with hip fracture under spinal anesthesia.

Materials and Methods: This retrospective study was conducted at a private tertiary hospital in Thailand. Data collected from January 2018 to December 2020 were reviewed. We included all patients aged > 50 years old who underwent hip surgery and excluded those who received general anesthesia, had high-energy or pathological fractures, or had multiple traumas. They were categorized into the no-IOH and IOH groups. The outcome measures were compared between the two groups.

Results: In total, 264 patients were included for analysis. The mean age was 80.9 ± 8.3 years, with 77.3% females. The incidence of IOH was 37.9% [95% CI: 30.8%, 46.1%] and an independent risk factor was age > 65 years (OR [95% CI]: 6.23 [1.13, 34.47]. The two protective factors for IOH were higher preoperative mean arterial pressure (OR [95% CI]: 0.96 [0.93, 0.99]) and time from fracture to surgery > 24 hours (OR [95% CI]: 0.43 [0.21, 0.89]). Postoperative blood transfusions were administered more frequently (53.7%) in the IOH group than in the no-IOH group (37.9%, p = 0.014).

Conclusion: The incidence of intraoperative hypotension in hip fracture surgery was 38%. Aging is the only identified risk factor. IOH was related to a higher frequency of blood transfusion, but no other postoperative complications or mortality rates.

Keywords: Hip fracture; spinal anesthesia; intraoperative hypotension; complications; incidence; risk factors (Siriraj Med J 2024; 76: 396-405)

INTRODUCTION

There is an increase in aging population worldwide, and osteoporotic hip fractures in elderly people have become a major health problem. The incidence of hip fractures in Thailand is approximately 180-240 per 100,000 people per year.[1,2] Osteoporotic hip fractures are a considerable problem on the healthcare system owing to the complications that arise from immobilization, leading to increased morbidity and mortality. Studies have reported a 1-year mortality rate of 18-19% following hip fractures in Thailand.[3,4]

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Surgical repair is the recommended treatment for osteoporotic hip fractures except when the patient's health status is severely unstable. Early or fast-track surgery within 36-48 h is essential for these patients to reduce the complications and mortality associated with immobilization.[5-6] Facilitating timely surgery and providing optimal anesthetic care for better postoperative outcomes pose challenges for anesthesiologists, particularly for frail elderly patients. A crucial aspect of the intraoperative management of hip fracture surgical repair is the avoidance of hypotension.[7]

Intraoperative hypotension (IOH) during hip fracture surgery is a significant risk factor for morbidity and mortality.[8,9] Despite the various definitions of IOH[10,11] prolonged periods of hypotension are associated with poor postoperative outcomes.[12,13] Recent systematic reviews have found no evidence of superiority in the choice of anesthesia; however, spinal anesthesia may offer the benefits of a lower incidence of venous thromboembolism and acute kidney injury.[14,15] Therefore, according to international consensus, spinal anesthesia is the preferred choice of anesthesia for hip arthroplasty[16] when no contraindications are present.[17,18] Unfortunately, IOH remains the most prevalent adverse effect in up to 33% of cases following spinal anesthesia, despite low-to-intermediate doses of spinal anesthesia.[19–21]

Several risk factors have been postulated, such as dehydration, anemia, aging, comorbidities such as obesity, hypertension (HT), and diabetes mellitus (DM), receiving cardiovascular drugs, preoperative blood pressure, and dose of spinal anesthesia.[22–24] Understanding these risk factors is crucial for effective planning of prevention and preparation strategies to manage IOH. However, the current focus of hip fracture patient care has evolved significantly. Hip fast track protocols have been implemented, facilitating early surgery and multidisciplinary team consultation to optimize patient outcomes. Consequently, the risk factors associated with IOH may have changed.

This study aimed to identify the incidence, risk factors, and outcomes of IOH in patients with hip fracture under spinal anesthesia.

MATERIALS AND METHODS

Study design and population

This retrospective cohort study was conducted at a single center in a tertiary private hospital in Thailand. This study was approved by the Institutional Review Board (COA no. Si 563/2021 dated July 21, 2021). The need for informed consent was waived because of the retrospective nature of the study. The medical records of adult patients who underwent surgical repair for hip fractures (including femoral neck, intertrochanteric, and subtrochanteric fractures) at Thonburi Hospital, a private hospital with 435 beds, were reviewed retrospectively. Fast-track hip fracture surgeries have been performed in this private hospital for several years. The data from January 2018 to December 2020 were reviewed. All adult patients aged over 50 years who underwent surgical repair for hip fractures were included in this study. The exclusion criteria comprised patients who underwent surgical hip repair under general anesthesia, those with hip fractures caused by high-energy trauma or cancer-related pathological fractures, and those with multiple bone fractures.

Outcome measurement

A retrospective review of the medical records was conducted, and the following information was collected:

- Preoperative data included age, sex, weight, height, American Society of Anesthesiologists (ASA) physical status classification, diagnosis, co-morbidity diseases, current medication, Charlson Comorbidity Index (CCI), preoperative laboratory results, and vital signs.
- The intraoperative data included the type of surgery, choice of anesthesia, anesthetic drug use, and anesthetic complications, including hypotension, blood loss, and blood transfusion.
- Postoperative data included postoperative complications, Clavien–Dindo classification of surgical complications, length of stay (LOS), and mortality rate.

The patients were categorized into two groups for analysis: no-IOH and IOH. IOH was defined as a mean arterial pressure (MAP) < 65 mmHg or systolic blood pressure (SBP) < 90 mmHg, or an MAP or SBP value < 80% of the baseline blood pressure in hypertensive patients[25] for at least 1 min or requiring vasopressors. The primary outcomes were the incidence of and risk factors for IOH following spinal anesthesia. The secondary outcome was the incidence of complications after hip fracture surgery.

Sample size calculation

For the primary outcome, we utilized the estimated proportion formula to calculate the required sample size, represented as $n = \frac{Z^2\alpha_{/2}\, P(1-P)}{d^2}$, where n is the sample size, $Z^2\alpha_{/2}$ is the confidence interval, P is the estimated proportion, and d is the desired precision. Based on a previous study reporting an incidence of spinal hypotension of 31.6% following hip fracture surgery[26], with a 95% confidence interval (CI) of ±6.0%, a sample

of 229 patients was required. Due to the retrospective cohort design, the sample size was increased to 252 to account for the estimated 10% of excluded patients and the possibility of missing or incomplete data.

For the analysis of associated factors logistic regression analyses were planned. Using a rule of the thumb of one variable per ten events, a minimum of 222 patients would be required to test seven variables potentially associated with spinal hypotension.[22–24] To account for missing data rate of 10%, 244 patients were required. We chose a sample size of 252 patients to cover both the primary and secondary objectives. Retrospective data spanning three years were collected to ensure an adequate sample size based on the number of patients treated annually at the hospital.

Statistical analysis

The collected data were analyzed by Statistical Package for the Social Sciences (SPSS) software version 18.0 (SPSS Inc., Chicago, IL, USA). A chi-square test, Fisher's exact test, or linear-by-linear association test was used to compare categorical data, which were presented as numbers and percentages. Student's t-test and Mann–Whitney U test were used to compare continuous data with normal and abnormal distributions and were reported as mean±standard deviation (SD) or median (interquartile range, IQR) when appropriate.

All variables were assessed using univariate analysis to determine their association with IOH. Subsequently, potential risk factors (those with p-values <0.10 in the univariate analysis) were incorporated into a multiple logistic regression model. We employed a backward stepwise algorithm for this process. The results were reported as odds ratios (OR) and 95% confidence intervals (CI). A p-value of <0.05 was considered statistically significant. The 95% CI of incidence was calculated using MedCalc statistical software.

RESULTS

Overall, 264 patients were included in this study (Fig 1). Intraoperative hypotension (IOH) following spinal anesthesia was observed in 100 patients, resulting in an incidence of 37.9% (95% CI: 30.8%, 46.1%). Table 1 presents the preoperative patient characteristics and medical conditions. The mean age was 80.9 ± 8.3 years overall, 77.7 ± 10.0 years in the no-IOH group, and 81.8 ± 8.9 years in the IOH group, showing a significant difference with higher age in the IOH group (p = 0.001). The number of patients with an ASA physical status classification greater than 2 and CCI greater than 4 was

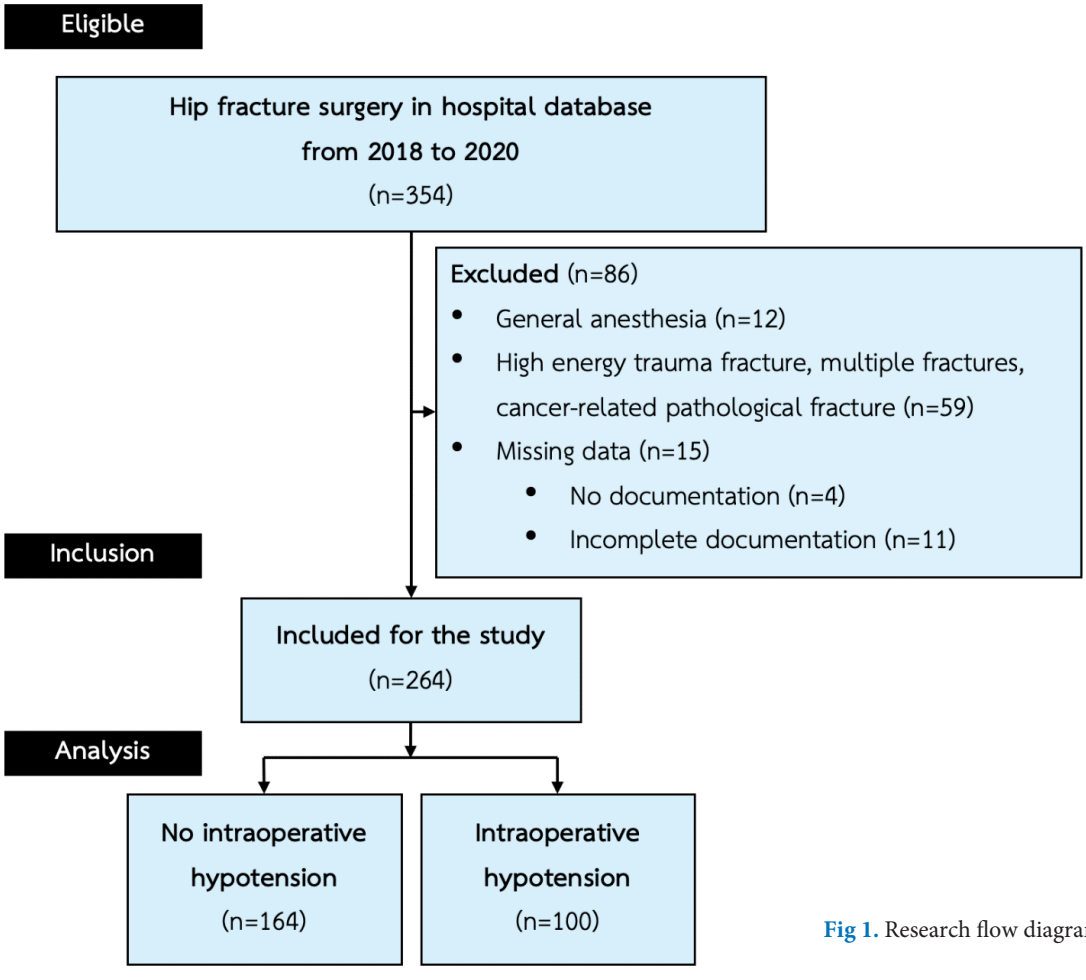


Fig 1. Research flow diagram

TABLE 1. Preoperative patient characteristics and laboratory results[t]

	No Intraoperative Hypotension (no-IOH, n=164)	Intraoperative Hypotension (IOH, n=100)	*P*
Age (year)	77.7 ± 10.0	81.8 ± 8.9	0.001*
Sex (Female)	123 (77.4%)	81 (81.8%)	0.392
Body mass index (BMI)	22.4 ± 4.1	22.2 ± 4.5	0.752
ASA physical status: III-IV	127 (77.9%)	87 (87.9%)	0.043*
Charlson Co-morbidity Index (CCI)			0.039*
CCI ≤2	16 (9.9%)	5 (5.1%)	
CCI 3-4	65 (40.1%)	29 (29.3%)	
CCI ≥5	81 (50.0%)	65 (65.7%)	
Medical condition			
Hypertension	118 (72%)	70 (70%)	0.734
Diabetes mellitus	62 (37.8%)	34 (34%)	0.533
Coronary artery disease	30 (20.7%)	12 (12.2%)	0.175
Chronic kidney disease	29 (17.7%)	15 (15.0%)	0.570
Cerebrovascular disease	27 (16.5%)	12 (12.0%)	0.321
Anemia	82 (50.0%)	49 (49.0%)	0.875
Antiplatelet use			
Single/dual antiplatelet	41/6	26/4	0.971
Anticoagulant use	12 (7.3%)	2 (2.0%)	0.061
Antihypertensive drug (s) at the day of surgery	38 (23.2%)	24 (24.0%)	0.649
Preoperative mean arterial pressure (mmHg)	100.2 ± 10.8	97.2 ± 10.4	0.031*
Preoperative heart rate (bpm)	80.4 ± 10.7	80.2 ± 11.2	0.902
Hematocrit (%)	35.9 ± 4.2	34.4 ± 4.5	0.007*
eGFR (ml/min/1.73 m^2)[#]	75.5 (53.6, 88.9)	62.0 (39.0, 84.0)	0.005*
BUN/creatinine ratio	20.3 ± 7.0	20.1 ± 6.7	0.887

[t]Data are presented as mean ± standard deviation (SD), number (%) or median (interquartile, IQR)[#] as appropriated.
* p <0.05.
Abbreviations: ASA, American Society of Anesthesiologists; bpm, beats per minute; eGFR, estimated glomerular filtration rate; BUN, blood urea nitrogen

significantly higher in the IOH group (p = 0.043 and 0.039, respectively; Table 1). The average preoperative mean arterial pressure (MAP) showed a significant lower MAP in the IOH group (p = 0.031). Significant differences between the groups were also observed in baseline hematocrit and estimated glomerular filtration rate (p = 0.064 and 0.005, respectively; Table 1).

Table 2 shows the diagnoses and intraoperative data. The no-IOH group had a higher number of delayed surgeries (> 24 h). Bupivacaine doses in both groups were similar, and 1.5–2.0 ml of bupivacaine was considered an intermediate dose. All patients received mild-to-deep sedation at the discretion of the anesthesiologist. The frequencies of fluid administration and blood transfusions were significantly higher in the IOH group (p = 0.002 and 0.025, respectively; Most of the patients were admitted to a regular ward post-operatively.

Table 3 presents the postoperative complications. There were no significant differences in postoperative complications between the groups, except for anemia

TABLE 2. Preoperative diagnosis and intraoperative data[t]

	No Intraoperative Hypotension (no-IOH, n=164)	Intraoperative Hypotension (IOH, n=100)	*P*
Diagnosis			0.442
Neck fracture	93 (56.7%)	52 (52%)	
Intertrochanteric fracture	65 (39.6%)	46 (46%)	
Subtrochanteric fracture	3 (1.8%)	2 (2.0%)	
Shaft	3 (1.8%)	0 (0.0%)	
Admission to surgery (h)[#]	11.8 (4.6, 23.4)	17.0 (5.0, 22.5)	0.602
Fracture to surgery (days)[#]	1 (0, 5)	1 (0, 1)	0.294
Fracture to surgery (h)[#]	20.5 (12, 28)	24 (13, 33)	0.231
Fracture to surgery > 24 h	59 (38.1%)	21 (22.8%)	0.013*
Operation			0.601
Hemiarthroplasty	79 (48.2%)	48 (48%)	
Intramedullary nail	68 (41.5%)	44 (44%)	
Hip Screw	12 (7.3%)	6 (6.0%)	
Others	5 (3.0%)	2 (2.0%)	
Operative time (min)[#]	60 (47, 75)	60 (50, 75)	0.741
Anesthetic time (min)[#]	102 (90, 115)	100 (90, 120)	0.816
Spinal 0.5% bupivacaine (ml)[#]	1.8 (1.7, 2.0)	1.8 (1.7, 2.1)	0.680
Spinal morphine use	127 (80.9%)	68 (72.3%)	0.115
Adjuvant nerve block	24 (15.2%)	17 (17.3%)	0.647
Fluid (ml)[#]	800 (500, 1000)	900 (700, 1100)	0.002*
Oliguria**	39 (25.5%)	31 (33.3%)	0.186
Blood loss (ml)[#]	150 (100, 200)	100 (100, 200)	0.777
Blood transfusion	15 (9.4%)	19 (19.0%)	0.025*
Postoperative care in ICU	15 (9.8%)	18 (18.6%)	0.071

[t]Data are presented as number (%) or median (interquartile, IQR)[#] as appropriate.
* p <0.05. ** Oliguria was defined as urine output < 0.5 ml/kg/hr.
Abbreviation: ICU, intensive care unit

requiring transfusion, which was significantly higher in the IOH group (P = 0.014). The overall one-month and one year mortality rate were 2/264 (0.56%), and 6/264 (2.27%). There were no significant differences in mortality rates between the groups.

In the multivariate analysis (Table 4), an independent risk factor for IOH was age greater than 65 years (OR [95% CI: 6.23 [1.13, 34.47]]. Two protective factors for IOH were higher preoperative mean arterial pressure (OR [95% CI]: 0.96 [0.93, 0.99]) and time from fracture to surgery later than 24 h (OR [95% CI]: 0.43 [0.21, 0.89]).

DISCUSSION

In the present study, the incidence of IOH after hip-fracture surgery was 38% [95% CI: 31%, 46%]. The frequency of IOH in patients with hip fractures in earlier studies[23,26] ranged from 31.6 to 46.8%, which is consistent with our study. Despite intermediate dosages

TABLE 3. Postoperative complications and Clavien-Dindo classification[t]

	No Intraoperative Hypotension (no-IOH, n=164)	Intraoperative Hypotension (IOH, n=100)	*P*
Postoperative complications			
Anemia with transfusion	61 (37.9%)	51 (53.7%)	0.014*
Myocardial infarction	1 (0.6%)	1 (1.0%)	1.000
Heart failure	1 (0.6%)	1 (1.0%)	1.000
Arrhythmia	0 (0.0%)	2 (2.0%)	0.143
Pneumonia	3 (1.8%)	2 (2.0%)	1.000
Respiratory failure	3 (1.8%)	0 (0.0%)	0.291
Pulmonary embolism	1 (0.6%)	0 (0.0%)	1.000
Acute kidney injury	53 (32.3%)	32 (32.0%)	0.957
Delirium	9 (5.5%)	11 (11.0%)	0.101
Fever	4 (2.4%)	5 (5.0%)	0.306
Sepsis	4 (2.4%)	0 (0.0%)	0.301
Total highest Clavien Dindo classification**			0.073
Grade 0	15 (9.9%)	6 (6.3%)	
Grade I	68 (44.7%)	36 (37.9%)	
Grade II	64 (42.1%)	53 (55.8%)	
Grade III	5 (3.3%)	0 (0.0%)	
Grade IV	5 (3.3%)	0 (0.0%)	
Length of stay	7 (5, 9)	7 (5, 11)	0.163
Death (one month mortality)	0 (0.0%)	2 (2.0%)	0.143
Death (one year mortality)	3 (1.8%)	3 (3.0%)	0.676

[t]Data are presented as numbers (%).

* p <0.05. ** Postoperative-complication severities classified by Clavien-Dindo Classification

Class I: Any deviation from normal postoperative care without requiring pharmacological, surgical, endoscopic, or radiological intervention; Class II, Requiring pharmacological therapy, blood transfusion, or parenteral nutrition; Class III, Requiring surgical, endoscopic, or radiological intervention not under general anesthesia (IIIa) or under general anesthesia (IIIb); Class IV: life-threatening complications requiring ICU management with single organ (IVa) or multiple organ (IVb) failure; Class V, Death of the patient.

of bupivacaine, the IOH incidences were slightly higher compared to the overall IOH in previous studies.[19,20,27] However, variations in the definition of IOH, the age group of the population, surgical type, and medication use for spinal anesthesia may contribute to the various incidences of IOH following spinal anesthesia. In our study, patient features, such as more advanced age, numerous comorbidities, or pre-operative hypovolemia, and early surgery may be linked to a higher incidence of IOH.[22–24] A study by Ting Li et al. reported only 31.6% of IOH in older patients undergoing hip fracture surgery using ropivacaine for spinal anesthesia without sedation during the procedure.[26] The lower incidence of IOH in that study may be attributed to the use of ropivacaine. According to some studies, ropivacaine decreases the incidence of hypotension.[28,29]

We found that the only independent risk factor for IOH was age > 65 years. Spinal anesthesia blocks the sympathetic chain, leading to vasodilation, venodilation, and possible bradycardia, resulting in hypotension by decreasing the preload, afterload, and cardiac output.[30] Autonomic changes in the elderly can impair beta receptor sensitivity and reduce the responsiveness of the baroreceptor reflex, thereby limiting the tachycardic

TABLE 4. Univariate and multivariate analysis using logistic regression of variables associated with intraoperative hypotension.

	Univariate Crude OR (95% CI)	*P*	Multivariate Adjusted OR (95% CI)	*P*
Age (year)				
50–64 (ref)	1	1.000		1.000
≥65	6.42 (2.03, 42.37)	0.014*	6.23 (1.13, 34.47)	0.036*
ASA classification ≥ 3	2.06 (1.01, 4.17)	0.046*	1.32 (0.48, 3.62)	0.589
Charlson Co-morbidity index (CCI)				
CCI <=2 (ref)	1	1.000		1.000
CCI 3–4	1.43 (0.48, 4.27)	0.524	0.65 (0.15, 2.77)	0.558
CCI ≥ 5	2.57 (0.89, 7.38)	0.080	0.92 (0.19, 4.47)	0.913
Anticoagulant use	0.26 (0.06, 1.18)	0.081	0.31 (0.07, 1.50)	0.145
Preoperative MAP	0.97 (0.95, 0.99)	0.033*	0.96 (0.93, 0.99)	0.005*
Preoperative Hematocrit < 30%	2.50 (0.92, 6.81)	0.072	1.93 (0.59, 6.28)	0.275
Preoperative eGFR < 60 ml/min/1.73 m^2	1.89 (1.12, 3.19)	0.017*	1.28 (0.67, 2.45)	0.456
Fracture to surgery > 24 h	0.48 (0.27, 0.86)	0.014*	0.50 (0.26, 0.96)	0.037*

* p <0.05.
Abbreviations: OR, Odds ratio; 95% CI, 95% confidence interval; MAP, mean arterial pressure

response to hypotension. Consequently, geriatric patients rely more on vascular tone and preload to maintain their blood pressure.[31-33] So, the dose of spinal anesthesia should be adjusted according to age.

Higher average preoperative blood pressure seems to be a protective factor against IOH in hip fracture surgery. This result is consistent with that of a previous study on the risk factors for spinal-induced hypotension in hip fracture surgery.[25] Additionally, there is an association between lower preoperative blood pressure and hypotension following spinal anesthesia in cesarean sections.[34,35] However, the difference in the average baseline blood pressure observed in this study was minimal and may not be clinically significant.

We also found that the IOH group had a significantly lower percentage of patients who underwent surgery after 24 hours compared to the no-IOH group (22.8% in the IOH group versus 38.1% in the no-IOH group). Patients with hip fractures are often hypovolemic or dehydrated due to blood loss, reduced fluid intake, and prolonged fasting.[36-40] The patients who undergo ultrafast track surgery may have less time to normalize their hydration and volume status before the procedure. However, delaying surgery beyond 36-48 h should not be considered solely to prevent IOH because this delay may result in more adverse outcomes, including thromboembolism, pneumonia, urinary tract infection, pressure sores, and delirium.[41-42] Clear oral fluid should be allowed up to 2 h before surgery, or intravenous fluid should be administered as soon as possible. Preloading before or co-loading techniques during spinal block in appropriately selected patients may be a valuable strategy to reduce the incidence and severity of this complication.[43,44]

Our study did not reveal a correlation between spinal bupivacaine dose and hypotension. Previous studies, including meta-analyses, have shown that a higher dose of bupivacaine is associated with a higher incidence of hypotension in the surgical repair of hip fractures.[8,33] The contradictory findings of our study might be attributed to the fact that an intermediate dose of spinal bupivacaine was administered to most patients. In this study, spinal bupivacaine (> 10 mg) was rarely administered.

Intraoperative hypotension did not result in any significant postoperative complications, apart from transfusion. Hypotension was promptly treated in all cases, and all patients experienced brief periods of hypotension.

The 30-day mortality rate after hip fracture has been reported to vary from 1.4% to 12.1%, depending on factors such as age, region, study period, and management.

Nevertheless, a consistent trend of continuous reduction in 30-day mortality has been observed over the past decade.[45] Recently, the 30-day mortality rate after hip fracture surgery in the United Kingdom was reported to be 6.1%, based on the National Hip Fracture Database (NHFD) from various hospitals across the United Kingdom.[46] The NHFD indicated that only 56% of patients underwent early surgery in accordance with NICE guidelines. The higher mortality rate was observed in both conservative and operative treatment. In our study, the 30-day mortality rate was 0.75%, which is consistent with the findings of a recent study conducted in Singapore. They showed a mortality rate of 8.58% in the nonoperative management group compared to 0% in the operative management group.[47] The lower mortality rate may be attributed to early surgery performed by a multidisciplinary care team[48], and the hospital's hip fast-track protocol following the current recommendations.[6,49]

The strengths of our study lie in the consistency and homogeneity of patient care. We collected data from a private hospital that offers comprehensive preoperative investigations, geriatric and/or cardiologist consultations, intensive care, and fast-track hip fracture surgeries.

One limitation of this study was its retrospective nature, which resulted in some missing data (15 patients). Additionally, the patient population in private hospitals may have had a better socioeconomic status, greater healthcare accessibility, and more preoperative health maintenance than the general population. In this study, we excluded patients with multiple or pathological fractures as they may be more fragile. Further research should focus on strategies to prevent intraoperative hypotension in patients with hip fractures.

CONCLUSION

Intraoperative hypotension following spinal anesthesia was a common adverse event, with an incidence rate of 38%. Aging is the only risk factor for intraoperative hypotension following spinal anesthesia during the surgical repair of hip fractures. IOH was related to a higher frequency of blood transfusion, however, there were no differences in major postoperative complications or mortality rates between the IOH and no-IOH groups. Hence, in well-managed IOH patients, IOH had no effect on major postoperative complications.

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Conflicts of interest

All authors declare that there are no conflicts of interest related to any aspect of this research.

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Author Contributions

MR and TJ: Conceptualization.: TJ and PS: Data curation.: TJ and PS: Formal analysis.: MR and TJ: Methodology.: MR: Supervision.: TJ and PS: Writing – original draft.: MR and TJ: Writing – review & editing.

REFERENCES

1. Wongtriratanachai P, Luevitoonvechkij S, Songpatanasilp T, Sribunditkul S, Leerapun T, Phadungkiat S, et al. Increasing incidence of hip fracture in Chiang Mai, Thailand. J Clin Densitom. 2013;16:347-52.
2. Sucharitpongpan W, Daraphongsataporn N, Saloa S, Philawuth N, Chonyuen P, Sriruanthong K, et al. Epidemiology of fragility hip fractures in Nan, Thailand. Osteoporos Sarcopenia. 2019;5:19-22.
3. Vaseenon T, Luevitoonvechkij S, Wongtriratanachai P, Rojanasthien S. Long-term mortality after osteoporotic hip fracture in Chiang Mai, Thailand. J Clin Densitom. 2010;13:63-7.
4. Daraphongsataporn N, Saloa S, Sriruanthong K, Philawuth N, Waiwattana K, Chonyuen P, et al. One-year mortality rate after fragility hip fractures and associated risk in Nan, Thailand. Osteoporos Sarcopenia. 2020;6:65-70.
5. Bhandari M, Swiontkowski M. Management of acute hip fracture. N Engl J Med. 2017;377:2053-62.
6. Griffiths R, Babu S, Dixon P, Freeman N, Hurford D, Kelleher E, et al. Guideline for the management of hip fractures 2020: Guideline by the Association of Anaesthetists. Anaesthesia. 2021;76:225-37.
7. Shelton C, White S. Anaesthesia for hip fracture repair. BJA Educ. 2020;20:142-9.
8. White SM, Moppett IK, Griffiths R, Johansen A, Wakeman R, Boulton C, et al. Secondary analysis of outcomes after 11,085 hip fracture operations from the prospective UK Anaesthesia Sprint Audit of Practice (ASAP-2). Anaesthesia. 2016;71:506-14.
9. Beecham G, Cusack R, Vencken S, Crilly G, Buggy DJ. Hypotension during hip fracture surgery and postoperative morbidity. Ir J Med Sci. 2020;189:1087-96.
10. Futier E, Lefrant J-Y, Guinot P-G, Godet T, Lorne E, Cuvillon P, et al. Effect of individualized vs standard blood pressure management strategies on postoperative organ dysfunction among high-risk patients undergoing major surgery: a randomized clinical trial. JAMA. 2017;318:1346-57.
11. Bijker JB, Van Klei WA, Kappen TH, Van Wolfswinkel L, Moons KG, Kalkman CJ. Incidence of intraoperative hypotension as a function of the chosen definition: literature definitions applied to a retrospective cohort using automated data collection. Anesthesiology. 2007;107:213-20.
12. Wesselink E, Kappen T, Torn H, Slooter A, Van Klei W. Intraoperative hypotension and the risk of postoperative adverse

outcomes: a systematic review. Br J Anaesth. 2018;121:706-21.
13. Brady KM, Hudson A, Hood R, DeCaria B, Lewis C, Hogue CW. Personalizing the definition of hypotension to protect the brain. Anesthesiology. 2020;132:170-9.
14. Guay J, Parker MJ, Gajendragadkar PR, Kopp S. Anaesthesia for hip fracture surgery in adults. Cochrane Database Syst Rev. 2016;2:CD000521.
15. Kunutsor SK, Hamal PB, Tomassini S, Yeung J, Whitehouse MR, Matharu GS. Clinical effectiveness and safety of spinal anaesthesia compared with general anaesthesia in patients undergoing hip fracture surgery using a consensus-based core outcome set and patient-and public-informed outcomes: a systematic review and meta-analysis of randomised controlled trials. Br J Anaesth. 2022;129:788-800.
16. Memtsoudis SG, Cozowicz C, Bekeris J, Bekere D, Liu J, Soffin EM, et al. Anaesthetic care of patients undergoing primary hip and knee arthroplasty: consensus recommendations from the International Consensus on Anaesthesia-Related Outcomes after Surgery group (ICAROS) based on a systematic review and meta-analysis. Br J Anaesth. 2019;123:269-87.
17. Maxwell BG, Spitz W, Porter J. Association of Increasing Use of Spinal Anesthesia in Hip Fracture Repair with Treating an Aging Patient Population. JAMA Surg. 2020;155:167-8.
18. Cao MM, Zhang YW, Sheng RW, Gao W, Kang QR, Gao YC, et al. General anesthesia versus regional anesthesia in the elderly patients undergoing hip fracture surgeries: A systematic review and meta-analysis of randomized clinical trials. World J Surg. 2023;47:1444-56.
19. Carpenter RL, Caplan RA, Brown DL, Stephenson C, Wu R. Incidence and risk factors for side effects of spinal anesthesia. Anesthesiology. 1992;76:906-16.
20. Hartmann B, Junger A, Klasen J, Benson M, Jost A, Banzhaf A, et al. The incidence and risk factors for hypotension after spinal anesthesia induction: An analysis with automated data collection. Anesth Analg. 2002;94:1521-9.
21. Wijnberge M, Schenk J, Bulle E, Vlaar A, Maheshwari K, Hollmann M, et al. Association of intraoperative hypotension with postoperative morbidity and mortality: systematic review and meta-analysis. BJS open. 2021;5:zraa018.
22. Sheehan KJ, Guerrero EM, Tainter D, Dial B, Milton-Cole R, Blair JA, et al. Prognostic factors of in-hospital complications after hip fracture surgery: a scoping review. Osteoporos Int. 2019;30:1339-51.
23. Akarapatima R. The risk factors for spinal anesthesia-induced hypotension in patients undergoing hip Fracture surgery among the alderly: A retrospective cohort study. Thai J Anesthesiol. 2021;47:85-92.
24. Singla D, Kathuria S, Singh A, Kaul TK, Gupta S. Risk factors for development of early hypotension during spinal anaesthesia. J Anaesthesiol Clin Pharmacol. 2006;22:387-93.
25. Griffiths R, Beech F, Brown A, Dhesi J, Foo I, Goodall J, et al. Peri-operative care of the elderly 2014: Association of Anaesthetists of Great Britain and Ireland. Anaesthesia. 2014;69(Suppl 1):81-98.
26. Li T, Li J, Yuan L, Wu J, Jiang C, Daniels J, et al. Effect of Regional vs General Anesthesia on Incidence of Postoperative Delirium in Older Patients Undergoing Hip Fracture Surgery: The RAGA Randomized Trial. JAMA. 2022;327:50-8.
27. Chinachoti T, Saetia S, Chaisiri P, Tritrakarn T. Incidence and risk factors of hypotension and bradycardia during spinal anesthesia. Siriraj Med J. 2006;58:696-701.
28. Whiteside JB, Burke D, Wildsmith JA. Comparison of ropivacaine 0.5% (in glucose 5%) with bupivacaine 0.5% (in glucose 8%) for spinal anaesthesia for elective surgery. Br J Anaesth. 2003;90:304-8.
29. Mohta M. Ropivacaine: Is it a good choice for spinal anesthesia? J Anaesthesiol Clin Pharmacol. 2015;31:457-8.
30. Ferré F, Martin C, Bosch L, Kurrek M, Lairez O, Minville V. Control of Spinal Anesthesia-Induced Hypotension in Adults. Local Reg Anesth. 2020;13:39-46.
31. Staheli B, Rondeau B. Anesthetic Considerations in the Geriatric Population. Treasure Island (FL): StatPearls Publishing LLC.; 2023.
32. Barnett S. Anesthesia for the older adult. In: Joshi GP, Nussmeier NA, ed. UpToDate. Waltham: MA; 2022.
33. Messina A, La Via L, Milani A, Savi M, Calabrò L, Sanfilippo F, et al. Spinal anesthesia and hypotensive events in hip fracture surgical repair in elderly patients: a meta-analysis. J Anesth Analg Crit Care. 2022;2:19.
34. Ariyanuchitkul T. Preoperative risk factors of hypotension after spinal anesthesia for elective cesarean delivery in Maharat Nakhon Ratchasima Hospital. Thai J Anesthesiol. 2022;48:241-8.
35. Shitemaw T, Jemal B, Mamo T, Akalu L. Incidence and associated factors for hypotension after spinal anesthesia during cesarean section at Gandhi Memorial Hospital Addis Ababa, Ethiopia. PLoS One. 2020;15:e0236755.
36. Carpintero P, Caeiro JR, Carpintero R, Morales A, Silva S, Mesa M. Complications of hip fractures: A review. World J Orthop. 2014;5:402-11.
37. Fawcett WJ, Thomas M. Pre-operative fasting in adults and children: clinical practice and guidelines. Anaesthesia. 2019;74:83-8.
38. Yeniay O, Tekgul ZT, Okur O, Koroglu N. Unexpectedly prolonged fasting and its consequences on elderly patients undergoing spinal anesthetics. A prospective observational study1. Acta Cir Bras. 2019;34:e201900309.
39. Lindholm C, Sterner E, Romanelli M, Pina E, Torra y Bou J, Hietanen H, et al. Hip fracture and pressure ulcers - the Pan-European Pressure Ulcer Study - intrinsic and extrinsic risk factors. Int Wound J. 2008;5:315-28.
40. Sutipornpalangkul W, Harnroongroj T, Harnroongroj T. Intracapsular hip fractures have poorer nutritional status and more complications than trochanteric fractures: a retrospective study of 255 Thai patients. Siriraj Med J. 2010;62:1-3.
41. Shiga T, Wajima Z, Ohe Y. Is operative delay associated with increased mortality of hip fracture patients? Systematic review, meta-analysis, and meta-regression. Can J Anaesth. 2008;55:146-54.
42. Suenghataiphorn T, Songwisit S, Tornsatitkul S, Somnuke P. An overview on postoperative cognitive dysfunction; pathophysiology, risk factors, prevention and treatment. Siriraj Med J. 2022;74:705-13.
43. Xie R, Wang L, Bao H. Crystalloid and colloid preload for maintaining cardiac output in elderly patients undergoing total hip replacement under spinal anesthesia. J Biomed Res. 2011;25:185-90.
44. Bajwa SJ, Kulshrestha A, Jindal R. Co-loading or pre-loading for prevention of hypotension after spinal anaesthesia! a therapeutic dilemma. Anesth Essays Res. 2013;7:155-9.

45. Giannoulis D, Calori GM, Giannoudis PV. Thirty-day mortality after hip fractures: has anything changed? Eur J Orthop Surg Traumatol. 2016;26:365-70.
46. Royal College of Physicians. National Hip Fracture Database Annual Report Web site. Available from: https://www.nhfd.co.uk/2022 report. [Accessed June 12, 2023].
47. Tan CMP, Park DH, Chen YD, Jagadish MU, Su S, Premchand AXR. Mortality rates for hip fracture patients managed surgically and conservatively in a dedicated unit in Singapore. Arch Orthop Trauma Surg. 2022;142:99-104.
48. Li D, Chang B, Yao P, Mao J. Application of the collaborative model for the treatment of elderly patients with hip fracture. Asian J Surg. 2023;46:2786-7.
49. The National Institute for Health and Care Excellence. Hip fracture Management Clinical Guideline 124 Web site. Available from: https://www.nice.org.uk/guidance/cg124/resources/hip-fracture-management-pdf-35109449902789. [Accessed June 12, 2023].