Characteristics and Perioperative Complications of Hip Fracture in the Elderly With Acute Ischemic Stroke: A Cross-Sectional Study

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Abstract

Background: Patients with acute ischemic stroke (AIS) after hip fracture in the elderly have worse prognosis. We aimed to describe the characteristics and complications of hip fracture with AIS in the elderly.

Methods: This cross-sectional study selected patients with hip fracture (age ≥ 65 years) from January 2018 to September 2020. The collected data included age, sex, fracture types, comorbidities. In above screened patients, we further collected cerebral infarction related information of AIS patients. Risk factors for AIS after hip fracture were identified.

Results: 60 patients (mean age 79.7 years; female 56.7%) occurred AIS after hip fracture in 1577 cases. Among 60 AIS patients, the most common cause of fall was limb weakness or instability(46.7%). The most common infarction type was PACI (70.0%). The majority of these infarction lesions were single (76.7%) and most infarction lesions(65.0%) were located in the left side. 81.7% of AIS patients had mild (NIHSS 0-4) AIS. Older patients with AIS after hip fracture were more frequently complicated by hypertension(73.3%), prior stroke (46.7%), diabetes(35.0%) and were more likely to have hypoproteinemia(68.3%), electrolyte disorders (66.7%), anemia (65.0%), deep vein thrombosis (51.6%), pneumonia (46.6%),cardiac complications (45.0%). Combined with hypertension (OR 2.743, 95%CI 1.471-5.115) and male sex(OR 1.946, 95%CI 1.146-3.304) were independent risk factors of AIS after hip fracture.

Conclusions: Older patients combined with hypertension are more likely to have AIS after hip fracture. For these patients, early preventions should be administered. AIS patients after hip fracture are prone to have multiple complications under traumatic stress, and we should enhance the management of these patients to reduce the stress and avoid occurrence of complications.

Introduction

As the accelerated rate of social aging, the number of older patients with hip fractures continually increase, which has become a global medical and health problem[1, 2]. There are approximately 1.5 million femoral fractures worldwide each year, and this number will rise to 6.3 million by 2050[3]. Hip fractures of the older adults, which are often referred to "the last fracture of life ", severely affect limb function and quality of life, and greatly increase social and family burdens[4]. A report showed that older patients have a high mortality of 8.4-36% within one year after the fracture[5].

Previous studies have found that complications were a substantial contributor to high mortality in older patients with hip fracture[6, 7]. AIS is one of the catastrophic complications and associated with increased mortality in the hip fracture patients[8]. Fracture patients with perioperative AIS have worse functional recovery than those with non-AIS and require more care in the first year[9]. Currently, the existing studies focuses on the occurrence of stroke in the perioperative period and 1 year after the surgeries of hip fracture[10–12], while there are few studies on AIS after fracture. AIS after hip fracture

makes patients unable to perform surgery in a short time and results in poor outcomes including impaired self-care, decreased quality of life and increased mortality[13]. Due to blood loss, pain and other factors, elderly patients with hip fracture are prone to traumatic stress reactions[14], which increase the risk of complications. We should pay more attention to these patients. However, there are few studies on the complications of AIS patients after fracture.

In this study, we retrospectively described characteristics and complications of hospitalized older adults with hip fractures who sustained AIS. These results will help people to understand characteristics of older hip fracture adults with AIS and provide treatment recommendations for these specific populations.

Materials And Methods

Patients and Groups

In this retrospective study, we collected data in a single Level I trauma center in China from January 2018 to September 2020. The study protocol was approved by the institutional review board of the third Hospital of Hebei Medical University, and an exemption from the informed consent was obtained. Inclusion criteria were hip fracture patients aged 65 years or older and complete data available in medical records. The exclusion criteria were as follows: (1) had multiple fracture; (2) had pathological fracture, (3) had secondary fracture (4) incomplete medical information. Diagnosis of AIS should be based on consciousness, physical performance, head CT, and MRI performance. All AIS patients fulfilled the World Health Organization criteria for AIS [15]. Patients were retrospectively divided into 2 groups: those who developed AIS (AIS group) and those without AIS (No-AIS group).

Data Collection

The collected data of screened patients included sex, age, and fracture types, comorbidities in both groups. The incidence of AIS after hip fracture was 3.8%. In AIS group, we further collected cerebral infarction related information. AIS was further classified into four subtypes as follows: total anterior circulation infarction (TACI), partial anterior circulation infarction (PACI), posterior circulation infarction (POCI), and lacunar infarction (LACI). Infarction lesions were classified into single infarction lesion and multiple infarction lesions. The sides of cerebral infarction included left side, right side or both sides. Severity of stroke was determined with the National Institutes of Health stroke scale (NIHSS) and categorized as mild (NIHSS<4), moderate (NIHSS 4–15), and severe (NIHSS > 15) stroke. According to the 10-year age interval, the AIS patients were divided into 3 groups: 65-74 years, 75-84 years, ≥85 years. Trauma mechanisms were classified as instability or fatigue, impacts injury, dizziness, slips and others.

Statistical Analysis

The Kolmogorov-Smirnov test was used to test the normality of continuous variables. Continuous parametric data was expressed as the mean ± standard deviation and analyzed by student's t test or

analysis of variance. Categorical variables were expressed as numbers and percentages and were compared using chi-squared test or Fisher's exact test. Univariate analysis was applied and variables with statistical significance were included in a multivariate model by stepwise logistic regression to identify independent risk factors of AIS. The p -value < 0.05 was considered statistically significant and all analyzes were performed using IBM SPSS software (IBM Corp, Armonk, NY).

Results

Age, Gender, Fracture types and Injury Mechanisms of AIS after Hip Fracture

A total of 60 (34 female, 26male) older hip fracture patients occurred AIS in 1577cases. The incidence of AIS after hip fracture was 3.8% and incidence was higher in male than female(5.4% vs 3.1%).Among 60 (34 female, 26male) patients, the average age of patients was 79.7 years old (range 65–96), and 75-84years account for the largest percentage (45%). 27(45.0%) suffered femoral neck fracture and 33(55.0%) suffered trochanteric fracture. The most common cause of fracture was instability or weakness, which was present in 46.7% of the patients. Other reasons included impact slips (10, 16.7%), dizziness (10, 16.7%), impact injury (5, 8.3%), and others (7, 11.6%). The specific information was presented in Table 1.

Table 1
Age, gender, fracture types and injury mechanisms

acute ischemic stroke	Number (n)	Percentage(%)
Gender		
Female	34	56.7
Male	26	43.3
Age		
65-74	17	28.3
75-84	27	45.0
≥85	16	26.7
Fracture type		
Neck of femur	27	45.0
Intertrochanteric	33	55.0
Injury mechanism		
Instability or weakness	28	46.7
Slips	10	16.7
Dizziness	10	16.7
Impact injury	5	8.3
Other	7	11.6
Notes: Values are presented as the number (n) and Percentage(%)		

Characteristics of AIS

Table 2 showed that the types of AIS in elderly hip fracture patients with AIS were PACI (42, 70.0%), POCI (9, 15.0%), LACI (8, 13.3%),TACI (1, 1.6%).There were 46(76.7%) cases of solitary lesion and 14(23.3%) cases of multiple cerebral infarction and most of them were located on the left side(65%). In addition, in these cases, there were 49(81.7%), 9(15.0%) and 2(3.3%) patients with mild (NIHSS<4), moderate (NIHSS 4–15), and severe (NIHSS > 15) stroke, respectively. The specific information was presented in Table 2.

Table 2
The characteristics of AIS

	Number (n)	Percentage(%)
Type of cerebral infarction		
PACI	42	70.0
POCI	9	15.0
LACI	8	13.0
TACI	1	5.0
Distribution of cerebral infarction lesions		
Single infarction lesion	46	76.7
multiple infarction lesion	14	23.3
Side of cerebral infarction		
Left side	39	65.0
Right side	18	30.0
Both sides	3	5.0
NIHSS score		
< 4	49	81.7
4-15	9	15.0
> 15	2	3.3
Notes: Values are presented as the number (n) and percentage(%)		

Comorbidities, Complications of AIS after Hip Fracture

Among 60 patients, there were 20 patients combined with three or more comorbidities, accounting for 33.3%. The most common comorbidity was hypertension, which was presented in 73.3% of the patients. Other common comorbidities included prior stroke (46.7%), diabetes (35.0%). 55(91.6%) patients were presenting with at least one complication, which consisted of hypoproteinemia (68.3%), electrolyte disorders (66.7%), anemia (65.0%), deep vein thrombosis (51.6%), pneumonia (46.6%), cardiac complications (45.0%). The cardiac complications included heart failure (30.0%), arrhythmia (16.6%) and myocardial infarction (1.6%).The specific information was presented in Table 3 and figure 1.

Table 3
Comorbidities and Complications of AIS after hip fracture

	Number (n)	Percentage(%)
Comorbidities n (%)		
Hypertension	44	73.3
Prior stroke	28	46.7
Diabetes	21	35.0
Coronary heart disease	14	23.3
Arrhythmia	5	8.3
Tumor	4	6.7
Pulmonary disease	4	6.7
Comorbidities $\geq$ 3	20	33.3
Complications, n (%)		
Total	55	91.6
Hypoproteinemia	41	68.3
Electrolyte disorders	40	66.7
Anemia	39	65.0
Deep vein thrombosis	31	51.6
Pneumonia	28	46.6
Cardiac complications	27	45.0
Heart failure	18	30.0
Arrhythmia	10	16.6
Myocardial infarction	1	1.6
Complications $\geq$ 3	24	60.0
Notes: Values are presented as the number (n) and percentage(%)		

The Comparison of the AIS Group and No-AIS Group

As shown in Table 4, among these 1577 patients, the average age was 79.7 years old (ranging from 65 to 104 years old). There were more female patients than male patients(69.4% vs 30.6%). There was a higher proportion of male in the AIS group compared with the non-AIS group (43.3% vs 30.1%, $p=0.029$). AIS

patients had more comorbidities(number $\geq$ 3, $p=0.039$), including hypertension ($p=0.000$) and diabetes ($p=0.035$). Other characteristics were similar between the two groups.

Table 4
The Comparison of the AIS group and No-AIS group

	Overall (n=1577)	AIS (n=60)	No-AIS (n=1517)	<i>p</i> Value
Age (year)				
mean years	79.7 $\pm$ 7.3	79.8 $\pm$ 6.9	79.7 $\pm$ 7.3	0.217
Gender n (%)				
Male	483(30.6)	26(43.3)	457 (30.1)	0.029
Female	1094(69.4)	34(56.7)	1060(69.9)	
Fracture type n (%)				
Neck of femur	758(48.1)	27(45.0)	731(48.2)	0.628
Intertrochanteric	819(51.9)	33(55.0)	786(51.8)	
Comorbidities n (%)				
Hypertension	794 (50.3)	44(73.3)	752(49.6)	0.000
prior stroke	658(41.7)	28(46.7)	624(41.1)	0.393
Diabetes	371(23.5)	21(35.0)	352(23.2)	0.035
Coronary heart disease	465(29.5)	14(23.3)	450(29.7)	0.291
Arrhythmia	94(6.0)	5(8.3)	89(5.9)	0.429
Pulmonary disease	45(2.9)	4(6.7)	44(2.9)	0.096
Tumor	74(4.7)	4(6.7)	70(4.6)	0.461
Comorbidities $\geq$ 3	352(22.3)	20(33.3)	334(22.0)	0.039
Notes: Values are presented as the number (n) and percentage(%) $p < 0.05$, statistical significance.				

Risk Factors of AIS after Hip Fracture

Table 5 shows the results of the multivariable analyses. In the whole sample, combined with hypertension (OR 2.743, 95%CI 1.471-5.115) and male sex(OR 1.946, 95%CI 1.146-3.304) were independently associated with AIS after hip fracture (Table 5).

Table 5

Multivariate logistic regression for prediction of AIS after hip fracture

Model variables	OR	95%CI	<i>p</i> Value
Hypertension	2.743	1.471-5.115	0.001
Diabetes	1.633	0.843-3.165	0.146
Comorbidities $\geq$ 3	0.906	0.450-1.825	0.783
Male	1.946	1.146-3.304	0.014
Notes: $p < 0.05$, statistical significance.			

Discussion

A total of 60 (3.8%) older hip fracture patients occurred AIS in all 1577 cases. Among 60 AIS patients, the number of female was higher than that of male, but the incidence was higher in male than female. The most common cause of fall was limb weakness or instability. The most cerebral infarction type was PACI and the most infarction lesion was single cerebral infarction in 60 AIS patients. Most of them were located on the left side. 81.7% of AIS patients had mild (NIHSS 0-4) AIS. Older patients with AIS after hip fracture were more frequently complicated by hypertension, previous stroke, diabetes and were more likely to have hypoproteinemia, electrolyte imbalance, anemia, deep vein thrombosis, cardiac complications and pneumonia. Combined with hypertension and male sex were independent risk factors of the AIS after hip fracture in the elderly.

There were significantly more female among AIS cases in our study, which is due to the reason that female tend to live longer and are more likely to develop stroke and fracture in older people[16, 17]. The AIS incidence was higher in male than female in older fracture people in our study. Studies have shown that male sex is a significant risk factor for stroke[18], and the incidence of stroke in male before the age of 85 is higher than in female[19]. 75-84 years was the most common age group in our study. This may be due to the largest number of fracture patients in this age group. Fall is a major cause of fracture in older adults, and the most common fall-related injury was hip fracture[20]. Elderly people often fall due to instability and weakness, which may be related to the decline of physical functions such as vision and movement, as well as the impairment of balance in the elderly[21]. The infarctions were solitary cerebral infarction and were located on the left side in our study. The result was consistent with previously published results of Hedna VS et al[22]. Left-sided strokes might be mentioned more often because they cause obvious symptoms like aphasia, while strokes on the right side can cause less obvious symptoms like hemineglect or spatial disorientation[23]. We think that this can also be applied to patients with AIS after fracture.

The prevalence of AIS after hip fracture was 3.8% in our study, which was consistent with prior study[24]. In our study, it was found that AIS patients after hip fracture were more frequently comorbid with chronic

medical illness diseases, including hypertension, prior stroke and diabetes. Hypertension and diabetes are significant risk factors for the occurrence of cerebrovascular accidents (CVA) after hip fracture[25]. It has been observed that the carotid arteries of patients with diabetes are thicker and harder than those of the general population[26]. In addition, it has been reported that the carotid stiffness index of hypertensive patients is significantly higher than that of the general population[27]. Hypertension and diabetes accelerate the progression of atherosclerosis. Atherosclerosis is an important pathological cause of ischemic stroke. 30% of ischemic stroke are caused by carotid atherosclerosis[28]. The pathogenesis of ischemic stroke is considered to be arterial embolism caused by rupture of carotid plaque, ulceration, and platelet activation.

A study has shown that hip fracture is associated with increased risk of stroke[29]. Physical inactivity, fear and pain are common in the elderly hip fracture patients. In this case, the pre-existing cerebrovascular risk may be exacerbated. This may be associated with traumatic stress response. Fracture can lead to the release of stress hormones such as glucocorticoids, glucagon, epinephrine, thyroxine and others, which is called the “stress response”[30]. Stress response induces platelet aggregation and promotes microcirculation dysfunction and thrombosis[30]. A large number of inflammatory mediators caused by stress are released after hip fracture, and inflammation in the acute phase can affect thrombosis. Inflammation is usually related to oxidative stress. The strong oxidative activity can also destroy normal cell structure and promote the progress of cardiovascular and cerebrovascular diseases[31].

Patients with both fractures and strokes have a worse prognosis than those with single injury[32], and this may be related to their stronger traumatic stress response. Our observations showed that AIS patients after hip fractures suffered other adverse events such as hypoproteinemia, anemia, electrolyte disturbances, pneumonia, lower limb venous thrombosis and cardiovascular complications. Complications also affected each other, resulting in worse prognosis.

Hypoalbuminemia, electrolyte imbalance, and anemia were common complications after bone fracture in our study. Factors such as excessive blood loss and pain after the fracture induce stress response. Stress response puts the body in a state of enhanced catabolism and decreased anabolism, which may be related to the occurrence of hypoproteinemia and electrolyte disorder[33]. Stroke related disorders such as cognitive dysfunction, impaired consciousness, neurogenic vomiting, neurogenic dysphagia, and motor dysfunction also contribute to the development of hypoalbuminemia and electrolyte imbalance[34]. One study has shown that hypoalbuminemia occurs more frequently in patients with bone fracture and stroke and is associated with a poor prognosis[35]. Several studies have shown that human albumin therapy can combat thrombosis, stagnation and leukocyte adhesion of the microcirculation in the early stage of stroke, and provide neuroprotection for stroke patients[36, 37].

The traumatic stress response leads to the release of hormones such as catecholamines[38], which increase pulmonary artery systolic pressure and initiate pulmonary vasoconstriction and pulmonary interstitial edema. Moreover, an excessive stress response would impair organism immunity. These

factors lead to the occurrence of pneumonia. In addition, swallowing difficulty, immune deficiency, nasogastric tube feeding, and poor oral hygiene from stroke can increase the risk of pneumonia. The occurrence of pneumonia increases the risk of in-hospital death[39]. In addition, after traumatic fracture, stress can activate the endogenous and exogenous coagulation system, resulting in hypercoagulability and coagulation dysfunction. This significantly increases the risk of deep vein thrombosis.

The persistent stress of older hip fracture patients can cause myocardial hypoxia and increase the imbalance between oxygen supply and myocardial demand. This is a common and complex pathophysiological mechanism that causes the occurrence of cardiac complications[40]. There are several common risk factors for stroke and ischemic heart disease. Underlying heart diseases, such as atrial fibrillation, valve defects, or congestive heart failure, increase the risk of stroke. Stroke interferes with autonomic control and can easily lead to cardiac complications in patients[41]. Cardiac complications in patients with fracture or stroke can be fatal for the patients[42]. All the occurrence of these complications after hip fracture is associated with traumatic stress, and we need to strengthen the management of patients' breathing, circulation, blood, and thrombus to attenuate the stress response and improve the quality of patients' survival.

Furthermore, after we performed multivariate logistic regression on patients participated in this study, the data showed that comorbid with hypertension and male sex were significant risk factors for the AIS after hip fracture in the elderly. The mechanism of stroke caused by hypertension was discussed above. For this reason, we propose the following recommendations. Firstly, elderly patients comorbid with hypertension should prevent falls and fractures in their daily life. Secondly, Elderly patients comorbid with hypertension should pay attention to monitoring blood pressure, blood lipids, and preventing the occurrence and development of cerebrovascular disease. In addition, for these elderly patients who develop fracture, we should strengthen management to reduce the stress reaction and avoid the occurrence of stroke and other complications.

Limitations

There are some limitations to our study that warrant discussion. First, it is a retrospective nature of the study and the intrinsic limitation of design seems to be inescapable. Second, there is the possibility of selection bias owing to small sample size. The conclusions drawn cannot completely and reliably represent the general clinical characteristics. Third, patients with AIS after fracture surgery were not included in our study. Further study is needed to compare the different characteristics of AIS after hip fracture and AIS after surgery.

Conclusions

Elderly patients with AIS after hip fracture more often comorbid with hypertension, prior stroke and diabetes. Older patients who had hypertension are more likely to have AIS after hip fracture. AIS patients after hip fracture are prone to have multiple complications under traumatic stress, and we should

enhance the management of these patients to reduce the stress response and avoid occurrence of complications.

Abbreviations

AIS: acute ischemic stroke; TACI: total anterior circulation infarction; PACI: partial anterior circulation infarction; POCI: posterior circulation infarction; LACI: lacunar infarction; NIHSS: National Institutes of Health stroke scale; CVA: cerebrovascular accidents

Declarations

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None.

Author contributions

ZQ.W and ZY.H conceived the study. YQ.Z, MM.F, JF.G and YQ. Z supported study preparation and data collection. YQ.Z collected the data and drafted the manuscript. ZQ.W and ZY.H critically reviewed the manuscript for important intellectual content. All authors approved the final version of the manuscript.

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Data Availability

The data used to support the findings of this study are available from Zhiqian Wang upon request.

Ethical approval and Informed consent

This study was approved by the institutional review board of the third Hospital of Hebei Medical University in compliance with the Helsinki and an exemption from the informed consent was obtained. All data were anonymized before the analysis to safeguard patient privacy.

Consent for publication

Not Applicable.

Conflicts of interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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Figures

Figure 1

The incidence of other complications