

Risk factors for early complications following arthroplasty in elderly patients with a femoral neck fracture

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Abstract.

BACKGROUND: Early complications after arthroplasty for geriatric femoral neck fractures are known to negatively affect postoperative recovery and increase postoperative mortality. Identifying risk factors associated with early complications after arthroplasty may offer an opportunity to address and prevent these complications in many patients.

OBJECTIVE: To evaluate preoperative risk factors for early complications after arthroplasty in elderly patients with a femoral neck fracture.

METHODS: 119 elderly patients with femoral neck fractures who had been treated with arthroplasty (hemiarthroplasty or total hip arthroplasty) between December 2015 and December 2018 were retrospectively analysed. Early complications were defined as any complications that did not exist preoperatively, and occurred during hospital stay after arthroplasty. Preoperative clinical, epidemiological and laboratory data were collected. Binary univariable and multivariable logistic regression analysis were applied to identify predictors of early complications after arthroplasty for geriatric femoral neck fractures.

RESULTS: Median age of all patients was 80.0 (IQR 74.0–84.0) years. We identified 28 (23.5%) early complications after arthroplasty. Univariable logistic regression analysis found that preoperative body mass index (BMI $p = 0.031$), C-reactive protein (CRP $p = 0.017$) and serum Albumin ($p = 0.006$) were potential risk factors for early complications. Then preoperative BMI, CRP and serum Albumin were stratified and used for multivariable logistic regression analysis. The multivariate logistic regression analysis showed that preoperative higher BMI ($\geq 28 \text{ kg/m}^2$; OR 10.440; 95% CI 2.674–41.170; $p = 0.001$) and lower serum Albumin ($\leq 35 \text{ g/L}$; OR 3.933; 95% CI 1.509–10.800; $p = 0.006$) were independent risk factors for early complications after arthroplasty in geriatric femoral neck fractures. However, preoperative higher CRP levels ($> 10 \text{ mg/L}$; OR 1.139; 95% CI 1034–1428; $p = 0.833$) was found to be not an independent risk factor for early complications.

CONCLUSION: Our results demonstrate that obesity and hypoalbuminemia are independent predictors for early complications during hospital stay after arthroplasty, which should be meticulously noted to minimize these risk factors in geriatric femoral neck fractures.

Keywords: Femoral neck fracture, geriatric, early complication, risk factor, arthroplasty

1. Introduction

Femoral neck fracture is a common orthopedic emergency and represents the majority of hip fractures. Geriatric femoral neck fractures are mostly fragility-type fractures caused by low-energy injuries. Due to the existence of several risk factors, such as advanced age, malnutrition, and systemic complications, if not treated

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in time, geriatric femoral neck fracture will significantly impair the post-traumatic quality of life, and is even associated with short-term and intermediate-term death [1].

Arthroplasty (hemiarthroplasty or total hip arthroplasty) is generally preferred for the management of geriatric femoral neck fractures if other treatment options (e.g., DHS) are not indicated, which provides quick mobilization after operation, and avoids the occurrence of systemic complications caused by immobilization [2,3]. However, for patients with geriatric femoral neck fractures, despite aggressive management including arthroplasty and rehabilitation, the 1-year mortality is still as high as 20% after surgery, which usually stems from the occurrence of various postoperative complications [4]. Therefore, the prevention and treatment of postoperative complications in geriatric femoral neck fractures are of utmost importance, and are also huge clinical challenges. In addition, identifying risk factors associated with early complications after arthroplasty in femoral neck fractures also may offer an opportunity to address and prevent these potential complications by preoperative correction and treatment in many patients.

Currently, although much research has been done on the risk factors associated with complications following arthroplasty in geriatric femoral neck fractures, and obesity, hypoalbuminemia and preoperative C-reactive protein/albumin ratio were found to be risk factors for complications after hip arthroplasty, they usually only focus on a single complication or long-term postoperative complications, such as periprosthetic joint infection, dislocation, delirium or mortality [5–9]. Only a few studies focus on the risk profile of postoperative early multi-system complications during hospital stay after arthroplasty, which is a more common issue requiring more attention. Although these complications might not be fatal, they could delay hospitalization, increase medical cost, and affect the patient's postoperative recovery process. Therefore, in the present study, we aimed to identify possible independent risk factors associated with early multi-system complications during hospital stay following arthroplasty in elderly patients with a femoral neck fracture.

2. Materials and methods

2.1. Study population

We retrospectively analysed 119 elderly patients with femoral neck fractures who had been admitted and

treated definitively with arthroplasty at the Department of Orthopedics, Peking University International Hospital between December 2015 and December 2018. Inclusion criteria were an age of 65 years or older, initial treatment with arthroplasty, a postoperative follow-up during hospital stay and a complete data set (including all parameters in data collection). Patients that received arthroplasty secondary to a failed internal fixation of a femoral neck fracture, those with general multiple injuries those who cannot tolerate arthroplasty and those with a pathological fracture due to malignancy were excluded. The study followed the principles of the Declaration of Helsinki in 2013 (seventh revision) and was approved by the ethics committee of Peking University International Hospital (2021-028(BMR)). Because of the retrospective nature of this study, and the personnel identifiers were removed from the database, the ethical committee of Peking University International Hospital approved the research protocol and waived the need for informed consent, and waiving informed consent will not adversely affect the rights and health of the study subjects.

2.2. Treatment algorithm

Blood samples for routine laboratory parameters in particular myocardial injury markers and arterial blood gas analysis, were drawn immediately after admission to the emergency room. Urinary, stool tests, electrocardiography, echocardiography and chest x-rays/CT were also performed as routine to determine whether there were related complications before surgery.

Total hip arthroplasty was performed if patient is relatively healthy, has no cognitive impairment, and ambulates independently. The implant brands (including DePuy, Indiana USA and AK Medical, Beijing, China) were selected according to the patient's personal choice and economic situation. All surgeries were performed with cementless stems using the modified Hardinge approach. All patients received a single-shot of 1.5 g cefuroxime (or clindamycin in case of hypersensitivity to penicillin or cefuroxime) prior to surgery and continued to use until 24 hours after surgery. Patients were mobilized with full weightbearing postoperatively as soon as their clinical state allowed.

2.3. Data collection

The following data before arthroplasty were extracted from medical records: demographic data such as age, sex, body mass index (BMI); clinical data includ-

Table 1
Patient characteristics

	Total study cohort (<i>n</i> = 119)
Age (years), median (IQR)	80.0 (74.0–84.0)
Females	86 (72%)
BMI (kg/m ²), mean (SD)	22.8 (4.1)
Time from onset to arthroplasty (days), median (IQR)	6.0 (3.5–14.0)
ASA classification	
I–II	62 (52.1%)
III–IV	57 (47.9%)
WBC (10 ⁹ /L), median (IQR)	7.6 (6.0–10.0)
CRP (mg/L), median (IQR)	33.8 (10.3–85.5)
ESR (mm/h), median (IQR)	28 (18–44)
D-dimer (ng/mL), median (IQR)	817 (453–1900)
Serum Albumin (g/L), mean (SD)	37.0 (3.9)
HGB (g/L), mean (SD)	122.0 (16.7)
Duration of operation (mins), mean (SD)	75.1 (19.7)
General anesthesia	20 (16.8%)
Hemiarthroplasty	69 (58.0%)
Diabetes mellitus	24 (20.2%)
Hypertension	62 (52.1%)
Coronary artery disease	12 (10.1%)
Early complications following arthroplasty*	28 (23.5%)

Values are given as absolute numbers (percentage), if not otherwise specified. *Early complications following arthroplasty were defined as any complications that did not exist preoperatively, and occurred during hospital stay.

ing the time from onset to arthroplasty, the American Society of Anaesthesiologists (ASA) score [10], the anesthetize mode (general or epidural anesthesia), the surgery time the surgical options (hemiarthroplasty or total hip arthroplasty) and the preoperative comorbidities; lab test results including white blood cell count (WBC), C-reactive protein (CRP), erythrocyte sedimentation rate (ESR), D-Dimer, hemoglobin (HGB) and serum Albumin.

The outcome variable was postoperative early complications occurring during hospital stay after arthroplasty, which was defined as any complications that did not exist preoperatively. The primary outcome was characterized as a binary variable.

2.4. Statistical analysis

Sample size calculations determined that 81 subjects were required in random sampling to have 90% power and testing with a two-sided 95% confidence interval in this study (the incidence of postoperative early complications in our pre-survey was 30%). Data were analysed using GraphPad Prism (version 9; GraphPad Software Inc., San Diego, CA, USA). The Shapiro-Wilk test was used to test continuous variables for normal distribution. Normal distributed values are presented as mean (standard deviation, SD), not normal distributed values are given as median (interquartile range, IQR 25–75 percentile), while incidences are presented with counts

(percentages). In binary univariable logistic regression analysis, the continuous variables were analyzed based on the original data, the categorical variables were analyzed after converting to 0 and 1. Only variables that showed statistical significance in the univariate analysis were included in the multivariate logistic regression analysis. Preoperative BMI, CRP and serum Albumin were stratified according to previous research [11–14], and used for multivariable logistic regression analysis. The results were reported as odds ratio (OR) with 95% confidence interval (CI), two-sided *p* value and area under the curve (AUC). In general, a two-sided *p* < 0.05 was considered to be statistically significant.

3. Results

3.1. Patient characteristics

A total of 119 elderly patients with femoral neck fractures were treated with arthroplasty at the Peking University International Hospital between December 2015 and December 2018. Preoperative baseline characteristics of the 119 femoral neck fracture patients are shown in Table 1. For demographic and clinical data, female patients represented 72.0% (*n* = 86) and male patients represented 28.0% (*n* = 33) of the study population. Median age of all patients was 80.0 (IQR 74.0–84.0) years. The average BMI was 22.8 (SD 4.1) kg/m².

Table 2
Univariable analysis of risk factors for early complications ($n = 28$) following arthroplasty

Parameter	Complications-free ($n = 91$)	Complications ($n = 28$)	OR (95% CI)	p value
Age (years), median (IQR)	79.0 (74.0–84.0)	82.0 (75.3–85.8)	1.039 (0.981–1.105)	0.210
Females	64 (70.3%)	22 (78.6%)	1.547 (0.591–4.578)	0.397
BMI (kg/m^2), mean (SD)	22.3 (3.6)	24.2 (5.2)	1.126 (1.013–1.260)	0.031*
Time before arthroplasty (days), median (IQR)	6.0 (4.0–15.0)	4.0 (2.0–10.0)	0.998 (0.977–1.013)	0.834
ASA classification			1.970 (0.839–4.787)	0.124
I–II	51 (56.0%)	11 (39.3%)		
III–IV	40 (44.0%)	17 (60.7%)		
WBC ($10^9/\text{L}$), median (IQR)	7.6 (5.9–9.7)	8.0 (6.5–10.3)	1.044 (0.931–1.164)	0.427
CRP (mg/L), median (IQR)	27.3 (10.0–75.6)	54.3 (18.8–127.6)	1.008 (1.001–1.015)	0.017*
ESR (mm/h), median (IQR)	30 (18–50)	27 (14–44)	0.994 (0.974–1.005)	0.489
D-dimer (ng/mL), median (IQR)	765 (438–2223)	950 (540–1261)	1.000 (1.000–1.000)	0.655
Serum Albumin (g/L), mean (SD)	37.6 (3.6)	35.2 (4.3)	0.840 (0.737–0.946)	0.006*
HGB (g/L), mean (SD)	121.1 (15.4)	125.0 (20.3)	1.014 (0.989–1.041)	0.285
Duration of operation (mins), mean (SD)	73.9 (20.2)	79.2 (17.7)	1.014 (0.992–1.036)	0.216
General anesthesia	15 (16.5%)	5 (17.9%)	1.101 (0.330–3.197)	0.865
Hemiarthroplasty	49 (53.8%)	20 (71.4%)	2.143 (0.881–5.632)	0.104
Diabetes mellitus	17 (18.7%)	7 (25.0%)	1.451 (0.505–3.865)	0.468
Hypertension	48 (52.7%)	14 (50.0%)	0.896 (0.382–2.102)	0.799
Coronary artery disease	8 (8.8%)	2 (7.1%)	1.093 (0.230–3.995)	0.899

Values are given as absolute numbers (percentage), if not otherwise specified. *Statistical significance, $p < 0.05$.

Table 3
Multivariable analysis of risk factors for early complications ($n = 28$) following arthroplasty

Predictor	Regression coefficient	OR (95% CI)	p value
BMI ≥ 28 (kg/m^2)	2.346	10.440 (2.674–41.170)	0.001*
CRP ≤ 10 (mg/L)	-0.130	0.878 (0.240–2.812)	0.833
Serum Albumin ≤ 35 (g/L)	1.369	3.933 (1.509–10.800)	0.006*

*Statistical significance, $p < 0.05$.

Time from onset to arthroplasty was 6.0 (IQR 3.5–14.0) days. A total of 62 patients (52.1%) were classified as ASA score I or II, and 57 patients (47.9%) were classified as ASA score III or IV. The average surgery time was 75.1 (SD 19.7) minutes. A total of 20 patients (16.8%) received general anesthesia, others received epidural anesthesia. Hemiarthroplasty were performed in 69 patients (58.0%) according to the patient's general condition. For lab test results, preoperative median WBC was 7.6 (IQR 6.0–10.0) $10^9/\text{L}$, median CRP was 33.8 (IQR 10.3–85.5) mg/L , median ESR was 28 (IQR 18–44) mm/h , and median D-dimer was 817 (IQR 453–1900) ng/mL . Preoperative average serum Albumin was 37.0 (SD 3.9) g/L and average HGB was 122.0 (SD 16.7) g/L . For preoperative comorbidities, there were 24 patients (20.2%) with diabetes mellitus, 62 patients (52.1%) with hypertension, 12 patients (10.1%) with coronary artery disease (CAD).

Overall, we identified 28 patients (23.5%) with early complications after arthroplasty (multiple complications occurred in some cases), including high fever (2 cases, temperature $> 39^\circ\text{C}$ except for infection), infection (9 cases, including respiratory infection, urinary tract infection, wound infection and other in-

fections), lower extremities DVT (4 cases, by ultrasound), atrial fibrillation (3 cases, by electrocardiography), respiratory failure (3 cases), delirium (3 cases), liver dysfunction (2 cases), acute myocardial infarction (1 case), leukopenia (1 case), gastrointestinal hemorrhage (1 case), renal dysfunction (1 case).

3.2. Univariable regression analysis referring to early complications

Univariable logistic regression analysis revealed preoperative BMI ($p = 0.031$), CRP ($p = 0.017$), and serum Albumin ($p = 0.006$) as potential risk factors for early complications after arthroplasty. No significant association was found for age, gender, time from onset to arthroplasty, surgery time, ASA score, WBC, ESR, D-dimer, HGB, anesthetize mode, surgery option, diabetes mellitus, hypertension and coronary artery disease (Table 2).

3.3. Multivariate regression analysis referring to early complications

Preoperative BMI, CRP and serum Albumin levels were stratified and used for multivariable regression

analysis. The multivariate logistic regression analysis referring to early complications showed that preoperative higher BMI (≥ 28 kg/m²; OR 10.440; 95% CI 2.674–41.170; $p = 0.001$) and lower serum Albumin (≤ 35 g/L; OR 3.933; 95% CI 1.509–10.800; $p = 0.006$) were independent predictors for early complications following arthroplasty in elderly patients with a femoral neck fracture (Table 3). Preoperative higher CRP levels (> 10 mg/L; $p = 0.833$) was found to be not an independent risk factor for early complications. In order to ascertain the accuracy of this prediction model, a ROC curve was calculated (AUC = 0.717; $p < 0.001$), which suggested the prediction model was accurate.

4. Discussion

A number of studies so far have suggested elderly patients with a femoral neck fracture are at substantial risk for death, health complications, and reduced quality of life [3,15,16]. At present, the way in which femoral neck fractures in elderly patients should be managed surgically is relatively clear. Options include hemiarthroplasty and total hip arthroplasty, which have greater advantages with regard to patient's postoperative function and quality of life [4]. However, elderly patients often had multiple preoperative comorbidities, poor nutritional status and weak surgical tolerance, who undergoing arthroplasty had an evidently higher incidence of serious adverse events. All these factors increase the treatment difficulty for geriatric femoral neck fractures.

In the present study, we identified 28 patients with early complications during hospital stay following arthroplasty, the rate of early complications was 23.5%. The top three complications were respiratory infection (21.4%), urinary system infection (17.9%) and thrombosis related diseases (14.3%). Although most of these postoperative complications were not immediate life-threatening, but they affected the rehabilitation of patients, prolonged the length of hospital stay and increased the economic burden on family and society. Therefore, it is of great clinical significance to preoperatively identify the possible independent risk factors associated with early complications following arthroplasty.

To exclude the potential risk factors, we focused on the demographic data, clinical data and lab test results, and analyzed the early complications in univariable and multivariable logistic regression model. The models ultimately revealed obesity (BMI ≥ 28 kg/m²) [11,12]

and hypoalbuminemia (serum Albumin ≤ 35 g/L) [14] as independent predictors for early complications following arthroplasty in geriatric femoral neck fractures.

Previous studies have shown that obesity is a recognized risk factor for a series of acute and chronic diseases such as diabetes mellitus, hypertension, cardiovascular diseases, cerebrovascular diseases and tumors [17]. Obesity not only associates with earlier hip fracture and higher post-fracture mortality [18], but also with impaired wound healing and prosthetic joint infection after arthroplasty [19]. Our study revealed that obese patients (BMI ≥ 28 kg/m²) had higher risk of early postoperative complications than non-obese patients, and obesity was an independent risk factor for postoperative early complications, which is consistent with previous trials. Therefore, in the treatment of obese elderly patients with a femoral neck fracture, more attentions should be paid to various measures including wound management, infection prevention and cholesterol lowering during perioperative period. Through targeted prevention and treatment, the risk for some postoperative complications could be reduced.

Malnutrition is very prevalent in elderly patients with femoral neck fracture. Nevertheless, its importance has not been fully recognized. Malnutrition in the elderly increases an individual's risk of a variety of chronic diseases, such as cardiovascular diseases, cachexia and sarcopenia, and further affects the emotional state, bone metabolism, and contributes to the development of femoral neck fracture [20–23]. Malnutrition and obesity are not contradictory, and there is also malnutrition in obese elderly patients [24]. Recent research shows that hip fracture patients who are both obese and malnourished, have significantly and substantially worse clinical outcomes than their well-nourished counterparts [25]. The serum Albumin level is one of several laboratory parameters commonly used to diagnose malnutrition, which is obviously related to the incidence of morbidity and mortality in hospitalized patients [26]. Low levels of Albumin are associated to worse recovery following acute pathologies, are also associated to a higher risk of post-surgery complications, especially infections [27]. Meanwhile, serum Albumin was also an independent risk factor for postoperative delirium and pneumonia in elderly subjects after arthroplasty [28,29]. In the present study, preoperative hypoalbuminemia (serum Albumin ≤ 35 g/L) was found to be an independent predictor for early complications in elderly patients treated with arthroplasty following a femoral neck fracture, which has not been reported before. Bleeding and chronic consumption after arthroplasty usually further aggravate

hypoalbuminemia. Therefore, our results remind us of the importance to monitor serum Albumin levels before and after arthroplasty in elderly patients, especially for patients with low serum Albumin before arthroplasty, or poor food and water intake after arthroplasty.

CRP is a non-specific reactive protein that plays a protective role in acute injury or infection. Some chronic diseases also have elevated CRP levels [30]. The role of preoperative CRP levels on the incidence of complications after arthroplasty is discussed controversially [31,32]. Although this study found that CRP was a potential risk factor for early complications in univariate logistic regression analysis, but through multivariate logistic regression analysis, we ultimately confirmed elevated CRP was not an independent risk factor for early complications. Since a large number of previous studies have suggested that there is a relationship between elevated CRP and many systemic comorbidities, we believe there might be some interactions between preoperative CRP levels and other preoperative comorbidities [33–35]. Confounding factors such as femoral neck fractures, cardiovascular diseases, etc., might lead to increases in preoperative CRP levels. This result also reminds us, for elderly patients with elevated CRP before arthroplasty, we should actively evaluate whether there are some occult infections or undetected preoperative comorbidities, which will help us reduce the incidence of early complications after arthroplasty.

5. Limitations

We acknowledge several limitations in our study. First, one limitation of this study is its retrospective design, which potentially implicated a study bias. Although numerous confounding variables were considered in this multivariable regression model, some unknown or unmeasured confounders were likely disregarded. Second, the study was also limited to the single center and small sample size. So, our findings need to be validated by future perspective studies with larger sample sizes. Third, CRP is a time-sensitive parameter, although we analyzed time before arthroplasty as a potential risk factor in univariable regression analysis, the time prior surgery might still affect the level of CRP at admission.

6. Conclusion

The results demonstrate that obesity and hypoalbuminemia are independent predictors for early complications during hospital stay after arthroplasty, which should be meticulously noted to minimize these risk

factors in geriatric femoral neck fractures. Preoperative CRP level is not an independent risk factor for early complications. Some confounding factors such as femoral neck fractures, cardiovascular diseases, etc., might lead to increases in preoperative CRP levels. These findings could contribute to further understand the preoperative risk factors for femoral neck fractures in elderly patients. Awareness of these risk factors and consideration in perioperative treatment protocols offer an opportunity to decrease these postoperative complications in geriatric femoral neck fractures.

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Author contributions

JW: Designed and performed the study, first draft of the manuscript and illustrations, analysis and interpretation of data. CZ: Investigation, resources, data curation. BY: Conceived the study and critical review of the manuscript.

Conflict of interest

None of the authors have any conflicts of interest to declare.

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Availability of data and materials

The source data are available from the corresponding author upon reasonable request.

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