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Moderate to severe anemia at admission increases the risk of complications in patients over 60 years with hip fracture

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Abstract

Background Anemia frequently occurs in patients with hip fractures and represents a risk factor that can potentially be altered. To evaluate the association between admission anemia and complications in older hip fracture patients while exploring the potential impact of anemia on complications from the perspective of overall, operation and non-operation.

Methods This retrospective study enrolled in-patients over 60 years old with hip fractures from January 2020 to November 2023. At admission, anemic patients were identified as having a hemoglobin level below 12 g/dL in females and 13 g/dL in males. Anemia was further classified as mild, moderate, or severe. Data encompassing demographics, comorbidities, medications, information on fracture and surgery, and complications were collected.

Results A total of 462/679 patients had anemia, including 348, 105, and 9 with mild, moderate, and severe anemia, respectively. A total of 281 individuals experienced complications, including 212 and 69 with and without operation, respectively. Multivariate regression analysis identified anemia as a greater risk for acute heart failure (OR = 2.056, $p = 0.037$, 95% CI 1.043–4.052) than non-anemia. Moderate to severe anemia was a significant risk factor for any complication (OR = 1.584, $p = 0.028$, 95% CI 1.050–2.390), ≥ 2 (OR = 2.364, $p = 0.001$, 95% CI 1.443–3.872) or 3 (OR = 2.311, $p = 0.022$, 95% CI 1.131–4.720) complications, delirium (OR = 2.301, $p = 0.018$, 95% CI 1.156–4.579), venous thromboembolism (OR = 2.031, $p = 0.042$, 95% CI 1.025–4.025), and acute heart failure (OR = 2.095, $p = 0.016$, 95% CI 1.145–3.834), compared with mild to non-anemia. Similar results were observed in operated patients, while anemia and its severity were not associated with complications in non-operated patients.

Conclusion Moderate to severe anemia caused complications in elderly hip fracture patients, but it was not observed in non-operated individuals. These findings would support orthopedic physicians' hierarchical management of anemic patients.

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Keywords Anemia at admission, Hip fracture, Complications

Background

Hip fracture is a common trauma in older adults. By 2050, it is projected that there will be around 6.3 million hip fractures worldwide [1]. Based on the survey, the annual incidence of hip fractures in China exceeds 1 million, with a consistent upward trend [2]. Hip fracture significantly affects the health of older adults. The condition is commonly known as the ‘final fracture of life’ because it dramatically impacts physical functioning and survival as well as imposes a substantial financial burden [3, 4]. Therefore, hip fracture in older adults is a serious public health problem.

Anemia frequently occurs in patients with hip fractures and represents a risk factor that can potentially be altered. It heightens the likelihood of getting a fracture and affects the complication and outlook for patients with hip fractures [5–8]. Research indicated that anemia was linked to higher rates of death within 30 days and 2 years in elderly adults with hip fractures [8, 9]. Moreover, increased hemoglobin levels significantly reduced the risk of death [10]. In addition, Sabbaghzadeh A. et al. found that hemoglobin levels were lower in patients with nonunion fractures than in patients with healing fractures. Another research revealed that anemia could predict delayed discharge in elderly hip fracture patients [11, 12]. Moreover, individuals suffering from anemia experience a delayed recovery of physical functionality and health-related quality of life following surgical procedures [13, 14].

Some studies have shown the relationship between complications and anemia [15–17]. Previous studies mainly focused on the association of admission or pre-operative anemia with postoperative complications in patients with hip fractures. The participants of the studies all had undergone surgery. However, there is a lack of research examining the impact of anemia on complications that may arise during hospitalization, not alone after surgery, in all patients with hip fractures, including with or without operation. The objectives of this study are: (1) to determine the occurrence of anemia in patients aged 60 or older with hip fractures upon admission to the hospital and examine the correlation between anemia and complications, and (2) to investigate the potential impact of anemia on complications as perceived by patients in terms of overall, operation and non-operation results.

Methods

Study design and participants

This observational study was conducted in the Fifth People’s Hospital affiliated with Chengdu University of

Traditional Chinese Medicine (TCM), a tertiary hospital in Chengdu. The Fifth People’s Hospital Ethics Committee, affiliated with the Chengdu University of TCM, approved the study.

This study comprised patients over 60 years who had femoral neck fracture, intertrochanteric fracture or subtrochanteric fracture with or without surgery hospitalized in the orthopedics department from January 2020 to November 2023, and whose admission hemoglobin (Hb) test results were available. The characteristics and reasons why patients did not undergo surgery included: (1) Patients have absolute contraindications, such as unstable vital signs, or severe comorbidities (myocardial infarction, pulmonary embolism, massive cerebral infarction, etc.); (2) The patients had multiple organ dysfunction or poor cardiopulmonary function and could not tolerate surgery; (3) Patients were not willing to undergo surgery. Patients with fractures that occurred more than three weeks ago were excluded from the study. Patients with periprostheses fractures and incomplete data were also eliminated from the study.

Anemia description

Upon hospital admission, blood samples were collected. Based on the criteria of the World Health Organization (WHO), patients were divided into anemia group (male <13 g/dL, non-pregnant female < 12 g/dL) and non-anemia group (male ≥13 g/dL, non-pregnant female ≥12 g/dL) according to the hemoglobin level at the time of hospital admission [18]. Patients diagnosed with anemia were categorized into three subgroups based on their hemoglobin levels: mild anemia (hemoglobin ≥9 g/dL), severe anemia (hemoglobin < 6 g/dL), and moderate anemia (hemoglobin between 6 and 9 g/dL).

Data collection

Demographic parameters such as age and gender, comorbidities, drugs used for comorbidities, information on fractures and surgeries, and complications were gathered from the original medical records of the patients. Two physicians performed this data collection and established it using Epidata software.

Comorbidities were categorized into various groups, including circulatory diseases (such as hypertension, coronary heart disease, and chronic heart failure), chronic obstructive pulmonary disease (COPD), liver cirrhosis, chronic kidney disease (CKD), nervous system diseases (such as cerebrovascular disease, cognitive impairment, and Parkinson’s disease), endocrine and metabolic diseases (such as diabetes), and immune diseases (such as rheumatoid arthritis, and systemic lupus erythematosus).

Furthermore, the cumulative number of comorbidity was computed.

The data on post-admission complications were collected in both surgical and non-surgical patients. Complications were as follows: pulmonary infection, urinary tract infection, sepsis, delirium, venous thromboembolism (VTE) (deep venous thrombosis [DVT], intermuscular vein thrombosis, and pulmonary embolism), acute heart failure, arrhythmia, respiratory failure, gastrointestinal bleeding, intracranial hemorrhage, and cerebral infarction. Furthermore, the study also documented the admission of patients to the intensive care unit (ICU) as well as instances of patient mortality.

Statistical analyses

All analyses were conducted using SPSS, version 22.0 (SPSS Inc., Chicago). The continuous variables were presented as mean and standard deviation (SD) or median (interquartile range [IQR]), and student *t*-tests or the Mann-Whitney U test were used for inter-group analysis, according to the distribution. The distribution of continuous variables was performed by Shapiro–Wilk tests. The categorical variables were represented using both the number and percentage. Comparative analysis was

conducted using the Chi-square or Fisher's exact tests. All tests were deemed significant if the two-sided *p*-value was less than 0.05.

For binary logistic regression analysis, anemia status and other relevant parameters are used as independent variables, and complications are used as the dependent variables to explore anemia's effect on complications of in-hospital elderly hip fracture patients. The factor with a *p*-value of less than 0.05 was considered protective or hazardous independently.

Results

Baseline characteristics of patients

11 patients with incomplete data were excluded from the analysis, 679 participants between the ages of 60 and 101 were included in this study, consisting of 249 males (36.67%) and 430 females (63.33%). Upon admission, 462 individuals (68.04%) were diagnosed with anemia, out of the total number of individuals, 348 (51.25%) were mildly anemic, 105 (15.46%) were moderately anemic, and 9 (1.33%) were severely anemic. The age of anemic patients was older than that of nonanemic patients (81.27 ± 8.2 vs. 78.4 ± 8.1 , $t=4.339$, $p < 0.001$), and patients with moderate to severe anemia were older than normal to mild anemia (82.3 ± 7.7 vs. 79.9 ± 8.4 , $t=2.801$, $p=0.005$). There were 204 (44.2%) patients of femoral neck fracture, 247 (53.5%) of intertrochanteric fracture and 11 (2.4%) of subtrochanteric fracture in anemia group, and 158 (72.8%), 58 (26.7%), 1 (0.5%) in non-anemia group respectively. A higher proportion of trochanteric fracture (intertrochanteric and subtrochanteric fracture) were in the anemia cohort, also the proportion of male patients.

Hypertension (51.4%), diabetes (25.6%), cerebrovascular disease (22.1%), coronary heart disease (18.4%), and COPD (18.7%) were the five highest prevalent comorbidities. No significant difference was observed in the number of comorbidity between the two groups. Patients with anemia had a higher rate of CKD, but lower rates of hypertension and diabetes, compared with patients having normal hemoglobin level. In contrast, anemic patients were more likely to have fewer medications than those nonanemic patients. There was no significant difference in length of stay between the two groups (Table 1). The percentage of surgical patients in anemia group was significantly less compared with patients with non-anemia [334 (72.3%) vs. 178 (82.0%), $\chi^2=7.542$, $p=0.006$].

A total of 512 patients underwent surgical treatment. In line with the overall patients, those with anemia were also older, had a lower prevalence of hypertension and diabetes, and were prescribed fewer drugs in this group undergoing surgery. The prevalence of CKD in the anemia group was higher, although it did not achieve statistical significance. More patients in the anemia group required more than 168 h for preoperative preparation

Table 1 Baseline characteristics of the patients ($n=679$)

	Non-anemia group ($n=217$)	Anemia group ($n=462$)	<i>p</i>
Age	78.4±8.1	81.3±8.2	<0.001
Gender			0.020
Male	66(30.4%)	183 (39.6%)	
Female	151(69.6%)	279(60.4%)	
Fracture pattern			<0.001
Femoral neck fracture	158 (72.8%)	204 (44.2%)	
Intertrochanteric fracture	58 (26.7%)	247 (53.5%)	
Subtrochanteric fracture	1 (0.5%)	11 (2.4%)	
Count of Comorbidities	2.00 (1.00, 3.00)	2.00 (1.00, 2.00)	0.249
Hypertension	129 (59.4%)	220 (47.6%)	0.004
Diabetes	68 (31.3%)	106 (22.9%)	0.019
Cerebrovascular disease	48 (22.1%)	102 (22.1%)	0.990
Coronary heart disease	41 (18.9%)	84 (18.2%)	0.823
COPD	35 (16.1%)	92 (19.9%)	0.238
Heart failure	27 (12.4%)	58 (12.6%)	0.967
Chronic kidney disease	12 (5.5%)	47 (10.2%)	0.045
Cognitive impairment	14 (6.5%)	28 (6.1%)	0.844
Parkinson's disease	4 (1.8%)	13 (2.8%)	0.450
Liver cirrhosis	0 (0.0%)	6 (1.3%)	0.092
Immune disease	8 (3.7%)	9 (1.9%)	0.176
Medication	1.00 (0.00, 3.00)	0.00 (0.00, 2.00)	<0.001
Length of stay (day)	12.00 (9.00, 15.00)	12.00 (9.00, 15.00)	0.356

COPD: Chronic obstructive pulmonary disease

and had intramedullary nail fixation. No significant differences were observed in terms of gender, length of stay, American Society of Anesthesiologists (ASA) anesthetic grade, and operation time between the two groups (Table 2). Among patients who did not undergo surgery, the anemic group had older age, fewer medications, and a lower prevalence of hypertension but a higher incidence of cerebrovascular disease. Also a higher proportion of trochanteric fracture (intertrochanteric and subtrochanteric fracture) was in the anemia cohort in both surgical and non-surgical subgroups (Table 2).

We divided the time from fracture to admission into four groups, including less than 24 hs, 24–48 hs, 48–72 hs, and more than 72 hs. The result showed that the proportion of patients with moderate and severe anemia increased with the extension of time, the difference was statistically significant ($\chi^2=16.722$, $p=0.001$). Similar results were observed in both the operation and non-operation groups (operation group: $\chi^2=7.681$, $p=0.021$; non-operation group: $\chi^2=7.917$, $p=0.019$), as well as in different fracture types (femoral neck fracture: $\chi^2=7.465$, $p=0.024$; trochanteric fracture: $\chi^2=11.320$, $p=0.003$).

Table 2 Baseline characteristics of patients and their Subgroup Analysis

	Operation group (n = 512)			Non-operation group (n = 167)		
	Non-anemia group (n = 178)	Anemia group (n = 334)	p	Non-anemia group (n = 39)	Anemia group (n = 128)	p
Age	77.9 ± 8.4	80.5 ± 7.8	0.001	80.2 ± 6.7	83.4 ± 8.8	0.042
Gender			0.072			0.138
Male	55 (30.9%)	130 (38.9%)		11 (28.2%)	53 (41.4%)	
Female	123 (69.1%)	204 (61.1%)		28 (71.8%)	75 (58.6%)	
Fracture pattern			<0.001			0.001
Femoral neck fracture	129 (72.5%)	149 (44.6%)		29 (74.4%)	55 (43.0%)	
Intertrochanteric fracture	49 (27.5%)	177 (53.0%)		9 (23.1%)	70 (54.7%)	
Subtrochanteric fracture	0 (0.0%)	8 (2.4%)		1 (2.6%)	3 (2.3%)	
Count of Comorbidities	2.0 (1.0, 3.0)	1.0 (0.75, 2.0)	0.076	2.0 (1.0, 3.0)	2.0 (1.0, 3.0)	0.869
Hypertension	101 (56.7%)	159 (47.6%)	0.049	28 (71.8%)	61 (47.7%)	0.008
Diabetes	58 (32.6%)	80 (24.0%)	0.036	10 (25.6%)	26 (20.3%)	0.479
Cerebrovascular disease	41 (23.0%)	57 (17.1%)	0.102	7 (13.5%)	45 (35.2%)	0.042
Coronary heart disease	33 (18.5%)	56 (16.8%)	0.614	8 (20.5%)	28 (21.9%)	0.856
COPD	28 (15.7%)	56 (16.8%)	0.763	7 (17.9%)	36 (28.1%)	0.203
Heart failure	16 (9.0%)	27 (8.1%)	0.725	11 (28.2%)	31 (24.2%)	0.615
Chronic kidney disease	8 (4.5%)	28 (8.4%)	0.101	4 (10.3%)	19 (14.8%)	0.467
Cognitive impairment	12 (6.7%)	20 (6.0%)	0.737	2 (5.1%)	8 (6.3%)	1.000
Parkinson's disease	2 (1.1%)	8 (2.4%)	0.513	2 (5.1%)	5 (3.9%)	1.000
Liver cirrhosis	0 (0.0%)	5 (1.5%)	0.243	0 (0.0%)	1 (0.8%)	1.000
Immune disease	6 (3.4%)	8 (2.4%)	0.719	2 (5.1%)	1 (0.8%)	0.136
Medication	1.00 (0.00, 3.00)	0.00 (0.00, 2.00)	<0.001	1.00 (0.00, 3.00)	0.00 (0.00, 1.00)	0.020
Length of stay (day)	13.00 (10.00, 16.00)	13.00 (10.00, 16.00)	0.851	7.00 (4.00, 13.00)	7.00 (5.00, 11.00)	0.511
Preoperative preparation time			0.033			
<48 hs	15 (8.4%)	12 (3.6%)				
48–72 hs	23 (12.9%)	36 (10.8%)				
72–168 hs	100 (56.2%)	182 (54.5%)				
>168 hs	40 (22.5%)	104 (31.1%)				
ASA grade			0.945			
I	6 (3.4%)	11 (3.3%)				
II	58 (32.6%)	104 (31.1%)				
III	90 (50.6%)	178 (53.3%)				
IV	24 (13.3%)	41 (12.3%)				
Operation type			<0.001			
Total hip arthroplasty	90 (50.6%)	87 (26.0%)				
Hemiarthroplasty	36 (20.2%)	63 (18.9%)				
Intramedullary nail fixation	52 (29.2%)	184 (55.1%)				
Operation duration (min)	135.8 ± 36.5	131.9 ± 40.8	0.291			

COPD: Chronic obstructive pulmonary disease; ASA: American Society of Anesthesiologist

Complications

Distribution of complications

Of all patients, 281 (41.4%) suffered complications. A total of 125 (27.1%) patients experienced 1 complication, 46 (10.0%) patients experienced 2 complications, and 30 (6.5%) had at least 3 complications in anemic patients, while 54 (24.9%), 17(7.8%), and 9 (4.1%) experienced 1, 2, and at least 3 complications in nonanemic patients, respectively. However, except for acute heart failure, no significant differences were observed in the incidence of complications, lung infection, and other systemic problems between the two groups (Table 3).

Upon analyzing the stratified anemia, there was no significant difference in complications between patients with mild and without anemia. The occurrence of any complication, ≥ 2 or 3 complications, and complications such as acute heart failure, delirium, or sepsis was more prevalent in the group with moderate to severe anemia compared to the group with mild and the group without anemia, respectively. With non- and mild anemia as one group and moderate to severe anemia as the other, the incidence of any complication, and ≥ 2 or 3 complications, acute heart failure, delirium, sepsis, and VTE was higher in moderate to severe anemia patients (Table 3). There were no significant discrepancies in the occurrence of ICU admissions and mortality rates among any of the categories.

Further subgroup analysis was performed. A total of 103 patients (34.1%) who were under 80 years old experienced complications. The group of individuals with

anemia experienced a greater occurrence of more than one complication and acute heart failure compared to the group without anemia. For individuals with moderate to severe anemia, complications, such as lung infection and delirium, were considerably greater compared to those with no or mild anemia. Out of the total of 377 patients above 80 years old, 177 (47.0%) experienced complications. The occurrence of two or more problems, acute heart failure, and sepsis was considerably greater in patients with moderate to severe anemia compared to those with no or mild anemia. The information can be found in eTable 1.

Complications were observed in 41.2% of females and 41.4% of males. The incidence of any complication, ≥ 2 complications, acute heart failure, delirium, and sepsis increased significantly in patients with moderate to severe anemia in female patients. Among male patients, the prevalence of ≥ 2 complications was higher in the group with anemia compared to the group without anemia. Moreover, there were statistically significant differences in the rates of VTE, malignant arrhythmia, ≥ 2 or 3 complications between moderate to severe and non-anemia to mild anemia groups (eTable 1).

Complications were present in 212 (41.4%) patients who underwent the operation. No significant differences were found in other complications between non- and anemia groups except for acute heart failure. Any complication, ≥ 2 or 3 complications, pulmonary infection, acute heart failure, delirium, and sepsis were observed more common in moderate to severe anemia compared

Table 3 Analysis of correlation between Anemia and Outcome

	Non-anemia group (n=217)	Anemia group (n=462)	p*	Moderate to severe anemia group (n=114)	p**	Mild anemia group (n=348)	p***	Normal to mild anemia group (n=565)	p****
Any complication	80 (36.9%)	201 (43.5%)	0.101	60 (52.6%)	0.006	141 (40.5%)	0.024	221 (39.1%)	0.008
≥ 2 complications	26 (12.0%)	76 (16.5%)	0.129	31 (27.2%)	<0.001	45 (12.9%)	<0.001	71 (12.6%)	<0.001
≥ 3 complications	9 (4.1%)	30 (6.5%)	0.221	13 (11.4%)	0.012	17 (4.9%)	0.014	26 (4.6%)	0.004
Pulmonary infection	69 (31.8%)	158 (34.2%)	0.536	45 (39.5%)	0.163	113 (32.5%)	0.171	182 (32.2%)	0.134
Urinary tract infection	4 (1.8%)	8 (1.7%)	1.000	2 (1.8%)	1.000	6 (1.7%)	1.000	10 (1.8%)	1.000
Acute heart failure	12 (5.5%)	48 (10.4%)	0.037	18 (15.8%)	0.002	30 (8.6%)	0.029	42 (7.4%)	0.004
Delirium	11 (5.1%)	32(6.9%)	0.354	14 (12.3%)	0.018	18 (5.2%)	0.009	29 (5.1%)	0.004
Sepsis	1 (0.5%)	14 (3.0%)	0.065	9 (7.9%)	0.001	5 (1.4%)	0.001	6 (1.1%)	<0.001
VTE	10 (4.6%)	36 (7.8%)	0.124	13 (11.4%)	0.021	23 (6.6%)	0.097	33 (5.8%)	0.031
Respiratory failure	7 (3.2%)	14 (3.0%)	0.891	5 (4.4%)	0.820	9 (2.6%)	0.510	16 (2.8%)	0.563
Malignant arrhythmia	3 (1.4%)	8 (1.7%)	0.992	3 (2.6%)	0.707	5 (1.4%)	0.663	8 (1.4%)	0.595
Gastrointestinal bleeding	1 (0.5%)	2 (0.4%)	1.000	1 (0.9%)	1.000	1 (0.3%)	0.433	2 (0.4%)	0.424
Intracranial hemorrhage	0 (0.0%)	1 (0.2%)	1.000	0 (0.0%)	-	1 (0.3%)	1.000	1 (0.2%)	1.000
Cerebral infarction	2 (0.9%)	1 (0.2%)	0.241	0 (0.0%)	0.547	1 (0.3%)	1.000	3 (0.5%)	1.000
ICU	1 (0.5%)	4 (0.9%)	0.925	1 (0.9%)	1.000	3 (0.9%)	1.000	4 (0.7%)	0.067
Death	1 (0.5%)	3 (0.6%)	1.000	2 (1.8%)	0.569	1 (0.3%)	0.152	2 (0.4%)	0.812

VTE: Venous thromboembolism; ICU: Intensive care unit

*: Anemia group comparison with non-anemia group; **: Moderate to severe anemia group comparison with non-anemia group; ***: Moderate to severe anemia group comparison with mild anemia group; ****: Moderate to severe anemia group comparison with normal to mild anemia group

to non-anemia to mild anemia. Of the total number of patients who did not undergo surgery, 69 individuals (41.3%) experienced complications. Significant variations in complications were not identified among any of the groups (eTable 1).

Anemia on the risk of complications

After adjusting for age, gender, and comorbidities, a multivariate binary logistic regression analysis revealed that anemia was associated with a higher risk of acute heart failure compared to non-anemia. Subsequent examination revealed that moderate to severe anemia, in contrast to normal to mild hemoglobin levels, was a significant risk factor for any complication, ≥ 2 or 3 complications, acute heart failure, delirium, and VTE.

Similar results were also observed in the patients with the operation. In the patients without operation, anemia was not associated with any system complication. Moderate to severe anemia was independently associated with an increased risk for ≥ 2 complications, delirium, and acute heart failure in female patients. In patients under the age of 80, moderate to severe anemia was associated with an increased likelihood of experiencing any

complication and lung infection. In patients over 80 years old, moderate to severe anemia was associated with an increased probability of experiencing ≥ 2 complications and acute heart failure (Table 4).

Discussion

In this study, it was demonstrated that there was a high incidence of anemia at admission in patients with hip fractures over 60 years old. Anemia had a greater risk for acute heart failure compared with non-anemia. Anemia, characterized by a hemoglobin level below 9 g/dL, was found to be linked to higher risks of complications, acute heart failure, delirium, sepsis, and VTE during hospitalization. Furthermore, it served as an autonomous risk factor for complications, acute heart failure, delirium, and VTE when compared to individuals with non-anemia and mild anemia. Similar results were observed in individuals who underwent surgery, although the presence and severity of anemia did not show any correlation with complications in patients who did not undergo surgery.

It was found that 68.04% of patients had various degrees of anemia, with mild anemia accounting for more than half. This was consistent with previous

Table 4 Multivariate analysis of the complications based on the patients' Anemia status

	Anemia vs. Non-anemia			Moderate to severe anemia vs. Normal to mild anemia		
	Exp(B)	95% C.I.	p	Exp(B)	95% C.I.	p
Overall						
Any complication	1.265	0.895–1.787	0.183	1.584	1.050–2.390	0.028
≥ 2 complications	1.498	0.908–2.473	0.114	2.364	1.443–3.872	0.001
≥ 3 complications	1.605	0.724–3.557	0.244	2.311	1.131–4.720	0.022
Delirium	1.151	0.549–2.413	0.709	2.301	1.156–4.579	0.018
Acute heart failure	2.056	1.043–4.052	0.037	2.095	1.145–3.834	0.016
VTE	1.971	0.946–4.105	0.070	2.031	1.025–4.025	0.042
<80 ys						
Any complication	1.460	0.873–2.441	0.149	2.590	1.268–5.292	0.009
≥ 2 complications	3.041	1.196–7.731	0.019	2.187	0.879–5.441	0.093
Pulmonary infection	1.289	0.755–2.202	0.352	2.342	1.145–4.787	0.020
≥ 80 ys						
≥ 2 complications	0.986	0.534–1.823	0.965	2.449	1.353–4.436	0.003
Acute heart failure	1.252	0.572–2.739	0.573	2.176	1.077–4.395	0.030
Male						
≥ 2 complications	3.156	0.909–10.962	0.070	3.256	1.371–7.732	0.007
Female						
≥ 2 complications	1.252	0.706–2.221	0.442	2.048	1.119–3.751	0.020
Delirium	0.975	0.409–2.324	0.955	2.503	1.076–5.823	0.033
Acute heart failure	1.776	0.842–3.745	0.131	2.361	1.158–4.813	0.018
Operation group						
Any complication	1.262	0.852–1.871	0.246	1.865	1.130–3.077	0.015
≥ 2 complications	1.686	0.894–3.180	0.107	3.318	1.804–6.105	<0.001
Delirium	1.374	0.578–3.265	0.472	3.028	1.379–6.649	0.006
Acute heart failure	3.978	1.326–11.939	0.014	3.285	1.497–7.210	0.003
VTE	1.704	0.691–4.197	0.247	2.402	0.998–5.778	0.050

VTE: Venous thromboembolism

studies, including patients of the same age group, which were 67.5% and 65%, respectively [8, 10]. However, it was 42.9% for the study of Praetorius K et al. and 23.3% for You F et al. [19, 20]. This could be attributed to the low incidence of trochanteric fracture and the variation in comorbidities observed in these studies, together with the relatively young mean age of individuals and the limited sample size of just 283 participants in the study conducted by You F et al. [20].

In this study, no significant difference was observed in the number of comorbidities between the anemia and non-anemia groups. However, chronic kidney disease was more prevalent in the anemia group, which is widely recognized as a cause of anemia [21]. In addition, the percentage of patients with combined medication was lower in the anemia group than in the non-anemia group. Patients in the anemia group exhibited a higher prevalence of CKD but a lower usage of medicine. This might be attributed to inadequate adherence to these patients' hospital visits and medication. Consequently, the comorbidities were not effectively managed, leading to anemia.

Prior researches mostly focused on the correlation between anemia and postoperative complications. This study investigated the association between admission anemia and complications in patients with and without surgery. Here, the surgical complications and any issues that occurred at any point throughout the hospital stay were analyzed.

For counts of the complication, there was no significant difference between the anemia and non-anemia group in all patients, also in patients with and without surgery. However, the incidence of any complication, ≥ 2 or 3 complications in moderate to severe anemia patients, was higher than that in non- and mild anemia groups, which were independent risk factors. Similar results were observed in patients with surgery, and patients of different genders. This indicates that moderate to severe anemia was not only more likely to develop complications but also more likely to have multiple complications. A retrospective cohort analysis also identified variations in the counts of major complications between the group with and without anemia [15].

The present study demonstrated that anemia was an independent risk factor for acute heart failure, the same results were seen in patients with the operation. This is consistent with a few previous studies. Jiang Y et al. and others found that preoperative anemia increased the risk of cardiovascular events, including acute heart failure [14]. According to Li M et al., having a hemoglobin level lower than 10 g/dL was linked to an increased risk of major adverse cardiovascular events (MACE) [22]. Also, You F et al. exhibited that anemia was a risk factor for heart failure in patients with hip fractures in old adults [20]. Previous studies have reported the prevalence

of anemia in heart failure, ranging from 14 to 56% [23, 24]. The precise mechanisms by which anemia increases the risk of heart failure remain uncertain. However, it is believed that anemia can contribute to myocardial hypoxia and acidosis, as well as an increase in oxygen consumption during myocardial work. This can result in an imbalance between oxygen supply and demand, leading to myocardial ischemia, hypoxia, and fibrosis [25, 26].

Delirium is common in surgical wards. Old age, environmental change, electrolyte disturbance, hypoxia, and so on are the factors that cause delirium. A prior retrospective investigation on femur neck fractures in individuals with hip fractures revealed that anemia was identified as a distinct risk factor for postoperative delirium following hip replacement surgery [27]. However, Li M et al. did not find any difference in the incidence of delirium between patients with hemoglobin ≥ 10 g/dL and < 10 g/dL [22]. The participants of these two studies were indeed different, which could have resulted in changes in the results obtained. The former population was > 65 years old, while the latter was > 80 years old. The main type of fracture of the latter was intertrochanteric fracture (53.4%), and the femoral neck fracture was only 43.9%. Another earlier study reported a significant increase in the incidence of delirium in preoperative anemia patients in univariate analysis but not in multivariate analysis [28]. The current results also demonstrated no difference in the occurrence of delirium between the non-anemia and anemia groups in all patients, and in patients older than 80 years. Whereas it showed that moderate to severe anemia was an independent risk factor for the occurrence of delirium. The relationship between the severity of anemia and delirium is thus evident.

Immobilization in hip fracture patients increases the likelihood of developing venous thromboembolism. Moderate to severe anemia was observed to be an independent risk factor for VTE. The study conducted by Feng L et al. on patients aged 70 and above likewise arrived at a comparable finding, with the threshold for anemia being a hemoglobin level below 12 g/dL in males and below 11 g/dL in females [29]. In contrast, no increased incidence of DVT after total hip arthroplasty (THA) was observed in the anemia group (hematocrit was 27-36% defined as mild anemia, $< 27\%$ was considered severe anemia) by Grosso MJ et al. [30]. Another investigation took the same anemia standard as the one in the present study. However, no difference was found in the occurrence of DVT or thrombophlebitis within 30 days after the revision of THA between the two groups [31]. The latter two studies included adults over 18, which may account for the lack of differences. A study by Gruson KI et al. showed that admission anemia did not predict postoperative thrombophlebitis, which did not compare the severity of anemia by stratification [16].

Furthermore, senior hip fracture patients frequently experience infections, including wound infections, pulmonary infections, urinary tract infections, and others. Prior research conducted on various populations has consistently demonstrated that preoperative anemia is associated with an elevated risk of postoperative infection, pneumonia, and urinary tract infection [15, 30–33]. This study also found the effect of moderate to severe anemia on pneumonia or sepsis in specific populations, such as patients with operations and different ages. There was no identified correlation between anemia and urinary tract infection. Anemia patients have a heightened susceptibility to infection due to the immunosuppressive effects of anemia on the body [34, 35].

In addition to explore the correlation between anemia and complications in older hip fracture patients with surgery, this is a initial investigation conducted to explore the impact of anemia on complications in elderly individuals with hip fractures who did not have surgery. However, the results showed no significant difference in the incidence of complications between non- and anemia groups and between non- to mild and moderate to severe anemia groups in patients without surgery. The patients who did not undergo surgery were unable to tolerate the procedure primarily due to factors such as poorly managed serious comorbidities or a weak general condition. These reasons are the main risk factors for complications, while anemia has a minor impact. Therefore, no correlation between anemia and complications was detected. Nevertheless, the sample size of the non-operation patients in the current study is quite limited. Therefore, it is imperative to increase the sample capacity to thoroughly investigate the correlation between anemia and complications in this population.

These findings of our study have important implications for surgical decision-making in operative patients. Moderate to severe anemia as a risk factor for various complications, early detection of anemia is necessary and intervention for moderate to severe anemia is a must. However, the efficacy of blood transfusion or drug therapy these patients is inconsistent, more rigorous randomized controlled trials are performed to verify it. Although negative results were obtained in non-operative elderly patients, these patients still should be managed comprehensively including intervention for severe anemia.

Limitations

There are several limitations in the study. First, the present study mainly focused on the effect of anemia and its severity on complications. Those who received blood transfusions were not counted, and the influence of blood transfusion was not considered in the relationship between anemia and complications analysis. Second, this is a single-center retrospective observational study

with some shortcomings. Further prospective studies are needed to confirm the results of this study.

Conclusions

The current findings have revealed that it is mainly moderate to severe anemia at admission that contributes to complications in old patients with hip fractures. Moreover, hemoglobin could be a low-cost and effective predictor for complications in these patients. This study might have significant implications for orthopedic physicians' effective, hierarchical management of patients with varying degrees of anemia.

Abbreviations

VTE	Venous thromboembolism
COPD	Chronic obstructive pulmonary disease
CKD	Chronic kidney disease
DVT	Deep venous thrombosis
ICU	Intensive care unit
SPSS	Statistical Package for the Social Sciences
IQR	Interquartile range
ASA	American Society of Anesthesiologists
MACE	Major adverse cardiovascular events
THA	Total hip arthroplasty

Supplementary Information

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Supplementary Material 1

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Author contributions

The authors' responsibilities were as follows: Study design: LJG, YXY, LHZ; literature search: LJG, QL, JY; Data collection: LJG, QL, LXW, YY, YCC; Data analysis: LXW, SPC; Tables: YP; Fundings: ZZ, LJG; Drafted the manuscript: LJG. All authors read and approved the final manuscript.

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Data availability

All data generated or analyzed during this study are included in this published article.

Declarations

Ethics approval and consent to participate

This study was a retrospective cohort study. This present study was approved by the Ethics Committee of the Fifth People's Hospital affiliated to Chengdu University of TCM. Written informed consent was waived.

Competing interests

The authors declare no competing interests.

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