

# In-Hospital Postoperative Pneumonia Following Geriatric Intertrochanteric Fracture Surgery: Incidence and Risk Factors

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**Purpose:** The in-hospital death rate in cases of hip fracture ranges from 6% to 10%. Pneumonia is a serious complication for hip fracture patients that contributes to longer hospital stays and higher mortality rates; however, the prevalence and risk factors are not well established. To address this issue, the present study investigated the incidence of and risk factors for in-hospital postoperative pneumonia (IHPOP) following geriatric intertrochanteric fracture surgery.

**Patients and Methods:** Information on 1495 geriatric patients (>65 years) who underwent intertrochanteric fracture surgery at our hospital between October 2014 and December 2018 was extracted from a prospective hip fracture database and reviewed. Demographic information, clinical variables including surgical data, and preoperative laboratory indices that could potentially influence IHPOP were analyzed. Receiver operating characteristic curve analysis was performed and the optimum cutoff value for quantitative data was determined. Univariate and multivariate analyses were carried out to identify risk factors for IHPOP.

**Results:** The incidence of IHPOP following geriatric intertrochanteric fracture surgery was 3.5% (53/1495 cases). The multivariate analysis showed that age >82 years (odds ratio [OR]=2.54,  $p=0.004$ ), male sex (OR=2.13,  $p=0.017$ ), chronic respiratory disease (OR=5.02,  $p<0.001$ ), liver disease (OR=3.39,  $p=0.037$ ), urinary tract infection (OR=8.46,  $p=0.005$ ), creatine kinase (CK) MB>20 U/l (OR=2.31,  $p=0.020$ ), B-type natriuretic peptide (BNP)  $\geq 75$  ng/l (OR=4.02,  $p=0.001$ ), and D-dimer >2.26 mg/l (OR=2.69,  $p=0.002$ ) were independent risks factor for the incidence of IHPOP following geriatric intertrochanteric fracture surgery.

**Conclusion:** The incidence of IHPOP was 3.5% following geriatric intertrochanteric fracture surgery; age, male sex, chronic respiratory disease, liver disease, urinary tract infection, CKMB, BNP, and D-dimer were significant risk factors. Targeted preoperative management based on these factors could reduce the risk of IHPOP and mortality in these patients.

**Keywords:** intertrochanteric fracture, postoperative pneumonia, in-hospital complication, geriatric population, risk factor

## Introduction

Intertrochanteric fracture is a common type of osteoporotic hip fracture in the geriatric population, accounting for approximately 50% of hip fractures and 3.13% of all fractures in adults.<sup>1,2</sup> With the aging of the global population, the incidence of intertrochanteric fracture is increasing and its treatment consumes a growing proportion of healthcare expenditure.<sup>3</sup> While intertrochanteric fracture surgery can be successfully performed under most conditions with an intramedullary or extramedullary device,<sup>4</sup> the

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30-day and 1-year mortality is 7.7% and 26%, respectively;<sup>5</sup> preexisting comorbidities at the time of fracture and postoperative complications are the major causes of these high rates.<sup>6</sup> One study found that postoperative infection was the leading cause of death in hip fracture patients.<sup>7</sup> Pneumonia is a devastating infection in elderly patients and is among the most frequent postoperative complications following geriatric intertrochanteric fracture surgery.<sup>8,9</sup> It was reported that the rate of pneumonia within 30 days after hip fracture surgery ranges from 4.1% to 11.9%.<sup>10,11</sup> Previous studies have shown that postoperative pneumonia (POP) is associated with increased 30-day and 1-year mortality;<sup>6,7,12</sup> the 30-day mortality for hip fracture patients who developed POP is 27–43%,<sup>10,13</sup> which is 4.18 times higher than in patients without POP.<sup>12</sup>

Factors contributing to increased risk of POP following hip fracture surgery have been investigated in previous studies.<sup>7,10,13</sup> However, these studies described the surgical treatment of both intertrochanteric and femoral neck fractures and there were significant differences in the demographic profile of the study population, fixation device that was used, and rehabilitation program.<sup>1,5,14</sup> The fixation device had a significant influence on the incidence of POP after hip fracture,<sup>10</sup> resulting in distinct risk factors for POP between the 2 fracture types. Meanwhile, few studies have examined the incidence and risk factors of POP following geriatric intertrochanteric fracture surgery. One reported an association between C-reactive protein (CRP) and postoperative systemic infections in cases of intertrochanteric fracture but did not separately evaluate the relationship between CRP and POP.<sup>15</sup> Intramedullary fixation was shown to increase the rate of POP, but there were differences in complication rates between patients with intertrochanteric femoral fracture treated with an intramedullary vs extramedullary device.<sup>16</sup> Potential risk factors for POP in patients with hip fractures are sex, advanced age, body mass index (BMI), smoking history, preexisting pulmonary disease, cerebrovascular disease, diabetes, chronic kidney disease, hypoproteinemia, anemia, number of comorbidities, American Society of Anesthesiologists (ASA) score  $\geq 3$ , mechanical ventilation, brain injury, previous infection, time from admission to surgery, fixation method, and certain laboratory indices.<sup>10,11,15,17–20</sup>

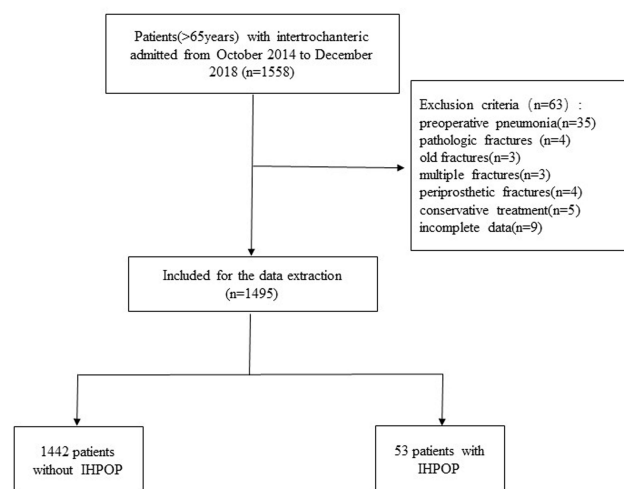
Most intertrochanteric fracture patients are of advanced age, fragile, and have a high risk of death. Internal factors and surgical trauma contribute to the generally poor outcome of patients who develop POP following generic intertrochanteric fracture. The purpose of this study was

to detect the incidence of in-hospital postoperative pneumonia (IHPOP) following geriatric intertrochanteric fracture surgery. Secondly, we aimed to detect whether advanced age and implant (intramedullary devices or extramedullary devices) were independent risk factors for the development of IHPOP, which may contribute to take individual treatment to prevent the developing of IHPOP in geriatric intertrochanteric fracture patients.

## Patients and Methods

### Patients

Information on geriatric patients ( $\geq 65$  years) who underwent surgery for intertrochanteric fracture at our hospital (a level I trauma teaching hospital) between October 2014 and December 2018 were extracted from a prospective database. A total of 1558 cases were reviewed, and 1495 were analyzed (Figure 1). The exclusion criteria were as follows: (1) received conservative treatment; (2) had preoperative pneumonia; (3) had periprosthetic fractures; (4) had old fractures (time from injury to surgery  $>21$  days); (5) had multiple fractures; and (6) incomplete data. The patients in our study were divided into 2 groups: those who developed IHPOP and those without IHPOP. The study was approved by the institutional ethics committee of the Third Hospital of Hebei Medical University, and all procedures were performed in accordance with the principles outlined in the Helsinki Declaration. Informed consent was obtained from all patients.



**Figure 1** The flow chart for the selection of study participants.

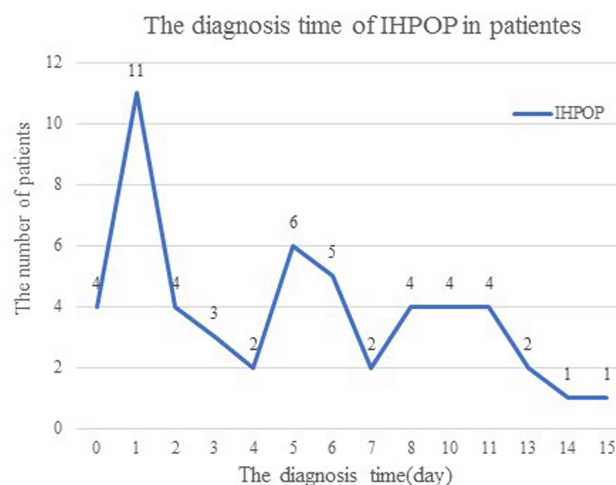
## Methods

IHPOP was defined as pneumonia occurring during hospitalization following intertrochanteric fracture surgery in the absence of preoperative pneumonia. At least 1 of the following criteria was required for diagnosis: (1) new or progressive respiratory symptoms such as coughing, expectoration, and shortness of breath; (2) fever or hypothermia ( $>38^{\circ}\text{C}$  or  $<36^{\circ}\text{C}$ ); (3) new infiltrations in postoperative chest X-rays or by computed tomography; (4) new signs of lung consolidation or moist rale detected by physical examination after surgery; (5) positive sputum or blood sample; (6) leukocytosis or leukopenia ( $>10 \times 10^9/\text{l}$  or  $<4 \times 10^9/\text{l}$ ).<sup>10,11,13,17</sup>

More than 90 variables that could affect the incidence of POP were analyzed in our study, including demographic and fracture characteristics, preoperative blood biochemical indices, and surgical data. Demographic characteristics included age, sex, BMI, residential location (rural or urban), medical complications, smoking history, and disease (eg, cancer). The medical comorbidities were hypertension, circulatory abnormalities (coronary heart disease and arrhythmia), cerebrovascular disease (hemorrhagic and ischemic encephalopathy), diabetes mellitus (type 1 and type 2 diabetes), respiratory disorders (chronic bronchitis, chronic obstructive pulmonary disease and bronchiectasis), liver diseases (viral hepatitis and cirrhosis), kidney diseases (glomerulonephritis and chronic renal failure), rheumatologic disease. The number of comorbidities (hypertension; circulatory abnormalities; type 2 diabetes; respiratory disorders; and cerebrovascular, liver, kidney, and rheumatologic diseases) was recorded as 0, 1, or  $\geq 2$ . The ASA score of each patient was also obtained. Fracture characteristics and surgical variables were reviewed including time from admission to surgery, duration of surgery, type of anesthesia, implant type (intramedullary or extramedullary device), intraoperative blood loss, etc. Preoperative laboratory indices were measured at the time of admission. A serum albumin level  $<35$  g/L was defined as malnutrition.<sup>21</sup>

## Statistical Analysis

Receiver operating characteristic (ROC) curve analysis was used to determine the optimum cut-off value for quantitative data including age, BMI, and time to surgery before subsequent analysis. We then applied descriptive statistics to the entire cohort. Continuous variables conforming to a normal distribution are presented as mean  $\pm$  standard deviation and were analyzed with the Student's *t*-test or Mann–Whitney *U*-test; non-normally distributed



**Figure 2** The diagnosis time of IHPOP in patients.

variables are presented as median values with quartiles; and categorical variables are presented as frequency and percentage and were analyzed with the chi-squared test or Fisher's exact test. After univariate analysis, potential risk factors were included in a multivariate logistic regression model to identify independent predictors of IHPOP. All statistical analyses were performed with SPSS v23.0 software (IBM, Armonk, NY, USA). A *p* value  $<0.05$  was considered significant.

## Results

### Clinical Parameters

A total of 1495 cases of intertrochanteric fracture were analyzed in this study. The incidence of IHPOP following geriatric intertrochanteric fracture surgery was 3.5% (53/1495 cases), while that of preoperative POP was 2.3% (35/1530 patients). The earliest diagnosis of IHPOP was on the day of surgery, and the latest was 15 days after surgery. The highest number of IHPOP cases (11 patients, 20.8%) was recorded on the first day after operation. The time to

**Table 1** Optimum Cutoff Value of Continuous Variables Detected by the ROC Analysis

Variables	Cutoff Value	Area Under the ROC Curve (AUC)	P value	95% CI
Age (years)	82	0.673	0.000	0.588–0.758
BNP (ng/L)	75	0.676	0.000	0.602–0.750
LYM (%)	5.2	0.383	0.013	0.302–0.465
D-Dimer(mg/L)	2.26	0.626	0.000	0.537–0.714

**Abbreviations:** ROC, receiver-operating characteristic; CI, confidence interval; BNP, brain natriuretic peptide; LYM, lymphocyte.

**Table 2** Comparison of Demographics and Fracture Characteristics Between the Two Groups

Variables	Overall (N=1495)	Without POP (N=1442)	With POP (N=53)	P value
Age (>82, years), n (%)	511(34.2)	480(33.3)	31(58.5)	<0.001
Sex (male), n (%)	547(36.6)	483 (33.5)	28 (52.8)	0.004
Residential location(urban), n (%)	689(46.1)	662 (45.9)	27 (50.9)	0.470
Hypertension, n (%)	724(48.8)	716 (49.7)	8 (45.3)	0.532
Diabetes, n (%)	328(21.9)	319 (22.1)	9 (17.0)	0.374
Cerebrovascular disease, n (%)	518(34.6)	492 (34.1)	26 (49.1)	0.025
Cardiovascular disease, n (%)	601(40.2)	565 (39.2)	36 (67.9)	<0.001
Chronic respiratory disease, n (%)	81(5.4)	69 (4.8)	12 (22.6)	<0.001
Smoking history, n (%)	70(4.7)	69 (4.8)	1 (1.9)	0.327
Tumors, n (%)	36(2.4)	36 (2.5)	0 (0.0)	0.244
Traumatic brain injury, n (%)	17(1.1)	17 (1.2)	0 (0.0)	0.427
Liver disease, n (%)	33(2.2)	28 (1.9)	5 (9.4)	<0.001
Renal disease, n (%)	49(3.2)	46 (3.2)	3 (5.7)	0.321
Urinary tract infection, n (%)	12(0.8)	9 (0.6)	3 (5.7)	<0.001
Rheumatoid diseases, n (%)	19(1.3)	19 (1.3)	0 (0.0)	0.400
Previous surgical history	235(15.7)	227 (15.7)	8 (15.1)	0.899
Comorbidities(no.), n (%)				<0.001
0	197(13.2)	197 (13.7)	0 (0.0)	
1	340(22.7)	338 (23.4)	2 (3.8)	
≥2	958(64.1)	907 (62.9)	51 (96.2)	
ASA3-4, n (%)	802(53.6)	765 (53.1)	37 (69.8)	0.016
BMI, n (%)				0.011
<18.5	100(6.7)	91 (6.3)	9 (17.0)	
18.5–24.9	860(57.5)	831 (57.6)	29 (54.7)	
25–29.9	483(32.3)	471 (32.7)	12 (22.6)	
≥30	52(3.5)	49 (3.4)	3 (5.7)	
Injury mechanism (high energy), n (%)	80(5.4)	79 (5.5)	1 (1.9)	0.503
Side (left), n (%)	777(52.0)	747 (51.8)	30 (56.6)	0.492
Transfer to ICU (yes), n (%)	43(1495)	36(2.5)	7(13.2)	<0.001

**Abbreviations:** ASA, American Society of Anesthesiologists; BMI, body mass index; ICU, intensive care unit.

development of IHPOP is shown in [Figure 2](#). Two of the 53 patients with IHPOP died while the others recovered.

The optimum cutoff value for quantitative data related to IHPOP was determined by ROC curve analysis ([Table 1](#)). The demographic and fracture characteristics are shown in [Table 2](#). The average age was  $78.9 \pm 7.5$  years; 34.2% of patients were male and 65.8% were female. The proportion of patients >82 years was higher in patients with IHPOP than in those without IHPOP (58.5% vs 33.3%) ( $p < 0.001$ ), whereas the opposite trend was observed for the proportion of female patients ( $p = 0.004$ ). The proportion of patients with  $\geq 2$  comorbidities was 96.2% (51/53) in the IHPOP group and 62.9% in patients without IHPOP ( $p < 0.001$ ). More patients with IHPOP had cerebrovascular disease ( $p = 0.025$ ), cardiovascular disease ( $p < 0.001$ ), chronic respiratory disease ( $p < 0.001$ ), liver disease ( $p < 0.001$ ), urinary tract infection

( $p < 0.001$ ), and an ASA score of 3–4 ( $p = 0.016$ ). There were also significant differences between the 2 groups in BMI ( $p = 0.011$ ) and transfer to the intensive care unit (ICU;  $p < 0.001$ ). The percentage of patients treated with an intramedullary device was lower in the IHPOP group than in the non-IHPOP group, but the difference was not statistically significant ( $p = 0.169$ ; [Table 4](#)). Other characteristics were similar between the 2 groups.

Preoperative laboratory indices are shown in [Table 3](#). Creatine kinase (CK) MB >20 U/l ( $p = 0.027$ ), B-type natriuretic peptide (BNP) ( $p < 0.001$ ), procalcitonin (PCT;  $p = 0.010$ ), and D-dimer >2.26 mg/l ( $p < 0.001$ ) were associated with an increased risk of developing IHPOP. The other variables showed no significant correlations, and no significant differences in surgical data were observed between the 2 groups ([Table 4](#)). However, the average

**Table 3** Comparison of Preoperative Laboratory Indicators Between the Two Groups

Variables	Without POP (N=1945)	With POP (N=53)	P value
TP <65 g/L, n (%)	1185(82.2)	47(88.7)	0.222
ALB<35g/L, n (%)	975(67.6)	37 (69.8)	0.737
GLOB (references 20–40 g/L), n (%)			0.693
<20	228(15.8)	7(13.2)	
>40	12 (0.8)	0(0.0)	
A/G (references 1.2–2.4), n (%)			0.676
<1.2	314(21.8)	13(24.5)	
>2.4	16(1.1)	0(0.0)	
ALT (references 9–50 U/L), n (%)			0.431
<9	162(11.2)	8(15.1)	
>50	72(5.0)	1(1.9)	
AST (references 15–40 U/L), n (%)			0.807
<15	269(18.7)	9(17.0)	
>40	140(9.7)	4(7.5)	
TBIL (>26), n (%)	192 (13.3)	9(17.0)	0.442
DBIL (>6), n (%)	648(44.9)	30(56.6)	0.145
IBIL (>14), n (%)	242(16.8)	10(18.9)	0.061
ALP (references 45–125 U/L), n (%)			0.720
<45	169(11.7)	7(13.2)	
>125	92(6.4)	2(3.8)	
GGT (references 10–60 U/L), n (%)			0.936
<10	83(5.8)	3(5.7)	
>60	116(8.0)	5(9.4)	
CHE (references 5–12 U/L), n (%)			0.254
<2	627(43.5)	29(54.7)	
>12	5(0.3)	0(0.0)	
TBA (references 1–10 umol/L), n (%)			0.411
<1	91(6.3)	3(5.7)	
>10	164(11.4)	3(5.7)	
HCRP (>8mg/L), n (%)	1210(83.9)	45(84.9)	0.846
CK (>310U/L), n (%)	297(20.6)	11(20.8)	0.978
CKMB (>20U/L), n (%)	219(15.2)	14(26.4)	0.027
LDH (>250U/L), n (%)	461(32.0)	16(30.2)	0.785
TC (>5.2 umol/L), n (%)	95(6.6)	2(3.8)	0.414
TG (>1.7 umol/L), n (%)	99(6.9)	4(7.5)	0.847
Na (references 137–147 mmol/L), n (%)			0.471
<137	663(46.0)	26(49.1)	
>147	9(0.6)	1(1.9)	
K (references 3.5–5.3 mmol/L), n (%)			0.610
<3.5	205 (14.2)	6(11.3)	
>5.3	16(1.1)	0(0.0)	
CL (references 99–110 mmol/L), n (%)			0.050
<99	225(15.6)	65(4.5)	
>110	65(4.5)	6(11.3)	

(Continued)

Table 3 (Continued).

Variables	Without POP (N=1945)	With POP (N=53)	P value
TCO2(references 20–30 mmol/L), n (%)			0.889
<20	69(4.8)	3(5.7)	
>30	721(5.0)	2(3.8)	
GLU (>6.1), n (%)	868(60.2)	34(64.2)	0.761
UREA (>8), n (%)	327(22.8)	15(28.3)	0.320
CREA (references 57–97 mmol/L), n (%)			0.563
<57	623(43.2)	20(37.7)	
>97	92(6.4)	5(9.4)	
UA (references 208–428 mmol/L), n (%)			0.302
<208	729(40.6)	22(41.5)	
>428	44(3.1)	3(5.7)	
CA (references 2.11–2.52 mmol/L), n (%)			0.600
<2.11	761(52.8)	31(58.5)	
>2.52	12(0.8)	0(0.0)	
P (references 0.85–1.51 mmol/L), n (%)			0.579
<0.85	185(12.8)	9(17.0)	
>1.51	50(3.5)	1(1.9)	
Mg (references 0.75–1.02 mmol/L), n (%)			0.671
<0.75	167(11.6)	44(3.1)	
>1.02	8(15.1)	1(1.9)	
BNP (ng/L), n (%)			<0.001
<75	558(38.7)	9(17.0)	
>75	416(28.8)	30(56.6)	
Unknown	468(32.5)	14(26.4)	
WBC (references 3.5–9.5*10 <sup>9</sup> /L), n (%)			0.307
<3.5	10(0.7)	0(0.0)	
>9.5	513(35.6)	24(45.3)	
NEU (references 2.8–6.3*10 <sup>9</sup> /L), n (%)			0.071
<1.8	3(0.3)	0(0.0)	
>6.3	749(51.9)	36(67.9)	
LYM (references 1.1–3.2*10 <sup>9</sup> /L), n (%)			0.818
<1.1	752(52.1)	29(54.7)	
>3.2	8(0.6)	0(0)	
MON (references 0.1–0.6*10 <sup>9</sup> /L), n (%)			0.520
<0.1	3(0.2)	0(0)	
>0.6	870(60.3)	36(67.9)	
EOS (references 0.02–0.05*10 <sup>9</sup> /L), n (%)			0.052
<0.02	373(25.9)	9(17.0)	
>0.52	4(0.3)	1(1.9)	
BAS (>0.06), n (%)	83(5.8)	3(5.7)	0.977
RBC (>5.8), n (%)	94(6.5)	4(7.5)	0.766
NEU% (references 45–75%), n (%)			0.650
<45	3(0.2)	0(0.0)	

(Continued)

**Table 3** (Continued).

Variables	Without POP (N=1945)	With POP (N=53)	P value
>75	865(60.0)	35(66.0)	
LYM% (>5.2), n (%)	1378(95.6)	50(94.3)	0.673
MON% (references 3–10%), n (%)			0.638
<3	24(1.7)	0(0.0)	
>10	343(23.8)	13(24.5)	
BAS% (>1%), n (%)	10(0.7)	11(0.7)	0.318
HGB (<110/120 g/L), n (%)	1334(92.5)	50(94.3)	0.618
MCV (references 82–100 fL), n (%)			0.086
<82	31(2.1)	0(0.0)	
>100	110(7.6)	8(15.1)	
MCH (references 27–34 pg), n (%)			0.189
<27	38(2.6)	0(0.0)	
>34	92(6.4)	6(11.3)	
MCHC (references 316–354 g/L), n (%)			0.074
<316	38(2.6)	3(5.7)	
>354	61(4.2)	5(9.4)	
RDW (references 11.6–16.5%), n (%)			0.912
<11.6	5(0.3)	0(0.0)	
>16.5	136(9.4)	5(9.4)	
PLT (references 125–350 *10 <sup>9</sup> /L), n (%)			0.996
<125	135(9.4)	5(9.4)	
>250	86(6.0)	3(5.7)	
MPV (references 7.4–11.0 fL), n (%)			0.246
<7.4	227(15.7)	12(22.6)	
>11.0	49(3.4)	3(5.7)	
PCT (references 0.16–0.43%), n (%)			0.010
<0.16	937(65.0)	34(64.2)	
>0.43	7(0.5)	2(3.8)	
PDW (references 12.0–18.1%), n (%)			0.934
<7.4	130(9.0)	4(7.5)	
>11.0	26(1.8)	1(1.9)	
PT (>12.5 S), n (%)	333(23.1)	10(18.9)	0.246
PTA (<80%), n (%)	175(12.1)	7(13.2)	0.873
INR (>1.4%), n (%)	11(0.8)	1(1.9)	0.368
APTT (references 28–42 S), n (%)			0.934
<28	500(34.7)	24(45.3)	
>42	20(1.4)	0(0.0)	
APTT-R (references 0.7–1.3), n (%)			0.528
<0.7	18(1.2)	0(0.0)	
>1.3	16(1.1)	0(0.0)	
TT (references 14–21 S), n (%)			0.696
<14	1026(71.2)	35(66.0)	

(Continued)



**Table 3** (Continued).

Variables	Without POP (N=1945)	With POP (N=53)	P value
>2l	151(10.5)	6(11.3)	
FIB (reference2.0–4.4 mg/L), n (%)			0.708
<2.0	16(1.1)	0(0.0)	
>4.4	350(24.3)	14(26.4)	
AT III (reference80–120%), n (%)			0.916
<80	295(20.5)	12(22.6)	
>120	33(2.3)	1(1.9)	
D-Dimer (>2.26 mg/L), n (%)	571(39.6)	34(64.2)	<0.001

**Notes:** RBC, red blood cell, reference range: female, 3.5–5.0\*10<sup>12</sup>/L; males, 4.0–5.5\*10<sup>12</sup>/L; HGB, hemoglobin, reference range: females, 110–150g/L; males, 120–160g/L; HCT, haematocrit, 40–50%; PLT, platelet, 100–300\*10<sup>9</sup>/L.

**Abbreviations:** ASA, American Society of Anesthesiologists; BMI, body mass index; TP, total protein; ALB, albumin; GLOB, globulin; A/G values, albumin/globulin; ALT, alanine transaminase; AST, aspartate aminotransferase; TBIL, total bilirubin; DBIL, direct bilirubin; IBIL, indirect bilirubin; ALP, alkaline phosphatase; GGT,  $\gamma$ -glutamyl transpeptidase; CHE, cholinesterase; TBA, total bile acid; HCRP, hypersensitive c-reactive protein; LDH, lactate dehydrogenase; CREA, creatinine; UA, uric acid; CA, calcium; P, phosphorus; Mg, magnesium; BNP, brain natriuretic peptide; WBC, white blood cell; NEUT, neutrophile; LYM, lymphocyte, MON, mononuclear cell; EOS, eosinophilic granulocyte; BAS, basophilic granulocyte; MCV, mean corpuscular volume; MCH, mean corpuscular hemoglobin; MCHC, mean corpuscular hemoglobin concentration; RDW, red blood cell distribution width; MPV, mean platelet volume; PCT, procalcitonin; pdw, platelet distribution width; PT, Prothrombin time; PTA, prothrombin activity; INR, international normalized ratio; APTT, activated partial thromboplastin time; APTT-R, activated partial thromboplastin time ratio; TT, thrombin time; TT-R, thrombin ratio; FIB, fibrinogen; AT III, antithrombin III.

**Table 4** Comparison of Surgical Data Between the Two Groups

Variables	Without HPPOP (N=1442)	With HPPOP (N=53)	P value
Intraoperative blood loss (mL), n (%)	263.19(298.50)	265.09(204.65)	0.963
Intraoperative blood transfusion (mL),mean(SD)	133.67(318.19)	105.19(229.72)	0.519
Reduction methods (open reduction, n (%))	152 (10.5)	7 (13.2)	0.536
Surgeon (Deputy Chief Physician, n (%))	178 (12.3)	5 (9.4)	0.526
Time to surgery(days), mean (SD)	5.19 (3.93)	6.15 (4.92)	0.083
Type of anesthesia (general, n (%))	591 (41.1)	18 (34.0)	0.307
Implant, n (%)			0.169
Intramedullary devices	1351 (93.7)	53 (100.0)	
Extramedullary devices	91 (6.3)	0 (0.0)	
Duration of surgery(mins), mean (SD)	106.03(41.00)	100.19 (33.18)	0.306

time to surgery was 6.15±4.92 days in the IHPOP group, which was longer than in the non-IHPOP group.

### Risk Factors for IHPOP

Age >82 years, sex (male), cerebrovascular disease, cardiovascular disease, chronic respiratory disease, liver disease, urinary tract infection, ASA score of 3–4, number of comorbidities, transfer to ICU, BMI, PCT, BNP, D-dimer, and CKMB were included in the multivariate analysis (Table 5). Age >82 years (OR=2.54, p=0.004), male sex (OR=2.13, p=0.017), chronic respiratory disease (OR=5.02, p<0.001), liver disease (OR=3.39, p=0.037), urinary tract infection (OR=8.46, p=0.005), CKMB >20 U/l (OR=2.31, p=0.020), BNP ≥75 ng/l (OR=4.02; p=0.001), and D-dimer >2.26 mg/l

(OR=2.69, p=0.002) were identified as independent risk factors for the occurrence of IHPOP following geriatric intertrochanteric fracture surgery. The other factors were non-significant.

### Discussion

The in-hospital death rate for hip fracture is 6–10%.<sup>22,23</sup> IHPOP is a devastating complication for hip fracture patients—especially the geriatric population—that inevitably prolongs hospital stay and increases the risk of mortality. According to one report, 80% of patients with POP after hip fracture surgery are readmitted and 33.3% of these patients die within 1 year after surgery.<sup>13</sup> The present study investigated the incidence of and risk factors for



**Table 5** OR, 95% CI, and P value for Independent Risk Factors in the Multivariable Logistic Regression Analysis of IHPOP

Variables	OR	95% CI	P value
Age (>82 years)	2.54	1.354–4.760	0.004
Gender(female)	2.15	1.149–4.017	0.017
Chronic respiratory disease	5.02	2.283–11.043	0.000
Liver disease	3.39	1.074–10.675	0.037
Urinary tract infection	8.46	1.922–37.193	0.005
CKMB(>20U/L)	2.31	1.141–4.760	0.020
BNP			0.003
≥75 ng/L	4.02	1.795–9.010	0.001
Unknown	2.98	1.199–7.384	0.019
D-Dimer (>2.26 mg/L)	2.69	1.440–5.006	0.002

**Abbreviations:** OR, odds ratio; CI, confidence interval; CKMB, creatine phosphokinase isoenzyme; BNP, brain natriuretic peptide.

IHPOP following geriatric intertrochanteric fracture surgery at a trauma hospital in China. The incidence of IHPOP in 1495 consecutive patients was 3.5%, and the multivariate analysis identified 8 independent risk factors associated with the occurrence of IHPOP including age, male sex, chronic respiratory disease, liver disease, urinary tract infection, CKMB, BNP, and D-dimer.

Advanced age is known to be correlated with the rate of POP after hip fracture.<sup>24,25</sup> The average age of patients in our cohort was 78.9±7.5 years, which is similar to previous studies.<sup>5</sup> The optimum cutoff value for age

related to IHPOP following geriatric intertrochanteric fracture surgery was 82 years by ROC curve analysis; age >82 years was an independent risk factor for the development of IHPOP, and patients >82 years were 2.54 times more likely to develop IHPOP than those ≤82 years. In agreement with our findings, it was previously reported that patients >80 years old were more susceptible to developing POP after hip fractures<sup>26</sup> and that the incidence of POP increased with age,<sup>27</sup> being 2.3, 3.9, and 5.6 times higher in patients aged 60–69, 70–79, ≥80 years, respectively, than in those aged 50 years. Geriatric patients with intertrochanteric fractures are generally fragile and have at least one comorbidity. Moreover, the trauma of fracture and surgery can cause posttraumatic systemic inflammation and organ damage.<sup>28</sup> Therefore, the number of comorbidities is a major contributor to the high risk of IHPOP following geriatric intertrochanteric fracture surgery.

Sex is a known risk factor for morbidity and mortality after hip fracture.<sup>18,29</sup> In an analysis of 293 patients, male sex was an independent risk factor for POP in hip fracture patients over the age of 80 years<sup>11</sup> and in a retrospective cohort study, it was the strongest risk factor for POP after hip fracture.<sup>13</sup> In our cohort, the ratio of males to females was 1:1.7, and male sex was an independent risk factor for the development of IHPOP following geriatric intertrochanteric fracture surgery. This result may be explained by the fact that more men

**Table 6** All Parameters in This Study

Clinical Data	Parameters
Demographics and fracture characteristics	Age, gender, residential location, hypertension, diabetes, cerebrovascular disease, cardiovascular disease, chronic respiratory disease, smoking history, tumors, traumatic brain injury, liver disease, renal disease, urinary tract infection, rheumatoid diseases, previous surgical history, the number of Comorbidities, ASA score, BMI, injury mechanism, side and transfer to ICU.
Preoperative laboratory indicators	TP, ALB, GLOB, A/G values, ALT, AST, TBIL, DBIL, IBIL, ALP, GGT, CHE, TBA, HCRP, LDH, CK, CKMB, TC, Na, K, CL, TCO <sub>2</sub> , GLU, urea, CREA, UA, CA, P, Mg, BNP, WBC, NEUT, LYM, MON, EOS, BAS, RBC, NEU%, LYM%, MON%, BAS%, HGB, HCT, MCV, MCH, MCHC, RDW, PLT, MPV, PCT, PDW, PT, PTA, INR, APTT, APTT-R, TT, TT-R, FIB, AT III and D-Dimer.
Surgical data	Intraoperative blood loss, intraoperative blood transfusion, reduction methods, surgeon, time to surgery, type of anesthesia, implant (intramedullary or extramedullary devices), and duration of surgery

**Abbreviations:** ASA, American Society of Anesthesiologists score; BMI, body mass index; ICU, intensive care unit; TP, total protein; ALB, albumin; GLOB, globulin; A/G, albumin/globulin; ALT, alanine transaminase; AST, aspartate aminotransferase; TBIL, total bilirubin; DBIL, direct bilirubin; IBIL, indirect bilirubin; ALP, alkaline phosphatase; GGT,  $\gamma$ -glutamyl transpeptidase; CHE, cholinesterase; TBA, total bile acid; HCRP, hypersensitive c-reactive protein; LDH, lactate dehydrogenase; CK, creatine kinase; CKMB, creatine kinase myoglobin; TC, total cholesterol; Na, sodium; K, potassium; CL, chlorine; TCO<sub>2</sub>, Total carbon dioxide; GLU, glucose; CREA, urea, creatinine; UA, uric acid; CA, calcium; P, phosphorus; Mg, magnesium; BNP, brain natriuretic peptide; WBC, white blood cell; NEUT, neutrophil; LYM, lymphocyte; MON, mononuclear cell; EOS, eosinophilic granulocyte; BAS, basophilic granulocyte; RBC, red blood cell; HGB, hemoglobin; HCT, haematocrit; MCV, mean corpuscular volume; MCH, mean corpuscular hemoglobin; MCHC, mean corpuscular hemoglobin concentration; RDW, red blood cell distribution width; PLT, platelet; MPV, mean platelet volume; PCT, procalcitonin; PDW, platelet distribution width; PT, prothrombin time; PTA, prothrombin activity; INR, international normalized ratio; APTT, activated partial thromboplastin time; APTT-R, activated partial thromboplastin time ratio; TT, thrombin time; TT-R, thrombin ratio; FIB, fibrinogen; AT III, antithrombin III.

are smokers and therefore have a worse respiratory condition than women. Indeed, we found that chronic respiratory disease was significantly associated with increased risk of IHPOP following geriatric intertrochanteric fracture surgery. Moreover, liver disease (OR=3.39,  $p=0.037$ ) and urinary tract infection (OR=8.46,  $p=0.005$ ) were also correlated with an elevated risk of IHPOP, which has not been previously reported.

Some preoperative laboratory indices including CKMB  $>20$  U/l (OR=2.31,  $p=0.020$ ), BNP  $\geq 75$  ng/l (OR=4.02,  $p=0.001$ ), and D-dimer  $>2.26$  mg/l (OR=2.69,  $p=0.002$ ) were independent risk factors for IHPOP following geriatric intertrochanteric fracture surgery. BNP is a biomarker that has been used extensively in perioperative treatment of orthopedic surgery patients.<sup>30,31</sup> However, there have been no studies investigating the relationship between BNP and POP after intertrochanteric fracture. We determined that a BNP cutoff value  $>75$  ng/l (OR=4.02,  $p=0.001$ ) was associated with increased risk of IHPOP following geriatric intertrochanteric fracture surgery. Villacorta Junior et al<sup>32</sup> found that BNP  $>60$  ng/l was also an independent risk factor for postoperative adverse cardiac events after orthopedic surgery. This association between BNP and adverse cardiac events could explain our observation. Although D-dimer has prognostic value for deep vein thrombosis, it is unclear whether it is useful for predicting the development of POP. Our results showed that D-dimer  $>2.26$  mg/l increased the risk for the development of IHPOP; however, further studies are needed to clarify the physiologic link between BNP or D-dimer and POP in geriatric patients who have undergone intertrochanteric fracture surgery.

We acknowledge some limitations to our study. It involved only one institution, and some diseases such as dementia and Parkinson's disease that may have contributed to an increased incidence of IHPOP were not included in our analysis. Multicenter studies should be conducted to investigate the incidence of and risk factors for IHPOP within 30 days or 1 year of intertrochanteric fracture surgery to confirm our findings.

Nonetheless, this is the largest and most comprehensive investigation of IHPOP incidence and risk in geriatric patients who specifically underwent intertrochanteric fracture surgery. A total of 1495 elderly patients ( $>65$  years) and  $>90$  variables that could influence IHPOP incidence were analyzed (Table 6). Additionally, all patient data were extracted from a prospective database, which eliminated selection and recall bias; and quantitative data were

evaluated by ROC curve analysis to identify the most sensitive cutoff value.

## Conclusion

In conclusion, we found that the incidence of IHPOP following geriatric intertrochanteric fracture surgery was 3.5%. Age, male sex, chronic respiratory disease, liver disease, urinary tract infection, CKMB, BNP, and D-dimer were significant risk factors for the occurrence of IHPOP after the surgery, and the implant (intramedullary devices or extramedullary device) was not independent risk factor for the developing of IHPOP. Targeted preoperative management based on risk factors can potentially reduce the risk of IHPOP in geriatric patients undergoing surgery for intertrochanteric fractures and thereby improve their chances of full recovery.

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## Disclosure

All authors declare that they have no conflicts of interest for this work.

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