Received: 19 May 2020 | Revised: 22 July 2020 | Accepted: 22 July 2020

DOI: 10.1111/iwj.13477

ORIGINAL ARTICLE

IWJ WILEY

# Incidence and risk factors of surgical site infection after intertrochanteric fracture surgery: A prospective cohort study

**Kuo Zhao | Junzhe Zhang | Junyong Li | Hongyu Meng | Zhongzheng Wang | Yanbin Zhu | Zhiyong Hou | Yingze Zhang**

Department of Orthopaedic Surgery, Third Hospital of Hebei Medical University, Shijiazhuang, China

**Correspondence**
Yingze Zhang, Department of Orthopaedic Surgery, Third Hospital of Hebei Medical University, Shijiazhuang, China.
Email: suryzz@163.com

**Abstract**

Surgical site infection (SSI) is a challenging complication after intertrochanteric fracture surgery but without a large-sample size study to investigate the incidence and risk factors of it. The present study was to investigate the incidence and risk factors of SSI after intertrochanteric fracture surgery. A total of 1941 patients underwent intertrochanteric fracture surgery between October 2014 and December 2018 were included. Demographic data, surgical variables, and preoperative laboratory indexes were obtained from a prospective database and reviewed by hospital records. The optimum cut-off value for quantitative data was detected by receiver operating characteristic analysis. The univariate analysis and multivariable analysis were conducted to analyse the risk factors. In total, 25 patients (1.3%) developed SSI, including 22(1.1%) superficial infection and 3(0.2%) deep infection. After adjustment of multiple variables, gender (odds ratio[OR] 2.64, $P = .024$), time to surgery>4 days (OR 2.41, $P = .046$), implant (intramedullary or extramedullary devices) (OR 2.96, $P = .036$), ALB<35 g/L (OR 2.88, $P = .031$) remained significant factors. In conclusion, the incidence of SSI after intertrochanteric fractures surgery was 1.3%, with 1.1% for superficial and 0.2% for deep infection. Gender, time to surgery>4 days, the implant (intramedullary or extramedullary devices), and ALB<35 g/L were independent risk factors for the rate of SSI.

**KEYWORDS**

incidence, intertrochanteric fracture, risk factors, surgical site infection

## 1 | INTRODUCTION

Intertrochanteric fracture is a frequent condition with significant mortality and morbidity, especially for the geriatric population.[1,2] It reported that the 30-day and 1-year mortality rates of intertrochanteric fractures were, respectively, up to 7.7% and 26% after surgery.[3] The substantial mortality is often associated with older age, male, comorbidities, and postoperative complications.[3,4] In previous studies, postoperative complications have been attributed to be one of the leading causes of death in hip fractures patients.[5] Surgical site infection (SSI) is a challenging postoperative complication for the patient and hospital, the rate of which following hip fractures is between 2.7% and 14.9%.[6-8] It not only leads to more hospital stay, poor functional outcomes, and greater costs but also results in a substantially increased mortality risk.[9,10]

  

A variety of risk factors of SSI were documented, including age, comorbidities, obesity, the experience of the surgeon, haematoma, surgical duration, increased duration of anaesthesia, body mass index (BMI), current smoking, preoperative hospital stay, serum albumin, warfarin treatment, and so forth.[6,11,12] As reported by Harrison,[13] the method of fracture fixation was also significantly associated with the SSI. However, most of the authors combined the rates of infection for femoral neck fractures and intertrochanteric fractures, in which different methods of internal fixation were used.[13,14] And, there are significant differences in surgical methods, operative time, particular nature of the fracture, the patient's health, postoperative activity levels, and the surgeon's experience between intertrochanteric fractures and femoral neck fractures, which may lead to large differences in the rate of SSI. While, only a few studies investigated the incidence and risk factors of SSI after intertrochanteric fracture surgery alone, in which the sample size or the number of included risk factors was small.[15,16] Shinet et al[17] conducted a retrospective study to investigate the relationship between the perioperative C-reactive protein (CRP) value and postoperative complications after an intertrochanteric femoral fracture. Ekström et al[18] found that 2 of 109 patients developed SSI after intertrochanteric fracture in their study.

Therefore, the purpose of this study was to clarify the incidence and risk factors of SSI after intertrochanteric fracture surgery, which would help to take actively intervention to prevent SSI and improve the prognosis.

**Key Messages**

- all data were obtained from a prospective database and reviewed by hospital records
- we selected over 65 variables that could be prognostic factors related to SSI, including demographic variables, surgical variables, and preoperative laboratory indexes
- the optimum cut-off value for quantitative data was detected by receiver operating characteristic analysis. The univariate analysis and multivariable analysis were conducted to analyse the risk factors
- the incidence of SSI after intertrochanteric fractures surgery was 1.3%, with 1.1% for superficial and 0.2% for deep infection
- gender (odds ratio [OR] 2.64, $P = .024$), time to surgery>4 days(OR 2.41, $P = .046$), implant (intramedullary or extramedullary devices) (OR 2.96, $P = .036$), ALB<35 g/L(OR 2.88, $P = .031$) were independent risk factors of SSI

## 2 | PATIENTS AND METHODS

The study was conducted at a single, academic, Level-1 trauma centre. A total of 2068 patients underwent surgical treatment for an intertrochanteric fracture between October 2014 and December 2018 were reviewed, of which 1941 patients were further analysed according to the exclusion criteria (Figure 1). The exclusion criteria: (a) pathologic fracture, (b) old fractures (>21 days), (c) periprosthetic fractures, (d) patients who received conservative treatment, (e) age < 18 years, (f) patients whose information was incomplete data, (g) patients who received SSI treatment in our hospital but did not undergo initial surgery. Our study was ratified by our institutional ethics committee and adhered to the principles outlined in the Helsinki Declaration. The baseline characteristics and clinical data, such as demographic data, surgical variables, and preoperative laboratory indexes, were obtained from a prospective database and reviewed by hospital records. According to the occurrence of SSI, the patients were divided into two groups, with SSI or without SSI.

Based on previous studies, we selected over 65 variables that could be prognostic factors associated with SSI, including demographic variables, surgical variables, preoperative laboratory indexes. The demographic variables, including age, gender, residential location (rural or urban), BMI, medical comorbidities (such as hypertension, diabetes mellitus, cardiac and cerebrovascular disease, respiratory disorders, liver, and kidney diseases), American Society of Anaesthesiologists (ASA) score, tumours (benign or malignant), and so forth, were collected. The number of comorbidities, the sum of the above major comorbidities, was also recorded. The surgical variables included: time to surgery (from admission to surgery), duration of surgery, type of anaesthesia, the implant (intramedullary devices or extramedullary devices), reduction methods, type of operating surgeon, intraoperative blood loss, and so forth. The preoperative laboratory indexes consisted of complete blood counts and biochemical analyses at the time of admission, including white blood cell (WBC), red blood cell (RBC), neutrophile granulocyte (NEUT), lymphocyte (LYM), haemoglobin (HGB), platelet (PLT), serum total protein (TP), serum albumin (ALB), alanine transaminase (ALT), and Serum globulin (GLU), and so forth.

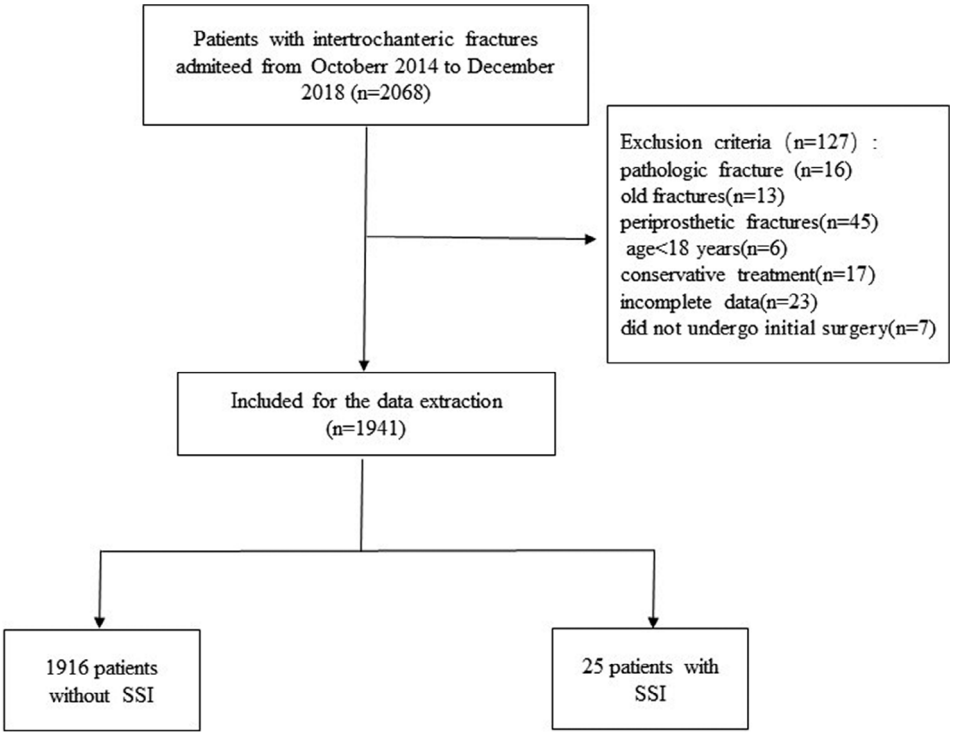


**FIGURE 1** The optimum cut-off value of some continuous variables associated with SSI were detected by ROC analysis

Based on the criteria of the United States Centres for Disease Control and Prevention (CDC criteria),[19] we defined an infection developing within 30 to 90 days post-operatively as SSI, including superficial infection and deep infection. Superficial infection is the infection of the skin or subcutaneous tissue occurring within 30 days post-operatively, with at least one more symptom involving: localised pain; purulent discharge; spontaneous incision dehiscence; and positive results of bacterial culture. The deep infection was diagnosed if an infection were associated with fascial and muscular layers occurring within 90 days, combined with at least one of the abovementioned symptoms.

Standard antibiotic prophylaxis was 1 to 3 g Cefazolin intravenously 30 minutes pre-operatively and 24 hours post-operatively. All surgeries were conducted in laminar airflow theatres. All operations were conducted by dedicated orthopaedic trauma surgeons, the experience of which was recorded. The follow up of patients was performed by telephone or outpatient review. If an infection was suspected, we would require the patient for further treatment.

## 3 | STATISTICAL ANALYSIS

The optimum cut-off value for quantitative data, such as BMI, time to surgery, duration of surgery and anaesthesia, and intraoperative blood loss, and so forth were detected by receiver operating characteristic (ROC) analysis. Continuous variables corresponding to a normal distribution were compared by Student's $t$ test, and those do not conform to a normal distribution were adopted by the Mann–Whitney $U$ test. Pearson chi-square test/Fisher' exact test was applied to categorical variables. Categorical variables were described as frequency and percentage, while continuous variables were described as mean ± SD/median with quartile. Risk factors having statistical differences ($P < .05$) were entered into a multivariable logistic regression model to identify independent predictors of SSI. The $P$-value <.05 indicated statistical significance. The Hosmer–Lemeshow test was applied to assess the goodness of fit, and acceptable fitness was accepted for $P$-values <.05. All statistical analyses were performed by the SPSS 23.0 software (IBM, Armonk, New York).

## 4 | RESULTS

In total, 1941 patients were included in this study, of which 25 patients (1.3%) developed SSI, including 22 (1.1%) superficial infection and 3 (0.2%) deep infection.

The optimum cut-off value of some continuous variables associated with SSI were detected by ROC analysis, and some of the results were shown in Table 1 and Figure 2. In the univariate analysis, gender ($P = .029$), the number of comorbidities ($P = .012$), reduction methods ($P = .039$),

| Variables | Cut-off value | Area under the ROC curve (AUC) | *P*-value | 95% CI |
|---|---|---|---|---|
| Time to surgery | 4 | 0.66 | .027 | 0.547-0.773 |
| duration of surgery | 92 | 0.653 | .034 | 0.525-0.782 |

Abbreviations: CI, confidence interval; ROC, receiver operating characteristic.

**TABLE 1** Optimum cut-off value of continuous variables detected by the ROC analysis

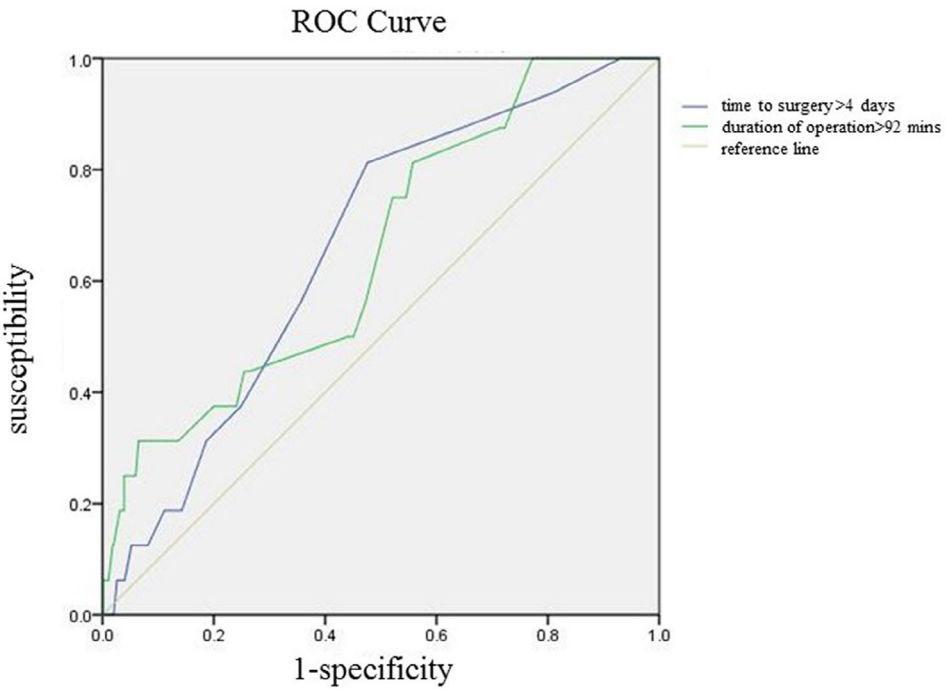


**FIGURE 2** The flow chart for the selection of study participants

time to surgery>4 days ($P = .042$), implant (intramedullary devices or extramedullary devices, $P = .007$), ALB<35 g/L ($P = .036$), and HGB < 110/120 g/L ($P = .026$) were identified as significant risk factors for the development of SSI (Table 2). Other demographic data, surgical variables, and preoperative laboratory indexes had no statistical differences between the two groups. In the multivariate logistic regression analysis model, all of the abovementioned factors were included. In the final multivariable analysis results, gender (OR 2.64, 95% CI 1.13–6.13, $P = .024$), time to surgery>4 days(OR 2.41, 95% CI 1.02–5.71, $P = .046$), implant (intramedullary devices or extramedullary devices) (OR 2.96, 95% CI 1.07–8.32, $P = .036$), ALB<35 g/L (OR 2.88, 95% CI 1.10–7.52, $P = .031$) remained significant factors (Table 3).

## 5 | DISCUSSION

In the present study, the incidence of SSI after intertrochanteric fractures surgery was 1.3%, with 1.1% for superficial infection and 0.2% for deep infection, which is comparable to previous studies.[15,16,18,20] To our knowledge, our analysis is the first large-sample cohort study to detect the incidence and risk factors of SSI after intertrochanteric fracture surgery alone. In this study, we found that gender, time to surgery>4 days, the implant (intramedullary devices or extramedullary devices), ALB<35 g/L were potentially remediable factors for the rate of SSI after intertrochanteric fractures surgery.

Gender was proved to be a vital factor affecting the rate of SSI in the present study. And, the rate of SSI in the male gender was 2.7 times than that of the female gender (OR 2.64, 95% CI 1.13–6.13, $P = .024$). Inconsistent with our study, Harrison et al[13] found that gender was not associated with the rate of SSI after hip fractures. Based on previous studies, smoking is an independent risk factor of SSI. Ma et al found that the incidence of SSI in patients with current smoking was 4.26 times than that without current smoking.[11] And Liang et al found similar results in their study.[21] Therefore, we insist that Tobacco smoking was a significant factor that resulted in this difference between females and males in our study.

**TABLE 2** Univariable analyses of risk and prognostic factors

| Variables | Total patients (N = 1941) | Without SSI (N = 1916) | With SSI (N = 25) | *P*-value |
|---|---|---|---|---|
| Intraoperative blood loss (ml), n (%) | | | | .605 |
| ≤200 | 1164 (60.0) | 1151 (60.1) | 13 (52.0) | |
| 201-400 | 505 (26.0) | 498 (26.0) | 7 (28.0) | |
| 401-600 | 165 (8.5) | 163 (8.5) | 2 (8.0) | |
| 801-1000 | 50 (2.6) | 49 (2.6) | 1 (4.0) | |
| >1000 | 57 (2.9) | 55 (2.9) | 2 (8.0) | |
| Intraoperative blood transfusion (ml), mean (SD) | 140.547 ± 338.21 | 139.9 ± 338.5 | 192.0 ± 318.1 | .444 |
| Age (years), mean (SD) | 72.92 ± 14.45 | 73.0 ± 14.4 | 68.0 ± 17.6 | .087 |
| Hypertension, n (%) | 858 (44.2) | 850 (44.4) | 8 (32.0) | .226 |
| Diabetes, n (%) | 386 (19.9) | 383 (20.0) | 3 (12.0) | .320 |
| Cerebrovascular disease, n (%) | 576 (29.7) | 574 (29.8) | 2 (12.5) | .131 |
| Cardiovascular disease, n (%) | 633 (32.6) | 626 (32.7) | 7 (28.0) | .621 |
| Chronic respiratory disease, n (%) | 96 (4.9) | 95 (5.0) | 1 (4.0) | .826 |
| Pneumonia, n (%) | 95 (4.9) | 94 (4.9) | 1 (4.0) | .835 |
| Tumours, n (%) | 42 (2.2) | 42 (2.2) | 0 (0.0) | .454 |
| Liver disease, n (%) | 40 (2.1) | 40 (2.1) | 0 (0.0) | .465 |
| Renal disease, n (%) | 60 (3.1) | 59 (3.1) | 1 (4.0) | .792 |
| Urinary tract infection, n (%) | 12 (0.6) | 12 (0.6) | 0 (0.0) | .691 |
| Comorbidities, no, n (%) | | | | .012 |
| 0 | 380 (19.6) | 375 (19.6) | 5 (20.0) | |
| 1 | 465 (24.0) | 453 (23.6) | 12 (48.0) | |
| >2 | 1096 (56.5) | 1088 (56.5) | 8 (32.0) | |
| Residential location (urban), n (%) | 840 (43.3) | 829 (43.3) | 11 (44.0) | .941 |
| Injury mechanism (high energy), n (%) | 181 (9.3) | 176 (9.2) | 5 (20.0) | .065 |
| Reduction methods (open reduction), n (%) | 269 (13.9) | 262 (13.7) | 7 (28.0) | .039 |
| Surgeon (Deputy Chief Physician), n (%) | 1697 (87.4) | 1674 (86.8) | 23 (92.0) | .448 |
| Time to surgery (>4 days), n (%) | 929 (47.9) | 912 (47.6) | 17 (68.0) | .042 |
| Type of anaesthesia (general), n (%) | 820 (42.2) | 809 (42.2) | 11 (44.0) | .837 |
| Side (left), n (%) | 1003 (51.7) | 990 (51.7) | 13 (52.0) | .974 |
| Implant, n (%) | | | | .007 |
| intramedullary devices | 1812 (93.4) | 1792 (93.5) | 20 (80.0) | |
| extramedullary devices | 129 (6.7) | 124 (6.5) | 5 (20.0) | |
| Duration of surgery (>92 minutes), n (%) | 1086 (56.0) | 1069 (55.7) | 17 (68.0) | .222 |
| ASA3-4, n (%) | 914 (47.1) | 905 (47.2) | 9 (36.0) | .131 |
| Gender (male), n (%) | 826 (42.6) | 810 (42.3) | 16 (64.0) | .029 |
| BMI, n (%) | | | | .863 |
| <18.5 | 106 (5.5) | 105 (5.5) | 1 (4.0) | |
| 18.5-23.9 | 1173 (60.4) | 1158 (60.4) | 15 (60.0) | |
| 24-27.9 | 494 (25.5) | 488 (25.5) | 6 (24.0) | |
| 28-31.9 | 140 (7.2) | 137 (7.2) | 3 (12.0) | |
| ≥32 | 28 (1.4) | 28 (1.5) | 0 (0.0) | |

(Continues)

**TABLE 2** (Continued)

| Variables | Total patients (N = 1941) | Without SSI (N = 1916) | With SSI (N = 25) | *P*-value |
|---|---|---|---|---|
| Tp < 65 g/L, n (%) | 1562 (80.5) | 1541 (80.5) | 21 (84.0) | .654 |
| ALB<35 g/L, n (%) | 1072 (55.2) | 1053 (55.0) | 19 (76.0) | .036 |
| GLOB (references 20-40 g/L), n (%) | | | | .406 |
| <20 | 319 (16.4) | 313 (16.3) | 6 (24.0) | |
| >40 | 51 (2.6) | 51 (2.7) | 0 (0) | |
| A/G (references 1.2-2.4), n (%) | | | | .337 |
| <1.2 | 405 (20.9) | 397 (20.7) | 8 (32.0) | |
| >2.4 | 28 (1.4) | 28 (1.5) | 0 (0) | |
| ALT (references 9-50 U/L), n (%) | | | | .230 |
| <9 | 186 (9.6) | 183 (9.6) | 3 (12.0) | |
| >50 | 146 (7.5) | 142 (7.4) | 4 (16.0) | |
| AST (references 15-40 U/L), n (%) | | | | .233 |
| <15 | 343 (17.7) | 341 (17.8) | 2 (8.0) | |
| >40 | 224 (11.5) | 219 (11.4) | 5 (20.0) | |
| TBIL (>26), n (%) | 279 (14.4) | 275 (14.4) | 4 (16.0) | .816 |
| DBIL (>6), n (%) | 873 (45.0) | 863 (45.0) | 10 (40.0) | .581 |
| IBIL (>14), n (%) | 371 (19.1) | 368 (19.2) | 3 (12.0) | .631 |
| ALP (references 45-125 U/L), n (%) | | | | .784 |
| <45 | 231 (12.0) | 227 (11.8) | 4 (16.0) | |
| >125 | 134 (6.9) | 132 (6.9) | 2 (8.0) | |
| GGT (references 10-60 U/L), n (%) | | | | .508 |
| <10 | 98 (5.0) | 98 (5.1) | 0 (0.0) | |
| >60 | 212 (10.9) | 209 (10.9) | 3 (12.0) | |
| CHE (references 5-12 U/L), n (%) | | | | .266 |
| <2 | 783 (40.3) | 769 (40.1) | 14 (56.0) | |
| >12 | 9 (0.5) | 9 (0.5) | 0 (0) | |
| TBA (references 1-10 umol/L), n (%) | | | | .597 |
| <1 | 131 (6.7) | 130 (6.8) | 1 (4.0) | |
| >10 | 204 (10.5) | 200 (10.4) | 4 (16.0) | |
| HCRP (>8), n (%) | 1623 (83.6) | 1604 (83.7) | 19 (76.0) | .300 |
| CK (>), n (%) | 479 (24.7) | 472 (24.6) | 7 (28.0) | .698 |
| CKMB (>), n (%) | 322 (16.6) | 318 (16.6) | 4 (16.0) | .936 |
| LDH (>), n (%) | 642 (33.1) | 634 (33.1) | 8 (32.0) | .908 |
| HBDH (>), n (%) | 497 (25.6) | 491 (25.6) | 6 (24.0) | .853 |
| TC (>), n (%) | 121 (6.2) | 120 (6.3) | 1 (4.0) | .642 |
| TG (>), n (%) | 165 (8.5) | 163 (8.5) | 2 (8.0) | .928 |
| Na (references 137-147 mmol/L), n (%) | | | | .922 |
| <137 | 875 (45.1) | 864 (45.1) | 11 (44.0) | |
| >147 | 11 (0.6) | 11 (0.6) | 0 (0) | .947 |
| K (references 3.5-5.3 mmol/L), n (%) | | | | .356 |
| <3.5 | 251 (12.9) | 250 (13.0) | 1 (4.0) | |
| >5.3 | 17 (0.9) | 17 (0.9) | 0 (0) | |

**TABLE 2** (Continued)

| Variables | Total patients (N = 1941) | Without SSI (N = 1916) | With SSI (N = 25) | *P*-value |
|---|---|---|---|---|
| CL (references 99-110 mmol/L), n (%) | | | | .060 |
| <99 | 313 (16.1) | 305 (15.9) | 8 (32.0) | |
| >110 | 95 (4.9) | 93 (4.9) | 2 (8.0) | |
| TCO2 (references 20-30 mmol/L), n (%) | | | | .546 |
| <20 | 85 (4.4) | 85 (4.4) | 0 (0.0) | |
| >30 | 92 (4.7) | 91 (4.7) | 1 (4.0) | |
| GLU (>6.1), n (%) | 1147 (59.1) | 1136 (59.3) | 11 (44.0) | .278 |
| UREA (>8), n (%) | 404 (20.8) | 396 (20.7) | 5 (20.8) | .663 |
| CREA (references 57-97 mmol/L), n (%) | | | | .936 |
| <57 | 835 (43.0) | 824 (43.1) | 11 (44.0) | |
| (>97) | 110 (5.7) | 109 (5.7) | 1 (4.0) | |
| UA (references 208-428 mmol/L), n (%) | | | | .367 |
| <208 | 940 (48.4) | 925 (48.3) | 15 (60.0) | |
| >428 | 76 (3.9) | 76 (4.0) | 0 (0.0) | |
| WBC (references 3.5-9.5$10^9$/L), n (%) | | | | .770 |
| <3.5 | 14 (0.7) | 14 (0.7) | 0 (0.0) | |
| >9.5 | 740 (38.1) | 729 (38.0) | 11 (44.0) | |
| NEU (references 2.8-6.3 $10^9$/L), n (%) | | | | .959 |
| <1.8 | 5 (0.3) | 5 (0.3) | 0 (0.0) | |
| >6.3 | 1058 (54.5) | 1044 (54.5) | 14 (56.0) | |
| LYM (references 1.1-3.2 $10^9$/L), n (%) | | | | .063 |
| <1.1 | 950 (48.9) | 937 (48.9) | 13 (52.0) | |
| >3.2 | 11 (0.6) | 10 (0.5) | 1 (4.0) | |
| MON (references 0.1-0.6 $10^9$/L), n (%) | | | | .969 |
| <0. 1 | 3 (0.2) | 3 (0.2) | 0 (0) | |
| >0.6 | 1211 (62.4) | 1195 (62.4) | 16 (64.0) | |
| EOS (references 0.02-0.05 $10^9$/L), n (%) | | | | .925 |
| <0.02 | 495 (25.5) | 488 (25.5) | 7 (28.0) | |
| >0.52 | 6 (0.3) | 6 (0.3) | 0 (0) | |
| BAS (>0.06), n (%) | 120 (6.2) | 118 (6.2) | 2 (8.0) | .704 |
| RBC (>5.8), n (%) | 159 (8.2) | 159 (8.3) | 0 (0) | |
| HGB (<110/120), n (%) | 1304 (67.2) | 1282 (66.9) | 22 (88.0) | .026 |
| HCT (references 40%-50%), n (%) | | | | .574 |
| <40 | 1816 (93.6) | 1791 (93.5) | 25 (100.0) | |
| >50 | 1 (0.1) | 1 (0.1) | 0 (0.0) | |
| MCV (references 82-100 fL), n (%) | | | | .208 |
| <82 | 43 (2.2) | 43 (2.2) | 0 (0.0) | |
| >100 | 146 (7.5) | 142 (7.4) | 4 (16.0) | |
| MCH (references 27-34pg), n (%) | | | | .605 |
| <27 | 48 (2.5) | 48 (2.5) | 0 (0.0) | |
| >34 | 133 (6.9) | 132 (6.9) | 1 (4.0) | |

(Continues)

**TABLE 2** (Continued)

| Variables | Total patients (N = 1941) | Without SSI (N = 1916) | With SSI (N = 25) | *P*-value |
|---|---|---|---|---|
| MCHC (references 316-354 g/L), n (%) | | | | .495 |
| <316 | 49 (2.5) | 48 (2.5) | 1 (4.0) | |
| >354 | 89 (4.6) | 89 (4.6) | 0 (0.0) | |
| PLT (references 125-350 $10^9$/L), n (%) | | | | .052 |
| <125 | 170 (8.8) | 168 (8.8 | 2 (8.0) | |
| >250 | 281 (14.5) | 138 (7.2) | 143 (7.4) | |
| MPV (references 7.4-11.0 fL), n (%) | | | | .559 |
| <7.4 | 311 (16.0) | 306 (16.0) | 5 (20.0) | |
| >11.0 | 70 (3.6) | 70 (3.7) | 0 (0.0) | |
| ICU, n (%) | 51 (2.6) | 51 (2.7) | 0 (0.0) | .408 |

*Note:* RBC, red blood cell, reference range: female, 3.5–5.0*1012/L; males, 4.0–5.5*1012/L. HGB, haemoglobin, reference range: females, 110-150 g/L; males, 120-160 g/L; HCT, haematocrit, 40%-50%; MCV, mean corpuscular volume; MCH, mean corpuscular haemoglobin; MCHC, mean corpuscular haemoglobin concentration; PLT, platelet, 100–300*109/L; MPV, mean platelet volume; ICU, intensive care unit.
Abbreviations: A/G values, albumin/globulin; ALB, albumin; ALP, alkaline phosphatase; ALT, alanine transaminase; ASA, American Society of Anaesthesiologists; AST, aspartate aminotransferase; BAS, basophilic granulocyte; BMI, body mass index; CHE, cholinesterase; DBIL, direct bilirubin; EOS, eosinophilic granulocyte; GGT, γ-glutamyl transpeptidase; GLOB, globulin; GLU, glucose; HBDH, hydroxybutyrate dehydrogenase; HCRP, hypersensitive c-reactive protein; IBIL, indirect bilirubin; LDH, lactate dehydrogenase; LYM, lymphocyte; MON, mononuclear cell; NEUT, neutrophile; TBA, total bile acid; TBIL, total bilirubin; TC, total cholesterol; TG, triglyceride; TP, total protein; UA, Uric acid; UREA, serum urea, CREA, Creatinine; WBC, white blood cell.

**TABLE 3** OR, 95% CI, and P-value for independent risk factors in the multivariable logistic regression analysis of SSI

| Variable | Odds radio | 95%CI | *P*-value |
|---|---|---|---|
| Gender (male) | 2.64 | 1.13–6.13 | .024 |
| Time to surgery (>4 days) | 2.41 | 1.02–5.72 | .046 |
| Implant (extramedullary devices) | 2.99 | 1.07–8.32 | .036 |
| ALB (<35 g/L) | 2.88 | 1.10–7.52 | .031 |

Abbreviations: ALB, albumin; Anaesthesiologists; CI, confidence interval.

Time to surgery following hip fracture played an important role in the prognosis of patients.[22] Some recent studies have suggested that delay in surgery after hip fracture increased the risk of in-hospital complications.[23,24] While some guidelines recommend that hip fracture surgery should be conducted within 24–48 hours, the optimal cut-off time for time to surgery is still controversial.[23] In the present study, time to surgery >4 days has been demonstrated a significant risk factor for SSI after intertrochanteric fractures surgery (OR2.41, 95% CI 1.02–5.71, $P = .046$). The correlation between time to surgery and the rate of SSI after hip fracture had been reported in previous studies.[7,25] According to Cordero,[25] delay in surgery for more than 24 hours was a significant risk factor for wound infection after hip fractures. Lau et al show that the time to surgery >7 days was associated with the rate of SSIs in hip hemiarthroplasty.[26] What resulted in surgical delay were that the sicker and frailer patients always needed medical adjustments to tolerate surgery. These patients were often accompanied with older age and more than one medical complication, explaining a higher risk of SSI.

The preferred implant for intertrochanteric fractures has been converted from the sliding hip screw to the intramedullary devices in recent years.[27,28] In our hospital, the treatment of intertrochanteric fractures is mainly with intramedullary devices. And the extramedullary devices include the sliding hip screw, proximal femoral locking compression plate, and hemiarthroplasty. Our study found that the extramedullary devices were associated with a higher risk for SSI after intertrochanteric fractures, compared with the intramedullary devices (Table 3). Harrison et al[13] found a similar result in their study of the incidence of SSI after hip fracture surgery. According to their data, the incidence of SSI after hip

fractures in extramedullary fixation was significantly higher than that in intramedullary fixation (0.78% vs 0.00%, $P = .002$). Compared with the extramedullary devices, some advantages of the intramedullary devices might result in a lower rate of SSI in this study, including small incision with less disruption to deep tissues, shorter operative time with less exposure, and further from the skin incision.

In recent years, the correlation between preoperative malnutrition and the prognosis of orthopaedic procedures has been reported in many studies.[29,30] Serum albumin is one of the most commonly used serum markers of nutritional status. It has been demonstrated that serum albumin is an independent risk factor for poor outcomes after hip fractures, such as postoperative complications and mortality.[14,31] Daniel et al[14] found that hypoalbuminemia was significantly associated with higher rates of death, sepsis, unplanned intubation, a longer mean length of stay, compared with normal albumin concentration. According to the study of Daniel et al and some previous studies, the serum albumin concentration < 35 g/L was considered to be malnutrition (hypoalbuminemia).[11] The prevalence of hypoalbuminemia in our study was 55.2%, which was similar to previous founding reported from 45.9% to 55.4%.[32,33] The current study revealed that a serum albumin concentration < 35 g/L is a risk factor for SSI after intertrochanteric fractures. The results of our study were similar to that of Ma et al,[6] in which hypoalbuminemia increased the risk of SSI after hip fractures. Therefore, we should pay more attention to the nutritional status of patients with a hip fracture for the timely nutritional supplementation may reduce the incidence of poor outcomes.

In previous studies, most of the authors described the risk factors for the rate of SSI after hip fracture surgery, combining the femoral neck fracture and intertrochanteric fracture together despite different fractures characteristics and surgical characteristics between them.[6,10,12,13,25,34] Compared with previous studies with a small simple size and few risk factors,[15-18,20,35] our analysis is the first large-sample cohort study to detect the incidence and risk factors of SSI after intertrochanteric fracture surgery alone. In addition, the present study had selected over 70 variables, including demographic variables, surgical variables, preoperative laboratory indexes. Besides, ROC analysis was conducted to find a better sensitive cut-off value. Last, all of the patients were chosen from a consecutive intertrochanteric fracture database so that the selection bias could be prevented. We acknowledge some limitations should be recognised in our study. The number of patients with SSI was small and our study was conducted in a single centre. Thus, we will conduct multi-centre studies to expand the sample size and avoid admission bias in the future. Besides, some other confounding factors still remain, including the experience of the surgeon, residential status, the type of fracture, and so forth.

In conclusion, first, we found the incidence of SSI after intertrochanteric fractures surgery was 1.3%, with 1.1% for superficial infection and 0.2% for deep infection. Second, gender, time to surgery>4 days, the implant (intramedullary devices or extramedullary devices), and ALB<35 g/L were significant risk factors associated with the rate of SSI after intertrochanteric fractures surgery. Last, we suggest that individual treatment should be applied for patients with sensitivity factors and corresponding preventive measures should be taken to mitigate the interference of modifiable factors.

## ACKNOWLEDGEMENTS

We are grateful to Z Jin and RP Zhang of the Department of Orthopaedics, and to YC Yin of the Department of statistics and applications for their kind assistance.

## CONFLICT OF INTEREST

All authors declare that they have no conflicts of interest.

## DATA AVAILABILITY STATEMENT

Research data are not shared.

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**How to cite this article:** Zhao K, Zhang J, Li J, et al. Incidence and risk factors of surgical site infection after intertrochanteric fracture surgery: A prospective cohort study. *Int Wound J*. 2020;17: 1871–1880. https://doi.org/10.1111/iwj.13477