

Prognostic risk factors of surgical site infection after primary joint arthroplasty

A retrospective cohort study

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Abstract

Surgical site infection (SSI) can be a devastating complication in joint arthroplasty. Objective of this study was to identify potential risk factors associated with SSI following primary joint arthroplasty.

This retrospective cohort study was performed from January 2016 to October 2017. A total of 986 patients were enrolled. We extracted the patients' baseline information, treatment-related variables and indexes of laboratory examination during their hospitalization. Receiver operating characteristic (ROC) analysis was performed to find the optimum cut-off value for serum albumin. Univariate and multivariate logistic analysis models were performed respectively to determine independent predictors of SSI.

Nine hundred eighty-six patients with complete data were included in the final analysis. There were 314 male and 672 females in this study with a mean age of 64.6 years, and twenty patients developed SSI. The overall incidence of SSI was 2.03%, with 0.20% for deep infection and 1.83% for superficial SSI. Independent predictors of SSI identified by multivariate analysis were ALB < 36.7 g/L (odds ratio = 3.42; 95% CI = 1.24–9.48; $P = .018$), BMI ≥ 28 (odds ratio = 5.08; 95% CI = 1.52–17.01; $P = .008$) and ASA class 3 or higher (odds ratio = 3.36; 95% CI = 1.22–9.30; $P = .019$). Drain use was demonstrated as a protective factor of postoperative wound healing.

The incidence of SSI following primary joint arthroplasty was 2.03%. ASA ≥ 3 , BMI ≥ 28 and ALB < 36.7 g/L were demonstrated as risk factors of postoperative wound infection. Supplementary nutrition support is necessary to reduce the risk of infection in patients who underwent artificial joint arthroplasty.

Abbreviations: A/G = albumin/globulin value, ALB = albumin, ALB = Serum albumin, ASA = American Society of Anesthesiologists, BAS = basophilic granulocyte, BMI = body mass index, CDC = Center for Disease Control, GLOB = globulin, LYM = lymphocyte, MON = monocyte, NEUT = neutrophile granulocyte, ROC = Receiver operating characteristic, SSI = surgical site infection, TP = serum total protein, WBC = white blood cell.

Keywords: arthroplasty, incidence, risk factors, serum albumin, surgical site infection

1. Introduction

Joint arthroplasty is a highly successful and cost effective surgical treatment to improve quality of life for patients with advanced arthritis and fractures.^[1–4] Surgical site infection (SSI) after joint

arthroplasty is one of the most disabling complications. From an economic perspective, SSI accounted for 17% of nosocomial infections and cost between 1 and 10 billion US dollars in direct and indirect medical expenses annually in the United States.^[5] Some studies have been performed to investigate the incidence of SSI and related risk factors following joint arthroplasty surgery, however, most of these data were reported in western countries. There are few researches conducted in Asian country especially in the developing ones.

The role of malnutrition in wound healing and complications following orthopedic surgery has been identified in previous studies.^[6–11] However, most studies did not demonstrate the association between different level of ALB and SSI. It is difficult for those literatures to extrapolate a clear picture of the impact of different ALB value on the wound healing status.

Given that, we designed this retrospective cohort study with two aims: first, to report incidence rate of SSI following primary joint arthroplasty and identify independent predictors of SSI during over 1 year follow up; second, to better define the threshold value of ALB on postoperative wound infection in joint arthroplasty.

2. Patients and methods

2.1. Inclusion and exclusion criteria

This study was conducted at a tertiary hospital in Hebei province. In order to ensure the homogeneity and reliability of data, final

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All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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study size was obtained when the incidence of SSI and statistical result did not significantly change with the increase of number of enrolled patients. Between January 2016 and October 2017, a consecutive series of 986 patients who underwent joint arthroplasty were recruited. The inclusion criteria were

1. patients aged 18 years or older;
2. patients who were admitted to our orthopedic department due to joint disease (rheumatoid arthritis of the joint, degenerative joint arthritis, traumatic joint arthritis, fractures) and treated by joint arthroplasty;
3. patients who agreed to participate in this study;
4. patients with a at least 12 months' follow up.

The exclusion criteria were:

1. patients who were diagnosed with postoperative SSI but do not underwent initial joint arthroplasty in our hospital;
2. patients who had underwent TKA due to tuberculosis, primary or metastatic tumor of the knee;
3. patients undergone the revision of joint arthroplasty;
4. patients with incomplete medical data;
5. patients lost follow up or dead after discharged from hospital.

2.2. Data collection and definition of interesting variables

Baseline information, surgery-related variables, laboratory index, medications and additional comorbidities for each patient were collected from their medical records. Variables of interest included 4 aspects:

1. baseline characteristics: age, gender, body mass index (BMI), living places (rural or urban), profession, preoperative and total hospital stay;
2. co-morbidities and lifestyle habits: smoking, previous operation for any disease, diabetes mellitus, hypertension, heart disease, anemia;
3. surgery-related characteristics: surgical season, ASA status, anesthetic type, operative time, intraoperative body temperature, intraoperative blood loss (ml) and transfusion, intraoperative and postoperative use of antibiotics, postoperative use of drain;
4. preoperative laboratory indexes: white blood cell (WBC), neutrophil granulocyte (NEUT), lymphocyte (LYM), monocyte (MON), eosinophil granulocyte (EOS), basophilic granulocyte (BAS), red blood cell (RBC), haemoglobin (HG), blood platelet (PLT), serum total protein (TP), albumin (ALB), globulin (GLOB) and A/G value (albumin/globulin). The full list of variables was summarized in Table 2.

BMI was grouped according to the Chinese reference criteria: underweight, < 18.5; normal, 18.5–23.9; overweight, 24–27.9; obesity, 28–31.9; morbid obesity, 32 and more. Co-morbidities were identified according to clinical diagnosis from the specialist during hospitalization. American Society of Anesthesiologists (ASA) physical status index (I–V) was used to evaluate the preoperative status of the patients, based on their medical conditions and surgical risks.

2.3. Definition of SSI

SSI was defined based on United States Center for Disease Control and Prevention (CDC) definitions.^[12] This classification system categories SSI into 3 types:

1. superficial incisional;
2. deep soft tissue of the incision;
3. organ/space infection.

Superficial SSI, defined as infection occurring within 30 days postoperative, involves the skin and subcutaneous tissue of the surgical site only; one or more symptom is observed: redness, swelling, pain of the incision; purulent discharge; spontaneous wound dehiscence; positive results of bacterial culture. Deep wound infection is defined as infection that occurs within 90 days post-operation, and involves the fascial and muscular layer. In the present study, during hospitalization of patients, we reviewed their electronic medical records (EMRs) and results of bacterial culture for the signs of wound infection. After discharged from hospital, all patients were followed up for any evidence of SSI via telephone, and EMRs were reviewed if the patients were hospitalized again due to SSI.

On the premise of guaranteeing the study quality, as many patients as possible were enrolled according to the pre-investigate sample size assessment. Finally, all enrolled patients were divided into two groups according to the occurrence of SSI. The case group was defined as patients with SSI, and the control group included patients who were not suffered from infection. All the data mentioned above were extracted and collected by two well-trained investigators. This study was approved by the Institutional Review Board of Third Hospital of Hebei Medical University (approval number: KE2014–015–1) and reception written consent from all the study participants.

2.4. Statistical analysis

Receiver operating characteristic (ROC) curves were performed to find the cut-off value for serum albumin. The optimal cutoff point was determined where the sum of sensitivity and specificity was maximized in the ROC curves. A univariate logistic analysis was used to assess the relationship between each categorical variable and SSI. Whitney U-test was used for non-normally distributed continuous variables and *t* test for normally distributed variables. The significance was set at $P < .05$. Multivariable logistic regression model was performed respectively to determine independent predictors of SSI. Adjusted odds ratios and their respective 95% CIs were reported in the multivariable analysis. The Hosmer–Lemeshow test was used to examine goodness-of-fit of this model, and a $P > .05$ indicated an acceptable fitness. All the tests were performed using the SPSS 19.0 software package (SPSS Inc., Chicago, IL).

3. Results

3.1. Baseline and Clinical features of study sample

During the study interval, a total of 1033 patients were admitted to our institutions based on our strict criteria. During the follow-up period (12–34 months), 47 patients lost to follow up (4.5%) due to telephone number change or patient unwilling to cooperate, therefore, 986 patients with complete data were included in the final analysis (Fig. 1 Flowchart for the selection of study participants). There were 314 male and 672 females in this study with a mean age of 64.6 years (SD 11.1, range 18–94) and male-female ratio of 1:2.14. The mean preoperative serum albumin level was 42.1 g/l (SD 4.4, range 24.8 to 53.3 g/l). Perioperative variables such as age (64.6 vs 64.4 years, $P = .942$), intraoperative body temperature (36.5 vs 36.5, $P = .925$), surgical

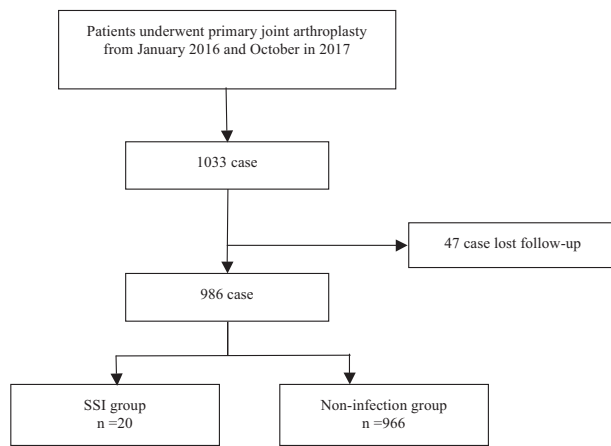


Figure 1. Flowchart for the selection of study participants.

duration (116.0 vs 122.4 minutes, $P = .551$), intraoperative blood loss (322.0 vs 436.2 ml, $P = .132$), serum albumin (40.4 vs 42.1, $P = .088$) between the patients with and without SSI are presented in Table 1. However, there were no significant differences for either variable mentioned above. Surgical wound infection prolonged a mean of 5.8 days of hospitalization in patients with SSI than that of non-SSI group (24.4 vs 18.6 days, $P = .011$).

3.2. Characteristics of SSI

Within the total of 986 patients, 20 cases (2.03%) developed SSI: 18 cases (1.83%) were superficial SSI and 2 (0.20%) cases were deep infection. Of them, 16 cases (80.0%) occurred during the hospitalization and 4 (20.0%) after hospital discharge, with SSI rate of 1.62% and 0.41% respectively. The earliest diagnosis of SSI occurred at 2 days after operation and the latest presentation was at 102 days, with a median time at 18 days. Wound secretion and swab from 14 infected patients during hospitalization were sent for microorganism examination and drug sensitivity. Nine (64.3%) cases were culture positive, 3 (33.3%) among whom were caused by multi-bacteria. *Pseudomonas aeruginosa*, the most commonly seen pathogens, were cultured in 4 (44.4%) cases. *Staphylococcus aureus* caused 22.2% (2/9) of the SSIs. All patients with positive bacterial culture were treated with antibiotics and twelve patients underwent irrigation and debridement to control the infection.

3.3. Risk factors for SSI

Receiver operating characteristic analysis identify a cut-off value of <36.7 g/l for serum albumin as optimum threshold for

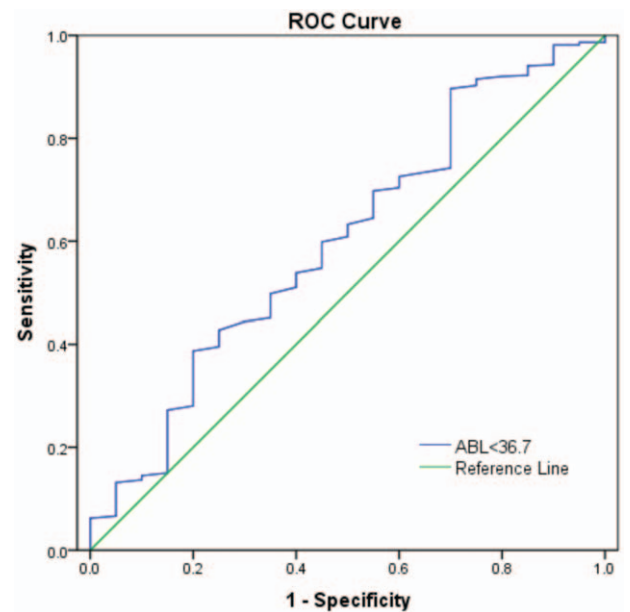


Figure 2. Optimum cut off value of the serum albumin identified by the receiver operating characteristic (ROC) curve analysis.

postoperative SSI (Fig. 2. Optimum cut off value of the serum albumin identified by the receiver operating characteristic (ROC) curve analysis). The area under a ROC curve for albumin lower than 36.7 is 0.600 (95% CI: 0.572–0.728).

In the univariate analysis, $BMI \geq 28$, $ALB < 36.7$ and $PLT < 100$ are confirmed to be the significant risk factors for SSI. Other variables of baseline information, medical comorbidities, biochemical indexes and surgical-related factors are not associated with the incidence of SSI ($P > .05$, Table 2). Factors that increased the risk of SSI are summarized in Table 2.

All variables entered into the multivariate logistic regression model to determine the independent ones. After adjustment for confounding factors, $ALB < 36.7$ ($P = .018$), $BMI \geq 28$ ($P = .008$) and $ASA \geq 3$ ($P = .019$) remain statistically significant for the occurrence of SSI, with the adjusted odds ratio being 3.42 (1.24–9.48), 5.08 (1.52–17.01) and 3.36 (1.22–9.30), respectively. However, $PLT < 100$ is eliminated from the multivariate analysis model (Table 3). Drainage usage is demonstrated as protective factor in postoperative wound healing in univariate and multivariable analysis respectively (OR: 0.37, 95%CI: 0.15–0.95; OR: 0.36, 95%CI: 0.14–0.95). The value of Hosmer-Lemeshow test

Table 1

Characteristics of patients with and without SSI.

| Variables | Patients with SSI (mean, range) (n=20) | Patients without SSI (mean, range) (n=966) | P value |
|---------------------------------|--|--|---------|
| Age (years) | 64.6 (42–82) | 64.4 (18–94) | .942 |
| Hospital stay (days) | 24.4 (14–44) | 18.6 (13–102) | .011 |
| Intraoperative body temperature | 36.5 (35.9–37.2) | 36.5 (35.0–38.0) | .925 |
| Surgical duration (minutes) | 116.0 (55–230) | 122.4 (55–280) | .551 |
| Intraoperative blood loss (ml) | 322.0 (10–1000) | 436.2 (5–3000) | .132 |
| Serum albumin (g/l) | 40.4 (31.5–48.5) | 42.1 (24.8–53.3) | .088 |

SSI=surgical site infection.

Table 2
Univariate predictors for SSI of perioperative variables.

| Variables | SSI (n=20, 2.03%) | NO SSI (n=966, 97.97%) | P value |
|--|-------------------|------------------------|---------|
| Intraoperative blood loss (ml) | | | .239 |
| 400–799 | 6 (30.0) | 382 (39.5) | |
| ≥800 | 1 (5.0) | 146 (15.1) | |
| Anesthetic time (min) | | | .355 |
| < 120 | 3 (15.0) | 64 (6.6) | |
| 120–180 | 10 (50.0) | 506 (52.4) | |
| > 180 | 7 (35.0) | 396 (41.0) | |
| Surgical season (summer) | 12 (60.0) | 518 (53.6) | .572 |
| Operative time (min) | | | .587 |
| <120 | 11 (55.0) | 452 (46.8) | |
| 120–180 | 7 (35.0) | 447 (46.3) | |
| > 180 | 2 (10.0) | 67 (6.9) | |
| Gender (male) | 7 (35.0) | 307 (31.8) | .760 |
| Living place (urban) | 3 (15.0) | 233 (24.1) | .351 |
| BMI | | | .027* |
| ≥28.0 (Obesity, morbid obesity) | 11 (55.0) | 250 (25.9) | |
| Diabetes mellitus | 5 (25.0) | 125 (12.9) | .124 |
| Hypertension | 12 (60.0) | 416 (43.1) | .138 |
| Coronary heart disease | 3 (15.0) | 141 (14.6) | .960 |
| History of anemia | 0 (0.0) | 9 (0.9) | .999 |
| Tobacco consumption | 2 (10.0) | 90 (9.3) | .904 |
| Long-term use of any medication | 4 (20.0) | 223 (23.1) | .754 |
| Cerebrovascular accident | 0 (0.0) | 25 (2.6) | .998 |
| History of surgery | 7 (35.0) | 244 (25.3) | .326 |
| ASA score | | | .702 |
| I-II | 11 (55.0) | 669 (69.3) | |
| III-IV | 9 (45.0) | 297 (30.7) | |
| Anesthetic type (general anesthesia) | 8 (40.0) | 400 (41.4) | .946 |
| Intraoperative body temperature | | | .874 |
| < 36.3 | 4 (20.0) | 149 (15.4) | |
| ≥37.3 | 0 (0.0) | 17 (1.8) | |
| Intraoperative antibiotics use | 18 (90.0) | 826 (85.5) | .574 |
| Postoperative antibiotics use | 18 (90.0) | 828 (85.7) | .582 |
| Intraoperative blood transfusion | 1 (5.0) | 336 (34.8) | .212 |
| Drain use | 13 (65.0) | 805 (83.3) | .039* |
| TP [†] (<58g/L) | 2 (10.0) | 42 (4.3) | .228 |
| ALB [†] (<36.7g/L) | 6 (30.0) | 101 (10.5) | .009* |
| GLOB [†] (<20g/L) | 1 (5.0) | 59 (6.1) | .234 |
| A/G [†] | | | .064 |
| References (1.5–2.5) | 7 (35.0) | 592 (61.3) | |
| <1.5 | 12 (60.0) | 359 (37.2) | |
| > 2.5 | 1 (5.0) | 18 (1.9) | |
| WBC [†] (10 ⁹ /L) | | | .929 |
| References (4–10) | 18 (90.0) | 865 (89.5) | |
| <4 | 1 (5.0) | 37 (3.8) | |
| > 10 | 1 (5.0) | 64 (6.6) | |
| NEUT [†] (10 ⁹ /L) | | | .223 |
| References (1.8–6.3) | 14 (70.0) | 798 (82.6) | |
| <1.8 | 1 (5.0) | 13 (1.3) | |
| >6.3 | 5 (25.0) | 158 (16.4) | |
| LYM [†] (10 ⁹ /L) | | | .664 |
| References (1.1–3.2) | 17 (85.0) | 809 (83.7) | |
| <1.1 | 2 (10.0) | 137 (14.2) | |
| >3.2 | 1 (5.0) | 23 (2.4) | |
| MON [†] (10 ⁹ /L) | | | .771 |
| References (0.1–0.6) | 15 (75.0) | 783 (81.1) | |
| <0.1 | 0 (0.0) | 5 (0.5) | |
| >0.6 | 5 (25.0) | 180 (18.6) | |
| EOS [†] (10 ⁹ /L) | | | .592 |
| References (0.02–0.52) | 19 (95.0) | 827 (85.6) | |
| <0.02 | 1 (5.0) | 125 (12.9) | |
| >0.52 | 0 (0.0) | 14 (1.4) | |
| BAS [†] (10 ⁹ /L) | | | .998 |
| References (0–0.06) | 20 (100.0) | 922 (95.4) | |
| >0.06 | 0 (0.0) | 44 (4.6) | |
| RBC [†] (10 ¹² /L) | | | .748 |
| <Lower limit | 1 (5.0) | 66 (6.8) | |
| HGB [†] (<Lower limit) | 2 (10.0) | 113 (11.7) | .815 |
| PLT [†] (10 ⁹ /L) | | | .017* |
| References (100–300) | 10 (50.0) | 808 (83.6) | |
| <100 | 4 (20.0) | 47 (4.9) | |
| >300 | 6 (30.0) | 113 (11.7) | |

* Significant variables.

[†] A/G = albumin/globulin; ALB = albumin; BAS = basophilic; EOS = eosinophils; GLOB = globulin; HGB = hemoglobin concentration; LYM = lymphocyte; MON = monocyte; NEUT = neutrophile; PLT = blood platelet count; RBC = red blood count; TP = total protein; WBC = white blood cell.

Table 3
Multivariable logistic regression analysis of factors associated with SSI after operation.

| Variable | P value | Odds ratio | 95% CI |
|---------------|---------|------------|------------|
| ALB < 36.7 | .018* | 3.42 | 1.24–9.48 |
| ASA ≥ 3 | .019* | 3.36 | 1.22–9.30 |
| BMI (≥28) | .008* | 5.08 | 1.52–17.01 |
| Drainage use† | .040* | 0.36 | 0.14–0.95 |

CI = confidential interval.

* Significant variables

† Protective factor.

demonstrated a preferable fitness of the analysis model ($X^2 = 5.129$, $P = .527$).

4. Discussion

In this study, the overall incidence of SSI following joint arthroplasty was 2.03%, with 0.20% for deep infection and 1.83% for superficial SSI respectively. In addition, we also identified that three risk were significantly associated with occurrence of wound infection, namely ASA ≥ III, BMI ≥ 28 and ALB < 36.7 g/L, and drainage usage could reduce the incidence of postoperative SSI.

Nutritional deficiency has been shown to be an independent predictor of postoperative morbidities, including infection, prolonged length of stay, hematoma, complications of the renal, neurovascular, and cardiovascular system.^[7,9,13–15] Serum albumin (ALB), total lymphocyte count and transferrin are commonly used to define nutritional status. The half-life is 20 days for ALB, and the relative long half-life of albumin makes it an important indicator of chronic malnutrition. The definition of malnutrition and the significance of using these markers in joint arthroplasty surgeries have been reported.^[16–18] Preoperative malnutrition rate was variously in different studies, and overall incidence of malnutrition in our study was 5.68% (56 of 986). Pimlott et al evaluated 583 patients with hip fractures and found levels of albumin were abnormal in 55%.^[15] 4.6% patients were malnourished on hospital admission in Walls's study^[16] and 8.5% in Huang's prospective study.^[17] The SSI rate in malnourished patients was 5.2%, which was almost 3-fold higher than that in patients with normal nutrition and mean preoperative level of serum albumin were 40.4 for the SSI group. A malnourished state in an orthopedic patient is likely to be exacerbated because fractures are associated with increased rates of catabolism.

Some literatures have demonstrated that malnutrition (ALB < 35 g/l) was risk factor of wound infection after joint arthroplasty.^[16,17] Malnutrition may predispose patients to SSI through several mechanisms. The first mechanism involves impairment in wound healing via diminished fibroblast proliferation and collagen synthesis. The second mechanism involves impairment in the ability of the immune system to fight infection, at least in part through lymphocytopenia.^[14,19] However, clear threshold of albumin that associated with postoperative SSI in arthroplasty surgeries has rarely been reported. Inconsistent with previous founding, we identified that ALB lower than 36.7 g/L was associated with postoperative SSI in present study. Incidence of SSI increased by 3.42 times (95% CI: 1.24–9.48) in patients with ALB < 36.7 g/L when compared to patients with a normal level of ALB. The mean albumin is 42.1 g/l among the 986 arthroplasty

patients, and this value is significantly lower compared to other orthopedic patients. Taking all the baseline information and surgical procedure factors into consideration, these patients are sensitive to the preoperative nutrition status compared to other surgeries. Based on our accurate standard of ALB level, more high-risk patients could be distinguished from suffering from wound infection. This finding highlighted the fact that low serum albumin has prognostic value for postoperative wound infection in joint arthroplasty and perioperative supplementary nutrition support is essential for this at-risk population.

Obesity is a pandemic phenomenon that is drawing increasing attention throughout medicine. Similar to previous studies, this study demonstrated that BMI (≥28) was associated with postoperative SSI. It is reported that higher BMI or obesity was a significant risk factor for prolonged operating time, postoperative adverse events in orthopedic surgery. The overall incidence of infection was 4.21% in obesity and morbid obesity patients. Currently, 24% to 36% of patients presenting for THA are classified as obese.^[20] One large study evaluated 40,919 medicare patients and confirmed that obesity was associated with increased risk of periprosthetic joint infection after THA.^[21] In addition, there appears to be an association between morbid obesity and malnutrition.^[17] Two hundred and sixty-one enrolled patients in this study were obese and obese patients represented nearly a quarter of the malnourished cohort.

Consistent with previous articles,^[22,23] this present study also identified ASA ≥ 3 as an independent risk factors for the development of SSI. The adjusted ORs for ASA score were 1.77 and 3.36 in univariate and multivariate analysis respectively, demonstrating their great clinical importance. Moreover, previous study demonstrated that malnutrition was positively correlated with high ASA scores.^[24] American Society of Anaesthesiologists score was an important and useful assessment tools to evaluate the surgical patients' physical status. As a comprehensive index, ASA graded III-IV was more likely an approximate marker of the seriousness of the underlying illness or comorbidities, especially in elderly patients. Given these situations into consideration, SSI incidence rate may increase accordingly in patients with a higher ASA score.

Blood platelet count (PLT) is an important biochemical index for surgical patients, this variable plays a crucial role in hemostasis. In the present study, PLT < 100 × 10⁹/L was associated with an increased risk of SSI in patients who underwent primary joint arthroplasty. Patients with a low level of blood platelet were prone to forming hematoma, and the collection of fluids in surgical incision provides pabulum for bacteria growth, and impairs wound healing by increasing wound tension and reduce tissue perfusion.^[25] The application of drain system remains controversial in different studies. Some authors advocated that wound drain has no benefit in joint arthroplasty^[26–28] and some reported studies confirmed that wound drain were associated with an increased risk of periprosthetic joint infection.^[29–31] However, drain use was identified as a protective factor of postoperative wound healing in this study. Closed suction drain systems are used to prevent hematoma accumulation and decrease the possibility of prolonged wound drain or infection and similar results were also found in previous studies.^[30,32] The drain systems were used in eight hundred and seventeen patients and drain systems were removed within 48 hours after surgery in 674 (82.5%) cases. In our study, the infection rate in patients with drain use is much lower than that without drain systems (4.1% vs 1.6%).

Some particular limitations should be mentioned. Firstly, the study size was not precisely estimated pre-investigation, sample size of recruited and infected patients was small, which did not permit us to investigate the significance of some variables such as history of severe cardiac disease, renal disease, cerebrovascular disease and glucocorticoid use. Secondly, some significant variables such as surgical sterility, history of alcohol consumption, foci of infection in other parts (dental caries, urinary tract infection, ear infection, thrombophlebitis) were not analyzed in our study. In addition, during the postoperative follow-ups, 4.5% of the participants were lost and we identified the SSIs only based on the telephone review. Since there is no serological test, we may underestimate the number of SSI. Although designed as retrospective, this study possesses its strengths and our research confirmed that the risk of SSI will increase when albumin lower than 36.7 g/L instead of malnutrition (35.0 g/L).

5. Conclusion

The incidence of SSI following primary joint arthroplasty was 2.03%. ASA ≥ 3 , BMI ≥ 28 and ALB < 36.7 were identified as significant risk factors for postoperative wound infection. Drain usage was demonstrated as protective factor of postoperative wound healing. Based on the accurate standard of ALB level, more high-risk patients could be saved against wound infection.

Author contributions

Data curation: Guang Yang, Yanbin Zhu.

Formal analysis: Guang Yang, Yanbin Zhu.

Methodology: Yanbin Zhu.

Project administration: Yingze Zhang.

Software: Guang Yang, Yanbin Zhu.

Supervision: Guang Yang, Yingze Zhang.

Writing – original draft: Guang Yang.

Writing – review & editing: Yingze Zhang.

References

- [1] Ibrahim MS, Twajj H, Giebaly DE, et al. Enhanced recovery in total hip replacement: a clinical review. *Bone Joint J* 2013;95-B:1587–94.
- [2] Garrett WE Jr, Swiontkowski MF, Weinstein JN, et al. American Board of Orthopaedic Surgery Practice of the Orthopaedic Surgeon: Part-II, certification examination case mix. *J Bone Joint Surg Am* 2006;88:660–7.
- [3] Kane RL, Saleh KJ, Wilt TJ, et al. The functional outcomes of total knee arthroplasty. *J Bone Joint Surg Am* 2005;87:1719–24.
- [4] Kurtz S, Ong K, Lau E, et al. Projections of primary and revision hip and knee arthroplasty in the United States from 2005 to 2030. *J Bone Joint Surg Am* 2007;89:780–5.
- [5] Perencevich EN, Sands KE, Cosgrove SE, et al. Health and economic impact of surgical site infections diagnosed after hospital discharge. *Emerg Infect Dis* 2003;9:196–203.
- [6] Smith TK. Prevention of complications in orthopedic surgery secondary to nutritional depletion. *Clin Orthop Relat Res* 1987;91–7.
- [7] Gu A, Malahias MA, Strigelli V, et al. Preoperative malnutrition negatively correlates with postoperative wound complications and infection after total joint arthroplasty: a systematic review and meta-analysis. *J Arthroplasty* 2019;34:1013–24.
- [8] Feinberg J, Nielsen EE, Korang SK, et al. Nutrition support in hospitalised adults at nutritional risk. *Cochrane Database Syst Rev* 2017;19:CD011598.
- [9] Jaber FM, Parvizi J, Haytmanek CT, et al. Procrastination of wound drainage and malnutrition affect the outcome of joint arthroplasty. *Clin Orthop Relat Res* 2008;466:1368–71.
- [10] Ries MD. Skin necrosis after total knee, arthroplasty. *J Arthroplasty* 2002;17:74–7.
- [11] Garcia Duque S, Pérez Segura G, Sanavia Morán E, et al. Nutritional control in orthopedic surgery patients. *Nutr Hosp* 2008;23:493–9.
- [12] Horan TC, Gaynes RP, Martone WJ, et al. CDC definitions of nosocomial surgical site infections, 1992: a modification of CDC definitions of surgical wound infections. *Am J Infect Control* 1992;20:271–4.
- [13] Steinberg EL, Amar E, Sagy Y, et al. The impact of serum albumin and serum protein levels on POSSUM score of patients with proximal femur fractures. *Injury* 2014;45:1928–31.
- [14] Cross MB, Yi PH, Thomas CF, et al. Evaluation of malnutrition in orthopaedic surgery. *J Am Acad Orthop Surg* 2014;22:193–9.
- [15] Pimlott BJ, Jones CA, Beaupre LA, et al. Prognostic impact of pre-operative albumin on short-term mortality and complications in patients with hip fracture. *Arch Gerontol Geriatr* 2011;53:90–4.
- [16] Walls JD, Abraham D, Nelson CL, et al. Hypoalbuminemia more than morbid obesity is an independent predictor of complications after total hip arthroplasty. *J Arthroplasty* 2015;30:2290–5.
- [17] Huang R, Greenky M, Kerr GJ, et al. The effect of malnutrition on patients undergoing elective joint arthroplasty. *J Arthroplasty* 2013;28:21–4.
- [18] Nelson CL, Elkassabany NM, Kamath AF, et al. Low albumin levels, more than morbid obesity, are associated with complications after TKA. *Clin Orthop Relat Res* 2015;473:3163–72.
- [19] Walls RJ, Roche SJ, O'Rourke A, et al. Surgical site infection with methicillin-resistant *Staphylococcus aureus* after primary total hip replacement. *J Bone Joint Surg Br* 2008;90:292–8.
- [20] Jibodh SR, Gurkan I, Wenz JF. In-hospital outcome and resource use in hip arthroplasty: influence of body mass. *Orthopedics* 2004;27:594–601.
- [21] Bozic KJ, Lau E, Kurtz S, et al. Patient-related risk factors for periprosthetic joint infection and postoperative mortality following total hip arthroplasty in Medicare patients. *J Bone Joint Surg Am* 2012;94:794–800.
- [22] Urquhart DM, Hanna FS, Brennan SL, et al. Incidence and risk factors for deep surgical site infection after primary total hip arthroplasty: a systematic review. *J Arthroplasty* 2010;25:1216–22.
- [23] Paryavi E, Stall A, Gupta R, et al. Predictive model for surgical site infection risk after surgery for high-energy lower-extremity fractures: development of the risk of infection in orthopedic trauma surgery score. *J Trauma Acute Care Surg* 2013;74:1521–7.
- [24] Ozkalkanli MY, Ozkalkanli DT, Katircioglu K, et al. Comparison of tools for nutrition assessment and screening for predicting the development of complications in orthopedic surgery. *Nutr Clin Pract* 2009;24:274–80.
- [25] Alexander JW, Korelitz J, Alexander NS. Prevention of wound infections. A case for closed suction drainage to remove wound fluids deficient in opsonic proteins. *Am J Surg* 1976;132:59–63.
- [26] Walmsley PJ, Kelly MB, Hill RM, et al. A prospective, randomised, controlled trial of the use of drains in total hip arthroplasty. *J Bone Joint Surg Br* 2005;87:1397–401.
- [27] Cheung G, Carmont MR, Bing AJ, et al. No drain, autologous transfusion drain or suction drain? A randomised prospective study in total hip replacement surgery of 168 patients. *Acta Orthop Belg* 2010;76:619–27.
- [28] Dora C, von Campe A, Mengiardi B, et al. Simplified wound care and earlier wound recovery without closed suction drainage in elective total hip arthroplasty. A prospective randomized trial in 100 operations. *Arch Orthop Trauma Surg* 2007;127:919–23.
- [29] Patel VP, Walsh M, Sehgal B, et al. Factors associated with prolonged wound drainage after primary total hip and knee arthroplasty. *J Bone Joint Surg Am* 2007;89:33–8.
- [30] Vince KG, Abdeen A. Wound problems in total knee arthroplasty. *Clin Orthop Relat Res* 2006;452:88–90.
- [31] Wilson MG, Kelley K, Thornhill TS. Infection as a complication of total knee-replacement arthroplasty. Risk factors and treatment in sixty-seven cases. *J Bone Joint Surg Am* 1990;72:878–83.
- [32] Vince K, Chivas D, Droll KP. Wound complications after total knee arthroplasty. *J Arthroplasty* 2007;22:39–44.