Incidence and risk factors for blood transfusion in simultaneous bilateral total hip arthroplasty

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A large proportion of hip joint diseases develop bilaterally, and studies have shown that about 15 to 17% of patients undergoing one total hip arthroplasty (THA) require a second arthroplasty in the contralateral side. Bilateral THA can be usually performed simultaneous bilateral hip arthroplasty (SimBTHA) or staged bilateral total hip arthroplasties (StBTHA).

Previous studies have demonstrated that SimBTHA has the advantages of shorter anesthesia and operation time, lower cost, and shorter recovery time. Although it has become increasingly preferred by physicians and patients recently, it often has more blood loss than StBTHA, with a higher incidence of blood transfusion. Therefore, due to the need for large amounts of blood transfusions, this may increase the risk of complications such as surgical site infection, venous thromboembolism, prolonged hospital stay, and mortality. Surgeons and patients are often hesitant to perform bilateral SimBTHA surgery simultaneously. How to minimize the transfusion rate after SimBTHA is an important concern for surgeons. In the present study, we aimed to evaluate the incidence and risk factors for blood transfusion in patients undergoing SimBTHA.

PATIENTS AND METHODS

This single-center, retrospective study was conducted at West China Hospital, Department of Orthopaedic Surgery simultaneously. How to minimize the transfusion rate after SimBTHA is an important concern for surgeons. In the present study, we aimed to evaluate the incidence and risk factors for blood transfusion in patients undergoing SimBTHA.
Surgery between January 1st, 2011 and June 31st, 2021. A total of 341 patients (289 males, 52 females; median age: 53 years; range, 43 to 66 years) who underwent SimBTHA were included in the study. A patient was considered eligible for SimBTHA, if both hips showed lesions and symptoms. In our routine practice, we discouraged simultaneous bilateral surgery, if any of the following criteria are met: age >80 years, American Society of Anesthesiologists (ASA) Class II-IV with medical comorbidities including active ischemic heart disease or decreased left ventricular function <45%, moderate-to-severe pulmonary disease, renal insufficiency with glomerular filtration rate (GFR) <60 mL/min/1.73 m², chronic liver disease, poorly controlled diabetes mellitus with hemoglobin A1c (HbA1c) >7%, cerebrovascular disease with history of cerebrovascular accident, and peripheral vascular disease with history of stents or bypass. In our clinic, all patients undergo optimization by an internist and anesthesiologist, who must agree on the patient’s eligibility for SimBTHA. All patients also undergo a preoperative echocardiogram and consultation with a cardiologist, if they are in ASA Class II or greater or have any concerning symptoms preoperatively.

Medical data of all patients were retrieved from the hospital database, and only patients whose surgical name included “bilateral THA” were included. We excluded those with incomplete information, coagulation disorders, and undergoing autologous blood predonation before surgery. The study protocol was approved by the West China Hospital Ethics Committee (Date/No: 2021/268, Date: 07/01/2021). The study was conducted in accordance with the principles of the Declaration of Helsinki.

All surgeries were performed by a single surgical team following standard procedures through a posterolateral approach. No patient received preoperative erythropoietin, and preoperative autologous donation did not occur. In practice, as the concept of the surgical team evolved, there was a gradual shift over the decade from the routine use of drainage tubes and no tranexamic acid (TXA) to the routine use of TXA and no drainage tubes. After 2016, the TXA administration for SimBTHA became a uniformly adopted practice, while drainage tubes were no longer routinely used. The TXA (20 mg/kg) was intravenously injected ~5 to 10 min before skin incision, and 1 g of TXA was added at 3 and 6 h, respectively after surgery. The use of intraoperative autologous blood transfusion from a closed suction drainage system was determined by the operating surgeon based on the expected intraoperative blood loss of the patient. The recommended postoperative thromboprophylaxis included chemical (starting 6 h after surgery, patients without contraindications were given 2000 AxaIU (0.2 mL) low-molecular-weight heparin of subcutaneously once a day). After discharge, patients were given oral rivaroxaban 5 mg once a day for two weeks) and mechanical methods (upon returning to the ward from surgery, patients were treated with intermittent pneumatic compression device for 12 h). All patients received unified rehabilitation after surgery.

Transfusion was defined as any allogeneic red blood cell or plasma given within 72 h after the commencement of surgery. Blood transfusion was performed, if the hemoglobin level was <70 g/L or 70 to 100 g/L with symptoms of anemia (including altered mental status, palpitations or shortness of breath not attributable to other causes). All intra- and postoperative blood transfusion events were recorded. We collected patient demographic characteristics from medical records, including sex, age, body mass index, smoking history, alcohol consumption history, and major diagnoses. Comorbidities included hypertension and diabetes mellitus. Preoperative laboratory values included hemoglobin, hematocrit, platelets, activated partial thromboplastin time (APTT), prothrombin time (PT), albumin, interleukin-6 (IL-6), C-reactive protein (CRP), and erythrocyte sedimentation rate (ESR). Surgical variables included ASA Class, operation time, intraoperative bleeding (intraoperative blood loss was calculated using the difference between the weights of used gauze and the original unused gauze, in addition to the blood volume accumulated in suction bottles), use of TXA, use of drainage tube, and use of autologous blood transfusion from a closed suction drainage system.

Statistical analysis

Statistical analysis was performed using the R version 3.6 software (America, Lucent Technologies Inc., NJ, USA). Continuous variables were presented in mean ± standard deviation (SD) or median (min-max), while categorical variables were presented in number and frequency. Descriptive and univariate logistic analyses were initially conducted to compare the demographic characteristics, comorbidities, preoperative laboratory values, and operative variables between the transfusion group and non-transfusion group. A multivariable logistic regression model was used to examine independent risk factors for blood transfusion. A \( p \) value of <0.05 was considered statistically significant.
TABLE I
Demographic, clinical, and surgical characteristics of patients

| Characteristics                        | Total (n=341) | Transfusion (n=44) | No transfusion (n=297) |
|----------------------------------------|---------------|--------------------|------------------------|
|                                       | n  | %   | Mean±SD | Median | 25th-75th percentiles | n  | %   | Mean±SD | Median | 25th-75th percentiles | n  | %   | Mean±SD | Median | 25th-75th percentiles |
| Demographic characteristics            | n  | %   | Mean±SD | Median | 25th-75th percentiles | n  | %   | Mean±SD | Median | 25th-75th percentiles | n  | %   | Mean±SD | Median | 25th-75th percentiles |
| Sex                                    |     |     |         |        |                       |     |     |         |        |                       |     |     |         |        |                       |
| Male                                   | 289 | 85  |         | 62     | 44-69                 | 255 | 86  |         |        |                       |     |     |         |        |                       |
| Age (year)                             | 53  | 43-66 |        | 77     |                       | 52  | 43-66 |        |        |                       |     |     |         |        |                       |
| BMI (kg/m²)                            | 25.1±3.8 | 24.5±4.5 |        | 25.2±3.7 |                       |     |     |         |        |                       |     |     |         |        |                       |
| Smoking                                | 221 | 65  | 24.5±4.5 | 11.2 | 26.9-30.5             | 194 | 65  | 27     | 61     |                       | 142 | 42  | 26.9-30.5 | 11.3 | 10.7-11.9 |
| Alcohol use                            | 232 | 68  | 23.2±4.8 | 9.1   | 1.4-4.3               | 202 | 68  | 30     | 68     |                       | 202 | 68  | 1.9-4.6 | 3.5   | 2.6-5.8  |
| Diagnosis                              | n  | %   | Mean±SD | Median | 25th-75th percentiles | n  | %   | Mean±SD | Median | 25th-75th percentiles | n  | %   | Mean±SD | Median | 25th-75th percentiles |
| ONFH                                    | 275 | 81  | 24.5±4.5 | 11.2 | 26.9-30.5             | 243 | 82  | 23     | 73     |                       | 123 | 37  | 26.9-30.5 | 11.3 | 10.7-11.9 |
| OA                                      | 33  | 10  | 23.2±4.8 | 9.1   | 1.4-4.3               | 26  | 9   | 7      | 16     |                       | 26  | 9   | 10.4-11.8 | 11.1 | 10.4-11.8 |
| AS                                      | 21  | 6   | 23.2±4.8 | 9.1   | 1.4-4.3               | 18  | 6   | 3      | 7      |                       | 18  | 6   | 10.4-11.8 | 11.1 | 10.4-11.8 |
| RA                                      | 12  | 4   | 23.2±4.8 | 9.1   | 1.4-4.3               | 10  | 3   | 2      | 5      |                       | 10  | 3   | 10.4-11.8 | 11.1 | 10.4-11.8 |
| Comorbidities                          | n  | %   | Mean±SD | Median | 25th-75th percentiles | n  | %   | Mean±SD | Median | 25th-75th percentiles | n  | %   | Mean±SD | Median | 25th-75th percentiles |
| Diabetes                                | 29  | 9   | 23.2±4.8 | 9.1   | 1.4-4.3               | 25  | 8   | 3      | 7      |                       | 25  | 8   | 1.9-4.6 | 3.5   | 2.6-5.8  |
| Hypertension                            | 42  | 12  | 23.2±4.8 | 9.1   | 1.4-4.3               | 36  | 12  | 2      | 5      |                       | 36  | 12  | 1.9-4.6 | 3.5   | 2.6-5.8  |
| Preoperative laboratories               | n  | %   | Mean±SD | Median | 25th-75th percentiles | n  | %   | Mean±SD | Median | 25th-75th percentiles | n  | %   | Mean±SD | Median | 25th-75th percentiles |
| Hb level (g/L)                          | 139 | 130-151 |        | 127     | 123-134               | 141 | 132-152 |        |        |                       |     |     |         |        |                       |
| Hct                                     | 0.42 | 0.40-0.45 |        | 0.40    | 0.38-0.43             | 0.43 | 0.40-0.46 |        |        |                       |     |     |         |        |                       |
| PLT (10^9/L)                            | 198 | 141-240 |        | 190     | 140-242               | 198 | 142-240 |        |        |                       |     |     |         |        |                       |
| PT (s)                                  | 11.2 | 10.5-11.9 |        | 11.3    | 10.7-11.9             | 11.1 | 10.4-11.8 |        |        |                       |     |     |         |        |                       |
| APTT (s)                                | 28.5 | 26.9-30.5 |        | 27.7    | 26.1-31.1             | 28.6 | 26.9-30.5 |        |        |                       |     |     |         |        |                       |
| ALB (g/L)                               | 45.6 | 43.0-48.0 |        | 45.4    | 41.9-47.2             | 45.6 | 43.3-48.0 |        |        |                       |     |     |         |        |                       |
| CRP (mg/L)                              | 3.5  | 2.4-6.2 |        | 3.7     | 2.6-5.8               | 3.5  | 2.4-6.3 |        |        |                       |     |     |         |        |                       |
| IL-6 (pg/mL)                            | 3.0  | 1.9-4.7 |        | 3.4     | 2.0-4.8               | 3.0  | 1.9-4.6 |        |        |                       |     |     |         |        |                       |
| ESR (mm/h)                              | 25   | 13-37 |        | 22     | 12-37                 | 25   | 14-37 |        |        |                       |     |     |         |        |                       |
| Operative variables                     | n  | %   | Mean±SD | Median | 25th-75th percentiles | n  | %   | Mean±SD | Median | 25th-75th percentiles | n  | %   | Mean±SD | Median | 25th-75th percentiles |
| ASA class ≥3                            | 37  | 11  | 132±39 |        | 147±45               | 11  | 25  |        |        |                       |     |     |         |        |                       |
| Operation time (min)                    | 147±45 |        |        |        |                       |     |     |         |        |                       |     |     |         |        |                       |
| Intraoperative blood loss (mL)          | 674 | 451-875 |        | 755     | 549-1090              | 800 | 700-1100 |        |        |                       |     |     |         |        |                       |
| Intraoperative fluid infusion (mL)      | 800 | 700-1100 |        | 800     | 600-1000              | 800 | 700-1100 |        |        |                       |     |     |         |        |                       |
| TXA use                                 | 143 | 42  | 10      | 23     |                       |     |     |         |        |                       |     |     |         |        |                       |
| Drainage use                            | 69  | 20  | 19      | 43     |                       |     |     |         |        |                       |     |     |         |        |                       |
| Intraoperative autologous blood transfusion | 101 | 30  | 6       | 14     |                       |     |     |         |        |                       |     |     |         |        |                       |

SD: Standard deviation; BMI: Body mass index; ONFH: Osteonecrosis of the femoral head; OA: Osteoarthritis; AS: Ankylosing spondylitis; RA: Rheumatoid arthritis; Hb: Hemoglobin; Hct: Hematocrit; PLT: Platelet; PT: Prothrombin time; APTT: Activated partial thromboplastin time; ALB: Albumin; CRP: C-reactive protein; IL-6: Interleukin-6; ESR: Erythrocyte sedimentation rate; ASA: American Society of Anesthesiologists; TXA: Tranexamic acid.
RESULTS
Of a total of 341 patients, 44 were in the transfusion group, while 297 were in the non-transfusion group with a median age of 62 (range, 44 to 69) years and 73 (range, 64 to 86) years, respectively. The incidence of transfusion in SimBTHA was 12.9%. Table I shows the demographic, clinical, and surgical characteristics of the patients.

According to the univariate logistic regression analysis, preoperative hemoglobin (p<0.001), hematocrit (p<0.001), albumin (p=0.031), ASA Class ≥3 (p=0.002), operation time (p=0.009), intraoperative blood loss (p<0.001), TXA use (p=0.007), drainage use (p<0.001), and intraoperative autologous blood transfusion (p=0.017) were associated with blood transfusion (Table II).

| TABLE II  |
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| Variables                                                                 | OR  | 95% CI     | p    |
|-----------------------------|-----|------------|------|
| Age                         | 1.02| 1.00-1.04  | 0.089|
| Sex                         |     |            |      |
| Male                        | 0.56| 0.26-1.22  | 0.144|
| Body mass index             | 0.95| 0.88-1.04  | 0.260|
| Smoking                     | 0.84| 0.44-1.62  | 0.608|
| Alcohol use                 | 1.01| 0.51-1.99  | 0.982|
| Diagnosis                   |     |            |      |
| ONFH                        | 1.00| (reference)| -    |
| Osteoarthritis              | 2.04| 0.77-4.88  | 0.124|
| Ankylosing spondylitis      | 1.27| 0.29-4.01  | 0.718|
| Rheumatoid arthritis        | 1.52| 0.23-6.09  | 0.600|
| Diabetes                    | 1.09| 0.36-3.29  | 0.881|
| Hypertension                | 1.14| 0.45-2.90  | 0.775|
| Preoperative level of Hb    | 0.92| 0.89-0.95  | <0.001*|
| Preoperative level of Hct   | 0.13| 0.05-0.32  | <0.001*|
| Preoperative level of PLT   | 1.00| 1.00-1.01  | 0.855|
| Preoperative level of PT    | 0.93| 0.78-1.12  | 0.470|
| Preoperative level of APTT  | 0.95| 0.87-1.05  | 0.340|
| Preoperative level of albumin| 0.92| 0.85-0.99  | 0.031*|
| Preoperative level of CRP   | 1.03| 0.99-1.07  | 0.189|
| Preoperative level of IL-6  | 1.00| 0.96-1.04  | 0.972|
| Preoperative level of ESR   | 1.00| 0.99-1.02  | 0.807|
| ASA Class ≥3                | 3.47| 1.57-7.67  | 0.002*|
| Operation time, min         | 1.01| 1.00-1.02  | 0.009*|
| Intraoperative blood loss   | 1.20| 1.08-1.32  | <0.001*|
| Intraoperative fluid infusion| 1.00| 1.00-1.00  | 0.687|
| TXA use                     | 0.36| 0.17-0.76  | 0.007*|
| Drainage use                | 3.75| 1.92-7.33  | <0.001*|
| Intraoperative autologous blood transfusion | 0.34| 0.14-0.82 | 0.017|

SimBTHA: Simultaneous bilateral total hip arthroplasty; OR: Odds ratio; CI: Confidence interval; ONFH: Osteonecrosis of the Femoral Head; Hb: Hemoglobin; Hct: Hematocrit; PLT: Platelet; PT: Prothrombin time; APTT: Activated partial thromboplastin time; CRP: C-reactive protein; IL-6: Interleukin-6; ESR: Erythrocyte sedimentation rate; ASA: American Society of Anesthesiologists; TXA: Tranexamic acid; P value calculated using univariate logistic regression; * Significant difference.
system (OR: 0.30, 95% CI: 0.09-0.80, p=0.024) were independent protective factors affecting transfusion in patients after SimBTHA. In addition, drainage use (OR: 3.52, 95% CI: 1.49-8.32, p=0.004) and intraoperative blood loss (OR: 1.17, 95% CI: 1.04-1.33, p=0.009) were the independent risk factors for blood transfusion (Table III). The Forest plot is shown in Figure 1.

**DISCUSSION**

Blood transfusion after THA is dose-dependent on surgical site infection.[13-15] Transfusion also increases the risk of postoperative venous thromboembolism, transfusions-related acute lung injury, arrhythmias, psychosis, and catheterization.[16-18] Moreover, transfusion appears to increase the rates of in-hospital and one-year postoperative mortality.[11,12,17] Compared to THA, blood transfusion risk of SimBTHA is significantly higher.[19] Only by clarifying the factors of transfusion, we can further optimize and prevent these factors preoperatively and reduce the transfusion rate in SimBTHA. Therefore, it is of utmost importance to elucidate the factors of transfusion in SimBTHA.

In the current study, we included a total of 341 patients who underwent SimBTHA. Univariate and multivariate logistic regression analysis were performed to identify the indicators of both the transfusion group and the non-transfusion group, and

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**TABLE III**

Multivariate logistic regression analysis to identify independent risk factors for transfusion in SimBTHA

| Parameter                                      | OR   | 95% CI          | p    |
|------------------------------------------------|------|-----------------|------|
| Preoperative Hb level                         | 0.91 | 0.86-0.96       | 0.001*|
| Preoperative Hct                              | 1.06 | 0.18-5.69       | 0.948 |
| Albumin                                       | 0.96 | 0.89-1.06       | 0.401 |
| ASA Class                                     | 1.53 | 0.51-4.30       | 0.432 |
| Operation time                                | 1.01 | 1.00-1.02       | 0.063 |
| Intraoperative blood loss                     | 1.17 | 1.04-1.33       | 0.009*|
| TXA use                                       | 0.25 | 0.09-0.58       | 0.002*|
| Drainage use                                  | 3.52 | 1.49-8.32       | 0.004*|
| Intraoperative autologous blood transfusion   | 0.30 | 0.09-0.80       | 0.024*|

SimBTHA: Simultaneous bilateral total hip arthroplasty; OR: Odds ratio; CI: Confidence interval; Hb: Hemoglobin; Hct: Hematocrit; ASA: American Society of Anesthesiologists; TXA: Tranexamic acid; P value calculated using multivariate logistic regression; * Significant difference.

**FIGURE 1.** The results of multivariate logistic regression analysis.

OR: Odds ratio; CI: Confidence interval; Hb: Hemoglobin; Hct: Hematocrit; ASA: American Society of Anesthesiologists; TXA: Tranexamic acid.
we concluded that higher preoperative hemoglobin level, TXA use, and intraoperative autologous blood transfusion had protective effects on allogeneic blood transfusion in SimBTHA. In addition, drainage use and intraoperative blood loss were independent risk factors for transfusion.

Higher preoperative hemoglobin level is protective against the need for transfusion in patients after SBTHA, which is consistent with previous studies. Salido et al. reported that patients with a preoperative hemoglobin level less than 13 g/dL were at a four-fold higher risk of having transfusion compared to those with a hemoglobin level of >13 g/dL. Therefore, to reduce the rate and associated risks of blood transfusion, patients with higher hemoglobin can be selected for SimBTHA. For patients with lower preoperative hemoglobin, surgery can be appropriately postponed and treatment to enhance hemoglobin can be performed, until the hemoglobin level is improved.

Furthermore, our study showed that TXA use had protective effects on postoperative blood transfusion in SimBTHA. This is consistent with findings reported in previous studies. Bemelmans et al. reported that low blood transfusion rate was found after implementation of a standardized perioperative TXA protocol for primary hip and knee arthroplasty. In addition, previous studies found that TXA was an effective tool in reducing blood loss and transfusion in simultaneous bilateral total joint arthroplasty. However, Partridge et al. reported that, compared to StBTHA, patients undergoing SimBTHA had a greater risk of pulmonary embolism, myocardial infarction, and in-hospital mortality. Therefore, TXA should be used with caution in SimBTHA. The safety of TXA application in SimBTHA needs to be further explored in well-designed studies.

In the present study, autologous blood transfusion from a closed suction drainage system was a protective factor for allogeneic transfusion in SimBTHA. Previous studies have reported varying recommendations in terms of autologous blood transfusion. Palmer et al. suggested that autologous blood transfusion was effective in cases where the indication was infection or fracture and where both femoral and acetabular components were to be revised should be prioritized. A study by Mayer-Rollnik et al. examined the effectiveness of intraoperative autotransfusion as part of a patient blood management program in elective total hip and knee arthroplasty. Recent Association of Anaesthetists guidelines on cell salvage for perioperative blood conservation recommend employing autologous blood transfusion, whenever anticipated blood loss exceeds 500 mL. We believe that the most important determinants of whether sufficient blood is salvaged for re-infusion is the procedure performed and the indication for surgery. Blood loss is greater in SimBTHA, compared to unilateral THA and, therefore, there may be greater benefits of autologous blood transfusion in SimBTHA. For SimBTHA, blood loss is not the same due to different hospital settings, techniques, and patients. Thus, different centers should decide whether to use autologous blood transfusion as appropriate to maximize the benefit.

Postoperative drainage after THA has always been considered as an effective measure to prevent local hematoma infection, but in recent years, some studies have shown that no drainage tube placement is more beneficial to postoperative recovery of THA. Over blood loss occurs, as the closed negative pressure drainage eliminates the tamponade effect. We found that drainage use was independent risk factors for transfusion, which is consistent with previous studies. Therefore, we do not recommend routine use of drainage tubes in SimBTHA. In addition, the amount of intraoperative blood loss was an independent risk factor for transfusion in our study. As intraoperative bleeding is an important component of perioperative blood loss, it may result in receiving a blood transfusion. Thus, reducing the amount of intraoperative blood loss is of utmost importance to reduce the transfusion rate in SimBTHA. Various methods to decrease perioperative blood loss associated with THA have been described in the literature.

Nevertheless, it is worth mentioning that, as this study consists of young and mostly male patients, findings should be cautiously interpreted and cannot be generalized to the main population of THA. In addition, this study has all limitations inherent to the retrospective design. Also, we only recorded the events of transfusion during hospitalization. Some patients may have received transfusion after discharge to another hospital for short-term inpatient care. Postoperative parameters (e.g., drainage volume, anticoagulants use) may have also affected the transfusion rates; however, these parameters were not considered in our study. Finally, this study is a single-center study with a relatively small sample size, which has a certain impact on the overall representativeness of the statistical results of this study. Further well-designed, multi-center studies are needed to draw more reliable conclusions on this subject.
In conclusion, the risk factors for transfusion after SimBTHA should be evaluated to establish specific, personalized transfusion risk assessments for each individual patient. For SimBTHA, the main risk factors include intraoperative bleeding and the use of drainage tube, while higher preoperative hemoglobin level, TXA use, and autologous blood transfusion from a closed suction drainage system may reduce the transfusion risk.

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