The effect of body mass index on blood loss and complications in simultaneous bilateral total hip arthroplasty: A multicenter retrospective study

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Abstract

**Background:** The effect of body mass index (BMI) on blood loss in simultaneous bilateral total hip arthroplasty (SBTHA) was still undetermined. The purpose of the study was to evaluate the blood loss, transfusion and incidence of complications in normal, overweight, and obese patients undergoing SBTHA.

**Methods:** A total of 344 patients following SBTHA were enrolled into this study. The patients were assigned into three groups on the basis of their BMI, including normal (BMI 18.0–24.9 kg/m²), overweight (BMI 25.0–29.9 kg/m²), or obese group (BMI ≥ 30.0 kg/m²). The primary outcome was total blood loss (TBL), and secondary outcomes were intraoperative blood loss, drain volume, ratio of TBL and patient’s blood volume (PBV), transfusion rate and volume, hemoglobin and hematocrit drop, length of stay, expenses, and complications.

**Results:** The PBV and TBL increased significantly along with the elevated BMI (p < 0.001; p = 0.019, respectively). There was no significant difference in intraoperative blood loss, drain volume, transfusion volume, length of stay, expenses, or incidence of complications among the three groups. In addition, the transfusion rate in normal group was higher than that in overweight (58.3% vs 39.6%, p = 0.001) and obese group (58.3% vs 31.9%, p = 0.001). The maximum hemoglobin drop in obese group was the highest (p = 0.001).

**Conclusion:** Obesity could increase perioperative blood loss but not increase transfusion risk in the setting of SBTHA. Conversely, obese and overweight patients maybe have lower transfusion need compared with normal patients because of more blood volume. In addition, obesity did not affect the incidence of complications.

Keywords

simultaneous bilateral total hip arthroplasty, body mass index, blood loss, transfusion, complications

Introduction

Total hip arthroplasty (THA) could alleviate pain, correct deformity, and improve function for advanced diseases of hip.¹,² In recent decades, the prevalence of obesity is growing rapidly.³ Obesity has been a troublesome public health problem, which could substantially increase the risk of diabetes, cardiovascular disease, and hip disease.⁴ Some studies have shown that

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obese patients took higher risk of suffering from hip disease and undergoing THA.\textsuperscript{5,6}

Hip disease often progresses bilaterally, so it is necessary to conduct simultaneous bilateral total hip arthroplasty (SBTHA).\textsuperscript{7} Compared with patients in unilateral THA, patients undergoing SBTHA enjoyed lower costs, lower anesthesia episodes and hospitalizations.\textsuperscript{8} In addition, recent researches demonstrated that the incidence of complications, the functional and clinical outcomes were comparable between SBTHA and unilateral THA. Therefore, more and more surgeons and patients selected SBTHA as the treatment for bilateral hip diseases.\textsuperscript{9–11}

To our best knowledge, investigations into the relationship between BMI and blood loss, transfusion as well as complications in THA was limited. Frish et al. found that patients with increased BMI had lower rates of blood transfusion and lost smaller percentage of estimated blood volume following primary THA.\textsuperscript{12} Another study showed that underweight patients undergoing primary THA had a higher risk for developing postoperative anemia compared with morbidly obese patients.\textsuperscript{13} Simultaneous bilateral total hip arthroplasty was always associated with much blood loss, higher transfusions and increased incidence of complications compared with primary unilateral THA.\textsuperscript{14,15} However, there have been no study to evaluate the effect of BMI on blood loss, transfusion as well as complications following SBTKA. Moreover, our previous study showed that I–II obesity did not affect blood loss or the incidence of complications after SBTKA, and obese and overweight patients may have lower transfusion needs compared with normal patients because of their greater blood volume.\textsuperscript{16}

Thus, we performed a multicenter retrospective study to evaluate the blood loss, transfusion risk, and incidence of complications in normal, overweight, and obese patients following SBTKA.

\textbf{Materials and methods}

\textit{Study population}

This was a retrospective study and the data was from a multicenter database established to evaluate the efficacy and safety of perioperative management following THA and TKA in China. The database included related data from 26 university teaching hospitals, sponsored by the Chinese Health Ministry (201,302,007).\textsuperscript{11,17} The study was approved by our hospital’s Institutional Review Board (2012-268).

We identified the patients of SBTHA using International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM) procedure codes from January 2013 to December 2016. SBTHA was defined as procedure performed under a single episode of anesthesia. We excluded the patients with BMI < 18 kg/m\textsuperscript{2}, incomplete demographic information, primary and bilateral single-stage procedures, diagnosed as infection, metastatic, and/or bone cancer. Eventually, the total number of patients following SBTHA including in this study was 344. The patients were divided into normal group (BMI 18.0–24.9 kg/m\textsuperscript{2}, 163 patients); overweight group (BMI 25.0–29.9 kg/m\textsuperscript{2}, 134 patients); and obese group (BMI \(\geq 30.0\) kg/m\textsuperscript{2}, 47 patients) on the basis of BMI with the criterion of World Health Organization obesity classification system.\textsuperscript{18}

\textbf{Surgery procedure and perioperative management}

The surgery was performed by experienced surgeons through the posterolateral approach. All the patients received cementless prosthesis. The drain was used at the end of the operation and removed when the volume of drain was less than 30 mL/h. The physical prophylaxis and chemoprophylaxis was applied to prevent deep venous thrombosis (DVT). Physical prophylaxis included the exercises of ankle pump and knee extension, and the application of intermittent pneumatic compression device early postoperatively. Chemoprophylaxis included the application of low-molecular-weight heparin or rivaroxaban, which was used 6–8 h postoperatively and repeated at 24 h intervals, continuing 14 days at last. Patients began to receive tranexamic acid (20 mg/kg) intravenously 5–10 min before the skin incision, or the combination of intravenous and topical tranexamic acid from January 2014.\textsuperscript{19}

Transfusions were given when the hemoglobin (Hb) level was < 70 g/L or 70–100 g/L with symptoms of anemia (defined as bad mental status, palpitation or shortness of breath not due to other causes) according to the guidelines by the National Ministry of Health.\textsuperscript{20}

\textbf{Outcome measurements}

The primary outcomes were total blood loss (TBL), calculated by the Gross and Nadler formula.\textsuperscript{21,22} TBL = patient’s blood volume (PBV) \times \left( \frac{Hct_{pre} - Hct_{post}}{Hct_{ave}} \right). Hct_{pre} = the initial preoperative Hct level, Hct_{post} = the Hct on the morning of POD3. PBV = \(k_1 \times \text{height (m)}^3 + k_2 \times \text{weight (kg)} + k_3\) (\(k_1 = 0.3669, k_2 = 0.03219, k_3 = 0.6041\) for men; and \(k_1 = 0.3561, k_2 = 0.03308, k_3 = 0.1833\) for women, Hct_{ave} = the average of the Hct_{pre} and Hct_{post}). If either reinfusion or allogeneic transfusion was performed, the TBL was equal to the loss calculated from the change in Hct plus the volume transfuse.\textsuperscript{23} The secondary outcomes were intraoperative blood loss (IBL), drain volume, the ratio of TBL and patient blood volume (PBV), transfusion volume and rate, maximum Hb and hematocrit (Hct) drop, length of stay (LOS), expenses, and the incidence of complications. IBL was calculated by anesthesiologist and nurse on the basis of our pervious study.\textsuperscript{16} The ratio showed the proportion of TBL in the estimated blood volume. The maximum Hb and Hct drop were the minus of preoperative
Hb or Hct and the lowest postoperative Hb or Hct during hospitalization.

Statistical analyses

All data were analyzed by using SPSS version 22.0 (SPSS Inc. USA). We compared the continuous variables using one-way analysis of variance, Wilcoxon Mann–Whitney U test or independent t-test. The Pearson chi-square test or Fisher exact test was applied to compare categorical variables. A p value < 0.05 was considered to be statistically significant.

Results

Demographics

The PBV increased significantly along with the elevated BMI (p < 0.001). The age in normal group was younger than that in overweight group (46.7 ± 12.9 vs 50.9 ± 11.6, p = 0.004). Other demographics indicators did not differ significantly among the three groups except age, BMI, and PBV (Table 1).

Blood loss

Patients suffered much TBL with increased BMI (p = 0.019), especially for normal and obese patients (979.1 ± 846.7 mL vs 1446.6 ± 933.3 mL, p = 0.007). There was a similar trend in the ratio of PBV and TBL. However, there was no significant difference in IBL, drain volume, or transfusion volume among the three groups. In addition, the transfusion rates were 58.3%, 39.6%, and 31.9% for normal, overweight, and obese patients respectively (p < 0.001). Moreover, the maximum Hb drop in obese patients was higher than that in normal (41.4 ± 12.7 g/L vs 29.9 ± 14.6 g/L, p = 0.003) and overweight groups (41.4 ± 12.7 g/L vs 28.7 ± 9.2 g/L, p = 0.001). The LOS and expenses were similar among the three groups. The results were shown in Table 2.

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Table 1. Baseline characteristics.

| Baseline characteristic | Normal group (n = 163) | Overweight group (n = 134) | Obese group (n = 47) | p    |
|-------------------------|------------------------|----------------------------|---------------------|------|
| Demographic characteristics |                        |                            |                     |      |
| Age (y)                 | 46.7 ± 12.9            | 50.9 ± 11.6                | 50.3 ± 12.2         | 0.010* |
| Gender (M/F)            | 121/42                 | 91/43                      | 31/16               | 0.369 |
| BMI (kg/m²)             | 22.8 ± 1.6             | 26.8 ± 1.1                 | 30.8 ± 1.3          | <0.001*|
| Diagnose: DA/IA         | 30/133                 | 20/114                     | 5/42                | 0.402 |
| Comorbidity             |                        |                            |                     |      |
| Hypertension            | 10                     | 6                          | 5                   | 0.316 |
| Diabetes                | 6                      | 2                          | 1                   | 0.591 |
| Coronary heart disease  | 2                      | 1                          | 1                   | 0.629 |
| COPD                    | 3                      | 0                          | 1                   | 0.254 |
| Preoperative laboratories|                        |                            |                     |      |
| Hb (g/L)                | 133.5 ± 10.3           | 133.1 ± 10.9               | 137.4 ± 11.7        | 0.151 |
| Hct                     | 0.419 ± 0.033          | 0.419 ± 0.032              | 0.424 ± 0.040       | 0.117 |
| PBV (mL)                | 4197.4 ± 560.0         | 4492.4 ± 618.6             | 4689.5 ± 470.1      | <0.001*|
| Operative variables     |                        |                            |                     |      |
| Anticoagulation methods |                        |                            |                     | 0.507 |
| LMWH/Rivaroxaban/Other  | 89/53/21               | 64/48/22                   | 25/14/8             |      |
| Drainage use            | 115 (70.6%)            | 85 (63.4%)                 | 27 (57.4%)          | 0.180 |
| TXA use                 | 75 (46.0%)             | 68 (50.7%)                 | 20 (42.6%)          | 0.557 |
| Anesthesia method       |                        |                            |                     | 0.550 |
| General/Regional        | 149/14                 | 118/16                     | 41/6                |      |
| ASA class               |                        |                            |                     | 0.611 |
| ≥ 3                     | 146 (89.6%)            | 116 (86.6%)                | 40 (85.1%)          |      |
| Intraoperative fluid infusion (mL) | 1525.6 ± 772.9 | 1542.9 ± 864.6 | 1331.3 ± 760.6 | 0.278 |
| Operating time (min)    | 145.0 ± 52.2           | 152.1 ± 58.4               | 152.9 ± 53.2        | 0.469 |

BMI: Body mass index = Weight/Height²; DA: Degenerative arthritis, including primary osteoarthritis and secondary osteoarthritis caused by developmental dysplasia of hip (type II and III) and osteonecrosis of the femoral head; IA: Inflammatory arthritis, including ankylosing spondylitis, rheumatoid arthritis and traumatic arthritis; COPD: Chronic obstructive pulmonary disease; Hb: Hemoglobin; Hct: Hematocrit; PBV: patient blood volume; LMWH: low-molecular-weight heparin; TXA, tranexamic acid; ASA: American Society of Anesthesiologists.

*Significant difference.
Complications

No death, pulmonary embolism, stroke, acute renal failure, or deep infection were detected in the study. Two patients in normal group (1.2%), one patient in overweight group (0.7%), and one patient in obese group (2.1%) developed deep venous thrombosis (DVT). There was no statistical difference in the incidence of complications, including DVT, cardiac infarction, acute renal failure, and superficial infection (Table 3).

Discussion

With the increased number of obese patients undergoing THA, the safety and effect for these people has been an essential issue.6 The majority of studies paid attention to the influence of BMI on pain, function, and complications after primary THA while the studies reporting the results after SBTHA were limited.24,25 Because of associated comorbidities of anesthesia and the surgical technique, performing THA in obese patients was more difficult than that in normal patients, not to mention SBTHA, which could lead to more blood loss, even higher risk of complications compared to primary THA.11,14 However, the effect of BMI on blood loss, transfusions as well as incidence of complications following SBTHA was still unknown.

To our best knowledge, the studies investigating the effect of BMI on blood loss in the setting of THA have been limited to just two published retrospective studies. Frish et al. divided patients undergoing primary THA into normal, overweight, and obese group on the base of BMI and compared the blood loss as well as transfusion rate among the three groups, revealing that patients with an elevated BMI had increased blood loss and decreased transfusion rate. Increased BMI lead to downward transfusion risk because of smaller percentage of blood loss in total blood volume.12 Sayeed et al. found that underweight patients had a greater risk for postoperative anemia compared to III obese patients in primary THA, but he just enrolled underweight and III obese patients. Our study firstly evaluated the relation of BMI and blood loss as well as transfusion following SBTHA. We found a similar trend with previous studies.

Table 2. Comparison of blood loss.

| Variable               | Normal (n = 163) | Overweight (n = 134) | Obese (n = 47) | p   | P1  | P2  | P3  |
|------------------------|------------------|----------------------|----------------|-----|-----|-----|-----|
| TBL (mL)               | 979.1 ± 846.7    | 1164.8 ± 847.2       | 1446.6 ± 933.3 | 0.019* | 0.134 | 0.007* | 0.162 |
| IBL (mL)               | 583.78 ± 391.2   | 630.3 ± 486.7        | 664.89 ± 480.1 | 0.625 | —   | —   | —   |
| Drain volume (mL)      | 383.0 ± 291.4    | 426.9 ± 358.0        | 521.7 ± 325.5  | 0.300 | —   | —   | —   |
| Ratio (TBL/PBV)        | 0.236 ± 0.203    | 0.265 ± 0.191        | 0.343 ± 0.224  | 0.090 | 0.310 | 0.035* | 0.116 |
| Transfusion volume (mL)| 322.6 ± 198.9    | 304.8 ± 148.1        | 365.0 ± 276.5  | 0.617 | —   | —   | —   |
| Transfusion rate (%)   | 95 (58.3%)       | 53 (39.6%)           | 15 (31.9%)     | <0.001* | 0.001* | 0.001* | 0.352 |
| Maximum hgb drop (g/L) | 29.9 ± 14.6      | 28.7 ± 9.2           | 41.4 ± 12.7    | 0.001* | 0.602 | 0.003* | 0.001* |
| Maximum hct drop       | 0.122 ± 0.057    | 0.128 ± 0.060        | 0.146 ± 0.059  | 0.221 | —   | —   | —   |
| LOS (days)             | 10.3 ± 10.0      | 9.0 ± 5.6            | 9.2 ± 6.4      | 0.327 | —   | —   | —   |
| Expenses Δ             | 122592 ± 32978   | 126432 ± 36613       | 123816 ± 34062 | 0.493 | —   | —   | —   |

TBL: Total blood loss; IBL: intraoperative blood loss; PBV: patient blood volume; Hb: Hemoglobin; Hct: Hematocrit; LOS: length of stay.
p represents p value of normal versus overweight vs obese group, P1 represents p value of normal versus overweight group, P2 represents p value of normal versus obese group, P3 represents p value of overweight versus obese group.

Table 3. LOS and complications.

| Variables                | Normal group (n = 163) | Overweight group (n = 134) | Obese group (n = 47) | p   |
|--------------------------|------------------------|-----------------------------|----------------------|-----|
| Death                    | 0                      | 0                           | 0                    | —   |
| DVT                      | 2 (1.2%)               | 1 (0.7%)                    | 1 (2.1%)             | 0.629|
| PE                       | 0                      | 0                           | 0                    | —   |
| Cardiac infarction       | 1 (0.6%)               | 1 (0.7%)                    | 0                    | 1.000|
| Stroke                   | 0                      | 0                           | 0                    | —   |
| Acute renal failure      | 0                      | 1 (0.7%)                    | 0                    | 0.526|
| Superficial infection    | 2 (1.2%)               | 2 (1.5%)                    | 1 (2.1%)             | 0.838|
| Deep infection           | 0                      | 0                           | 0                    | —   |

DVT: deep venous thrombosis; PE: pulmonary embolism.
studies, that was to say, elevated BMI was associated with increased estimated blood volume, blood loss, and decreased transfusion rate.

Our previous study indicated that obesity could not increase blood loss following SBTKA while we found that increased BMI contributed to more TBL following SBTHA in this study. The possible reason was that THA had significantly greater blood loss and transfusion risk than TKA, and patients undergoing THA was more sensitive to rising BMI.

Whether elevated BMI is associated with increasing incidence of complications after THA has been the focus of debate. In the short term (<90 days), the relation of BMI and complications was still controversial. Gurunathan et al. found the overweight and obese class II patients had a lower likelihood of developing overall, especially cardiac complications. In addition, Shohat et al. demonstrated that the risk for infection increases gradually throughout the full range of BMI. However, more and more studies supported that BMI alone was not an independent risk factor for a higher complication rate and obesity could not lead to higher risk of complications.

In the long term, after the analysis of nationwide billing data in Germany, Jeschke et al. showed that elevated BMI could increase the risk of remotely 90 day complications and 1 year revision rates. Notably, above papers reached a consensus, which was that the complication risk will dramatically increase when the BMI was more than 40 kg/m². Patients with a BMI > 40 kg/m² should lose body weight prior to THA. As we knew, our study was the first one to evaluate the influence of BMI on complication after SBTHA. The results indicated that incidence of complications was not related to BMI in patients undergoing SBTHA, providing positive evidence for surgeons to perform SBTHA in 1 obese and overweight patients.

We used Gross and Nadler formula to calculate blood loss in this study. Meanwhile, we add that if either reinfusion or autologous transfusion was performed, the TBL was equal to the loss calculated from the change in Hct plus the volume transfuse. So our calculating method is also similar to Mercuriali’s formula (calculated blood loss + transfused red blood cell), which is considered most suitable formula for comparable studies regarding blood loss in surgery in the research of Gibon and his colleagues. In addition, the calculating method (Gross and Nadler formula) is widely used in other studies. Moreover, the calculating method is the same among the three groups, which is the basis of comparison. Therefore, we think the method to calculate blood loss in our study is suitable.

There were some limitations in the current study. First, the maximum of BMI in this study was only 33.99 kg/m², all the obese patients belonged to 1 obesity. Shohat et al. showed that patients with a BMI > 40 kg/m² carried higher complication risks but we could not consider this situation in this study. Second, with the development enhanced recovery after THA, the use of drain decreased while the application of TXA in TKA increased, so drain and TXA were not used in all patients. Nevertheless, the proportion of the application of drain and TXA was similar among the three groups, and we thought this factor would not impact the validity of the results. Third, a further confounding factor is that all the calculations of PBV also relate to height and weight which contribute to BMI, which is the subject under study. Fourth, this was a retrospective study, the follow-up period was merely 1 month, and the number of enrolled patients was still low, especially obese patients. Therefore, further studies with higher level of evidence were requisite. Last but not least, because the patient data was from different hospitals, and the surgeries were performed by different surgeons, it was difficult to keep perioperative management methods completely consistent. However, the nationally representative database elevated the reliability and generalizability of the findings, giving us a credible overview of the relationship between BMI and blood loss, transfusion, and complications following SBTHA.

In summary, obesity could increase perioperative blood loss but not increase transfusion risk in the setting of SBTHA. Conversely, obese and overweight patients maybe have lower transfusion need compared with normal patients because of more blood volume. In addition, obesity did not affect the incidence of complications.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This research was funded by the National Health and Family Planning Commission of the People’s Republic of China (CN) program (201,302,007).

Ethical approval

The study was approved by the local institutional review board of West China Hospital, Sichuan University (2012-268).

Informed consent

Written informed consent (including patients’ details, images or videos) was obtained from all participants.

Data availability

Availability of data and materials The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.
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