

Blood loss closely correlates with body mass index in total hip arthroplasty performed through direct lateral approach

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ABSTRACT

الأهداف: دراسة فقد الدم الإجمالي أثناء العملية، ونزح بعد العملية، والمتغيرات المتعلقة الأخرى في رآب مفصل الورك الكامل التي استخدمت الطريقة الجانبية.

الطريقة: أجريت هذه الدراسة في مستشفى شنقهاي، الصين خلال الفترة من يناير وديسمبر 2010م. قمنا بتحليل 113 مريض خضعوا لرآب مفصل الورك الكامل بالطريقة الجانبية. تم قياس فقدان الدم المسجل والاجمالي باستخدام معادلة. كما أجري لتحليل الانحدار اللوجستي لفقد الدم الإجمالي أثناء العملية ونزح بعد العملية مع الجنس والعمر ومؤشر كتلة الجسم ومدة المرض ووقت العملية كمتغيرات مستقلة.

النتائج: كان متوسط مدة العملية 10.4 ± 51.5 المدى (35-70) دقيقة، متوسط الدم المسجل 454 ± 144 المدى (150-180) مل. كان متوسط فقد الدم الإجمالي عالياً (المدى 430-2020 ملل) 975 ± 355 ، القيمة الإحصائية $p < 0.001$. في تحليل المتغيرات ارتبط مؤشر كتلة الجسم مع فقد الدم الإجمالي، وفقد الدم أثناء العملية ونزح بعد العملية، ونسبة الرجحية 4.80 (2.63-8.78) و 5.39 (2.84-10.25) مستوى الثقة 95%، و 4.37 (2.43-7.89)، إضافة إلى ذلك فقد الدم الإجمالي (54.172)، وخسارة الدم أثناء العملية (54.172) ونزح بعد العملية (39.139) الذي ارتبط بمؤشر كتلة الجسم.

خاتمة: ارتبط كلاً من فقد الدم الإجمالي، وفقد الدم أثناء العملية، ونزح بعد العملية مع مؤشر كتلة الجسم في المرضى الخاضعين لرآب مفصل الورك الكامل بالطريقة الجانبية.

Objectives: To investigate total blood loss (TBL), intraoperative blood loss (IBL), post-operative drainage (POD), and other related variables in total hip arthroplasty (THA) performed through direct lateral approach.

Methods: This study was completed in Shanghai Sixth People's Hospital, Shanghai, China, between January and December 2010. We analyzed 113

patients treated by THA through direct lateral approach. Recordable blood loss (RBL) was measured and TBL was calculated according to the Gross formula. Ordinal logistic regression analysis was used for TBL, IBL, and POD, with gender, age, body mass index (BMI), disease duration, and operative time as independent variables.

Results: The average operative time was 51.5 ± 10.4 (range: 35-70) minutes, with an average RBL of 454 ± 144 (range: 150-180) ml. Average TBL was significantly higher (975 ± 355 , range: 430-2020 ml; $p < 0.001$). In the analysis of variables, BMI closely correlated with TBL, IBL, and POD, with odds ratios of 4.80 (95% CI: 2.63-8.78 [TBL]), 5.39 (95% CI: 2.84-10.25 [IBL]), and 4.37 (95% CI: 2.43-7.89 [POD]). Moreover, TBL (54.172), IBL (55.198), and POD (39.139) correlated with trend test BMI.

Conclusion: The TBL, IBL, and POD closely correlate with BMI in patients undergoing THA through direct lateral approach.

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Total hip arthroplasty (THA) can be performed by posterior and lateral approaches.¹⁻⁴ Due to the higher incidence of implant dislocation in the posterior approach, the direct lateral approach is considered as an alternative for THA.^{5,6} Recently, various modifications have been developed to broaden the indications for the lateral approach, which has been considered versatile for operations of the hip joint.⁷ Clinical results, including regaining function and pain relief can be achieved similarly in both approaches.⁸ However, prior studies suggested that the lateral approach led to more blood loss.^{9,10} Moreover, there are no prospective studies investigating blood loss and other associated factors in THA performed through the direct lateral approach. Therefore, this prospective study of consecutively treated patients was designed to analyze the relationship between blood loss and other associated factors in THA performed through the direct lateral approach.

Methods. This study was carried out at the Shanghai Sixth People's Hospital, Shanghai, China between January and December of 2010. This study was approved by our institutional ethics committee; all procedures are in accordance with the Helsinki Declaration of 1975. Data were collected prospectively in 224 primary THAs performed by our surgical team, in 209 consecutive patients. Indications for surgery were as follows: osteonecrosis of the femoral head (ONFH), n=135; primary osteoarthritis (OA), n=52; developmental dysplasia of the hip (DDH), n=28; and femoral neck fractures, n=9. Patients with OA, DDH, and fractures were excluded and 11 patients had bilateral THAs performed; resulting in 113 patients with 113 THAs treated for ONFH for analysis. As far as etiology of ONFH, 52 patients had a history of corticosteroid use, 33 abused alcohol, and 28 were considered idiopathic (Figure 1). Radiographic examinations showed deformities of the femoral head and narrowing of the joint space in advanced stage ONFH (Figure 2). There was no history of prior surgery to preserve the femoral head in any of the 113 patients. The average patient age was 56.3 (range: 26-79) years, and 71 were male. The right hip was involved in 59 cases. Average BMI was 24.91 ± 4.12 (range: 17.9-35.2) kg/m², with a disease duration of 32.7 (range 4-120) months. The average preoperative Harris Hip Score (HHS) was 62 (range: 49-78), and Visual Analogue Score (VAS) was 4.4 (range: 3-7). The direct lateral approach, which was approximately 10 cm long and centered on great trochanter with the hip and knee flexed 45°. The gluteal fascia and iliotibial band were exposed and divided longitudinally along the midlateral line and in the same direction as the skin incision. The tensor fascia

was retracted to anterior while the gluteus maximus to posterior. The Hardinge approach was modified by authors in the manner of removing less abductor musculature from trochanter region. The gluteus medius tendon was incised in a direct longitudinal fashion, starting at the uppermost end of the vastus lateralis ridge and extending distally. A thick muscle cuff was left attached to great trochanter to facilitate following restoration. Distally, the incision passes down through vastus lateralis. The gluteus medius, gluteus minimus, and anterior capsule then are dissected subperiosteally from the anterior femoral neck to gain access to the hip joint, which was then positioned extreme adduction and external rotation for dislocation. The level of osteotomy was positioned about 2 cm above less trochanter. The lower limb was placed neutrally with the hip and knee joint flexed 45°. Three specially designed retractors were placed superior, anterior and posterior acetabulum to retract iliopsoas, gluteus maximus, and proximal femur respectively to expose acetabulum clearly. Subsequently, anterior capsule and circumferential cartilage were removed, but posterior capsular structure was kept intact. Based on preoperative measurement on template, acetabular cup, and liner were installed after gradual reaming. Then, the limb was placed adduction and external rotation again for the management of proximal femora. Similarly, gradual reaming and installation of femoral prosthesis were done based on preoperative measurement. When appropriate femoral stem was installed after thorough intramedullary irrigation, the limb was placed neutrally to draw for reposition. Post-operative imaging was employed to assess the position of acetabular cup, meanwhile, the length of the limb and motion of the hip joint was assessed. Periacetabular drainage was placed, and gluteus medius and minimus were sutured to in situ musculature at great trochanter, and the incision was closed layer by layer. The artificial hip joint used in current study was all cementless, UHMWPE on ceramic, which was from Link Inc. (Hamburg, Germany). Peripheral blood count was detected preoperatively and on post-operative day 2, including red blood cell count (RBC), hemoglobin (Hb), hematocrit (Hct), and so forth. Recordable blood loss (RBL) was defined as the sum of intraoperative blood loss (IBL) and post-operative drainage (POD), obtained from anesthesia, and nursing notes. Total blood loss (TBL) was calculated based on the following formula:¹¹ $TBL = PBV \times [(H_i - H_f) / H_{av}]$, where PBV was abbreviated for patient's blood volume (mL), H_i for initial Hct, H_f for final Hct and H_{av} for the average of the initial and final Hct. The PBV was estimated based on the formula of Nadler:¹² $PBV = k_1 \times \text{height (m)} + k_2 \times \text{weight (kg)} + k_3$, where $k_1 = 0.3669$, $k_2 = 0.03219$,

and $k_3 = 0.6041$ for men, while $k_1 = 0.3561$, $k_2 = 0.03308$, and $k_3 = 0.1833$ for women. Operative time was obtained from the anesthesia note. In the follow-up period, post-operative complications were recorded. Anteversion and abduction angle, and improvement of HHS and VAS was measured pre- and post-operatively. All patients had normal coagulation parameters pre-operatively.

Statistical analysis. Post-operative complications, improvement of HHS and VAS, anteversion and abduction angle, and other numerical data were expressed as the mean \pm standard deviation (SD). The TBL, IBL, and POD were divided into 4 categories by P_{25} (290 ml), P_{50} (450 ml), and P_{75} (515 ml): $TBL/IBL/POD < 290$ ml, $290 \text{ ml} \leq TBL/IBL/POD < 450$ ml, $450 \text{ ml} \leq TBL/IBL/POD < 515$ ml, and $TBL/IBL/POD \geq 515$ ml. Age was also divided into 4 categories: < 45 years, 45-54 years, 55-64 years, and > 64 years. The BMI was divided into 3 categories: < 24 , 24-26, and > 26 . Disease duration was divided into 4 categories: < 12 , 12-, 24-, and ≥ 36 months. Operative time was divided into 2 categories: less than (< 60 minutes), more than or equal to 60 minutes (≥ 60 minutes). All statistical analysis was performed using the Statistical Package for Social Sciences software version 14 (SPSS Inc, Chicago, IL, USA). Ordinal logistic regression analysis was used for TBL, IBL, and POD, with gender, age, BMI, disease duration, and operative time as independent variables. The paired t-test was used to analyze pre- and post-operative Hb and Hct. A $p < 0.05$ was considered to be statistically significant.

Results. There were no complications of deep space infection or implant dislocation. Functional exercises of muscle strength and motion of the hip joint were initiated on post-operative day one. Partial load-bearing ambulation was initiated on post-operative day 2, when the drainage tube was removed. The average angle for abduction was $39.5 \pm 5.8^\circ$ and $13.2 \pm 4.0^\circ$ for anteversion. The HHS improved from 62-89 at 3 months, and to 94 at 12 months post-operatively. The VAS was reduced from 4.4-0.3 at one year post-operatively without analgesics in all patients. The average operative time was 51.5 ± 10.4 (range: 35-70) minutes with an average IBL of 240 ± 63 (range: 150-350) ml. Average POD was 213 ± 110 (range: 0-550) ml. The RBL was 454 ± 144 (range: 150-850) ml. Post-operative RBC ($4.71 \times 10^{12}/L - 3.47 \times 10^{12}/L$), Hb (101.2 g/L - 135.7 g/L), and Hct (43.02 - 30.51%) were reduced ($p < 0.001$). Average TBL was 975 ± 355 (range 430-2020) ml. Eight (7.1%) patients required blood transfusion. The BMI was the only factor that could increase TBL by logistic regression analysis (OR: 4.80, 95% CI: 2.63-8.78).

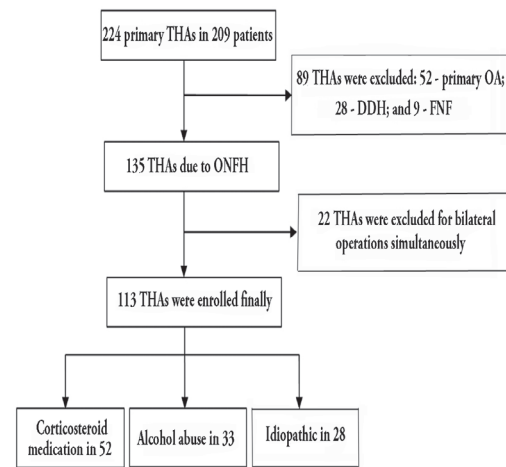


Figure 1 - Treatment algorithm for patients undergoing total hip arthroplasty (THA). ONFH - osteonecrosis of the femoral head, OA - osteoarthritis, DDH - developmental dysplasia of the hip, FNF - femoral neck fracture

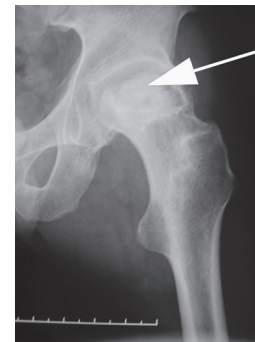


Figure 2 - Radiographic features of osteonecrosis of the femoral head. Anteroposterior view of the hip joint (arrow) demonstrated critical collapse of the femoral head with osteophyte formation.

Gender, age, disease duration, and operative time did not affect TBL (Table 1). By linear-by-linear association, it was 54.172 ($p < 0.001$), thus confirming that TBL and BMI are closely related. The BMI, disease duration, and operative time may affect IBL, with OR values of 5.39 (95% CI: 2.84-10.25), 0.64 (95% CI: 0.43-0.96), and 3.97 (95% OR: 1.22-12.98). Gender and age were not found to be related to IBL (Table 2). Higher BMI and longer operative time may lead to higher IBL, however, disease duration negatively correlated with IBL. The linear-by-linear association between BMI and IBL was 55.198 ($p < 0.001$). The BMI determined POD, with an OR value of 4.37 (95% CI: 2.43-7.89). Gender, age, disease duration, and operative time did not affect POD (Table 3). The value of linear-by-linear association was 39.139 ($p < 0.001$), which meant that the severity of BMI closely correlated with POD.

Table 1 - The relationship between TBL and related variables revealed by ordinal logistic regression analysis of patients included in a study at the Shanghai Sixth People's Hospital, Shanghai, China.

Variables	β	S_b	Wald χ^2	P-value	OR (95%CI)
Gender	-0.331	0.393	0.710	0.399	0.72 (0.33-1.39)
Age	0.124	0.205	0.362	0.547	1.13 (0.76-1.69)
Body mass index	1.569	0.308	25.932	<0.001	4.80 (2.63-8.78)
Disease duration	-0.160	0.185	0.743	0.389	0.85 (0.59-1.22)
Operative time	0.757	0.523	2.095	0.148	2.13 (0.76-5.94)

TBL - total blood loss, S_b - value of ordinal logistic regression analysis, OR - odds ratio, CI - confidence interval

Table 2 - The relationship between IBL and related variables revealed by ordinal logistic regression analysis of patients included in a study at the Shanghai Sixth People's Hospital, Shanghai, China.

Variables	β	S_b	Wald χ^2	P-value	OR (95%CI)
Gender	0.567	0.447	1.604	0.205	1.76 (0.73-4.23)
Age	0.334	0.218	2.353	0.125	1.40 (0.91-2.14)
Body mass index	1.685	0.328	26.370	<0.001	5.39 (2.84-10.25)
Disease duration	-0.447	0.205	4.730	0.030	0.64 (0.43-0.96)
Operative time	1.380	0.604	5.221	0.022	3.97 (1.22-12.98)

IBL - intraoperative blood loss, S_b - value of ordinal logistic regression analysis, OR - odds ratio, CI - confidence interval

Table 3 - The relationship between POD and related variables revealed by ordinal logistic regression analysis of patients included in a study at the Shanghai Sixth People's Hospital, Shanghai, China.

Variables	β	S_b	Wald χ^2	P-value	OR (95%CI)
Gender	0.551	0.384	2.056	0.152	0.58 (0.27-1.22)
Age	0.299	0.204	2.148	0.143	0.74 (0.50-1.11)
Body mass index	1.477	0.300	24.200	<0.001	4.37 (2.43-7.89)
Disease duration	0.342	0.185	3.406	0.065	1.41 (0.98-2.02)
Operative time	-0.212	0.515	0.169	0.681	0.81 (0.29-2.22)

POD - post-operative drainage, S_b - value of ordinal logistic regression analysis, OR - odds ratio, CI - confidence interval

Discussion. Total hip arthroplasty is one of the most successful contributions to medicine, as it relieves pain, and restores joint function effectively.¹³ The success of THA depends on the ability of the surgeon to achieve adequate surgical exposure while minimizing complications.⁵ The posterior approach has the advantage of improved exposure and protection of the abductors; however, it also has a higher incidence of dislocation. Although previous meta-analyses have found no difference in post-operative implant dislocation between the posterior and lateral approaches, it was reported that an incidence of less than 1% could be achieved via a lateral approach.¹⁻⁵ Therefore, the direct lateral approach is currently more

practical and appealing.⁹ With careful management and reliable restoration of the abductor muscles, nerve damage, abnormal gait, and heterotopic ossification can be prevented.¹⁴⁻²³ Since the direct lateral approach was developed, it has attracted more attention after it was modified by Hardinge.²⁴ Earlier reports indicated that the direct lateral approach would lead to more blood loss.⁷ A recent study indicated that the lateral approach had shorter operative times,²⁵ and less blood loss.²⁶ In our cohort, the average operative time was 51.5 minutes, average intraoperative blood loss was 240 ml, average post-operative drainage was 213 ml, and average total blood loss was 975 ml. The greatest outliers in RBL and TBL were noted in patients with hypovolemic shock, although only 8 patients required blood transfusion. Secure closure of the gluteus medius and minimus can improve blood loss.

We have demonstrated that BMI plays a critical role in blood loss in patients undergoing THA through the direct lateral approach. The BMI has been considered an important predictor for outcome in total hip and knee arthroplasties, although this is still controversial.²⁷⁻³¹ Flugsrud found a strong dose-response association between BMI and total hip arthroplasty in OA.²⁷ The BMI was found to be a risk factor for implant dislocation following THA,²⁸ however, the effect of BMI on early outcome was not confirmed in subsequent studies.^{29,30} Singh and Lewallen³² found that BMI was closely related with moderate-severe pain following primary THA. In our study, BMI closely correlated with TBL, IBL, and POD, and blood loss was also associated with BMI. Patients with higher BMI may require a longer incision and operative time, which may contribute to greater intra- and post-operative blood loss.

Our study is limited by small sample size, which may have contributed to the finding that disease duration has a negative relationship to IBL. Moreover, several studies have showed no benefit of drain placement in primary THA.³³⁻³⁵ However, drainage techniques are also evolving. In addition, the indications for routine drainage are becoming fewer. The current research was just an observational prospective study to investigate blood loss and related variables in THA performed through the direct lateral approach. However, a randomized controlled study was persuasive and invaluable to compare blood loss in THA performed through different incisions. In the near future, blood loss should be considered as an important factor to determine a preferable approach for THA.

In conclusion, TBL, IBL, and POD closely correlate with BMI in patients treated by THA through the direct lateral approach. Patients with a higher BMI have

more blood loss when THA is performed through the direct lateral approach. Further research is necessary to establish the relationship between BMI and THA in a larger number of patients; to improve quality and decrease the risks associated with THA.

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