Joint Diseases and Related Surgery

Jt Dis Relat Surg
2026;37(2):344-350

ORIGINAL ARTICLE

Hidden blood loss in total hip arthroplasty: A comparison of the direct anterior versus posterolateral approach

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ABSTRACT

Objectives: This study aims to compare the volume and impact of hidden blood loss (HBL) following total hip arthroplasty (THA) performed via the direct anterior approach (DAA) versus the posterolateral approach (PLA).

Patients and methods: Between January 2016 and January 2024, a total of 134 patients (63 males, 71 females; mean age: 69.7 ± 7.7 years; range, 48 to 79 years) who underwent primary THA were retrospectively analyzed. The patients were stratified into two cohorts according to surgical approach: DAA group (n = 63) and PLA group (n = 71). Preoperative blood volume and visible blood loss (VBL) were quantified for both cohorts. Total blood loss (TBL) was derived from hematocrit (Hct) levels measured preoperatively and on postoperative Day 3, which subsequently allowed calculation of HBL and its proportion relative to TBL. Intergroup comparisons were performed for these parameters.

Results: The most common etiology for THA was hip osteoarthritis. The mean operative time was 120.4 ± 10.2 min in the DAA group and 117.7 ± 8.2 min in the PLA group, indicating no statistically significant difference between the two groups ($p = 0.093$). The mean TBL was 366.3 ± 54.3 mL in the DAA group and 477.0 ± 71.6 mL in the PLA group ($p < 0.001$), while the mean HBL was 206.3 ± 40.4 mL and 318.9 ± 44.9 mL, respectively ($p < 0.001$). The reductions in Hb and Hct were significantly lower in the DAA group compared to the PLA group ($p < 0.001$ for both).

Conclusion: During the perioperative period of THA, HBL represents a considerable clinical concern regardless of the surgical approach employed. Compared to the PLA, the DAA is associated with a significant reduction in both HBL and TBL.

Keywords: Anterior approach, hidden blood loss, posterior lateral approach, total hip arthroplasty.

Total hip arthroplasty (THA) effectively alleviates hip pain and restores joint mobility and function, and is widely regarded as one of the most successful surgical interventions for the management of end-stage hip pathologies.[1] In recent decades, the volume of hip replacement procedures has risen in parallel with increasing life expectancy.[2] Postoperative blood loss following THA still remains a significant concern and is widely recognized to impede patient recovery. Several studies have reported perioperative total blood loss (TBL) reaching up to 2,000 mL, with transfusion rates as high as 37%.[3,4] Substantial blood transfusion not only elevates surgical risks, but also introduces transfusion-related complications such as transmission of viral infections, hemolytic reactions, and immune responses.[5] Despite the implementation of effective perioperative blood management strategies, a considerable number of patients continue to experience varying degrees of anemia, with some developing severe forms. Notably, this phenomenon often cannot be fully explained by visible blood loss (VBL), including intraoperative bleeding and postoperative drainage.

This phenomenon of unnoticed blood loss, termed hidden blood loss (HBL), was first defined by Sehat et al.[6] in 2000. Using the Gross equation, the

Received: September 21, 2025
Accepted: October 20, 2025
Published online: March 18, 2026

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Doi: 10.52312/jdrs.2026.2642

Citation: Zeng JW, ChenX, Wang YJ, Jiang X, Yao XK. Hidden blood loss in total hip arthroplasty: A comparison of the direct anterior versus posterolateral approach. Jt Dis Relat Surg 2026;37(2):344-350. doi: 10.52312/jdrs.2026.2642.

authors demonstrated that HBL could not account for approximately 50% of TBL. Factors influencing HBL include sex, age, body mass index (BMI), transfusion volume, incision length, hematocrit (Hct) change, preoperative hemoglobin (Hb) level, operative duration, and use of tranexamic acid (TXA).[7-9] The prevailing mechanism underlying HBL is thought to be the loss of red blood cells due to accumulation in the joint cavity, extravasation into tissue spaces, and hemolysis.[10] In particular, the administration of TXA has been demonstrated to be an effective pharmacological intervention for reducing HBL by inhibiting fibrinolysis and stabilizing clot formation.[11]

The choice of surgical approach significantly influences outcomes and recovery process.[12] In recent years, minimally invasive approaches such as the direct anterior approach (DAA) have gained popularity.[13] Compared to the conventional posterolateral approach (PLA), DAA offers several advantages including improved muscle preservation, protection of motor nerves, lower postoperative dislocation rates, and more rapid rehabilitation. However, it also entails certain drawbacks such as a steeper learning curve and longer operative time.[14] Currently, there is limited literature comparing HBL between these two surgical approaches. In the present study, we aimed to compare DAA and PLA in primary unilateral THA cases and to provide clinicians with more accurate and scientific guidance in selecting the surgical approach in order to optimize surgical outcomes in THA.

PATIENTS AND METHODS

This single-center, retrospective cohort study was conducted at Chengdu First People's Hospital, Department of Orthopedics and Traumatology between January 2016 and January 2024. Patients who underwent THA were screened. Inclusion criteria were as follows: (1) primary unilateral THA; (2) use of either the DAA or PLA; (3) primary diagnosis of osteonecrosis of the femoral head, hip osteoarthritis, or low-grade developmental dysplasia of the hip (DDH, e.g., Crowe type 1 and 2); (4) all procedures performed by the same surgical team; (5) normal coagulation function; (6) use of cementless prostheses; and (7) no administration of postoperative blood salvage. Patients with high dislocation (e.g., Crowe type 3 or 4) were excluded to maintain homogeneity of the cohort and surgical technical consistency. Exclusion criteria were as follows: (1) previous ipsilateral hip surgery; (2) high dislocation (e.g., Crowe type 3 or 4); (3) chronic use of antiplatelet/anticoagulant medications; (4) severe medical comorbidities contraindicating surgery; (5)incomplete medical records; and (6) perioperative blood loss exceeding 1.0 L. Finally, a total of 134 patients (63 males, 71 females; mean age: 69.7 ± 7.7 years; range, 48 to 79 years) who met the inclusion criteria were recruited. Written informed consent was obtained from each patient. Ethical Review Committee Statement as a retrospective cross-sectional study, all data collection and analysis were performed anonymously and without potential harm to patients. Consequently, The Ethics Committee of Chengdu First People's Hospital waived the requirement for informed consent. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Surgical technique

Patients undergoing primary unilateral THA were classified into two groups according to the surgical approach: the DAA group (n = 63) and the PLA group (n = 71).

Direct anterior approach protocol

A curved incision approximately 9 to 13 cm in length was made starting approximately two fingerbreadths distal to the anterior superior iliac spine and extending toward the fibular head. The subcutaneous tissue was exposed through layered dissection. The intermuscular interval between the tensor fasciae latae and sartorius was identified and developed. Blunt dissection was carried out through the subcutaneous tissue, followed by proximal extension to expose the joint capsule. After capsulotomy, the femoral neck was visualized. The hip was placed in full internal rotation to bring the greater trochanter from a posterolateral to a lateral position. A femoral neck osteotomy was performed 1.0 to 1.5 cm proximal to the lesser trochanter. The femoral head was extracted using a corkscrew device, providing adequate exposure of the acetabulum. Redundant osteophytes, synovium, and capsular tissue around the acetabulum were debrided. The acetabulum was, then, reamed, and the acetabular cup and liner were implanted. The proximal femur was elevated and externally rotated. The tight posterolateral capsule was released. With distal elevation of the femur, the medullary canal was prepared and the femoral component was inserted. Reduction of the hip joint was performed. Before layered wound closure, a closed-suction drain was placed deep to the fascia latae and was typically removed within 24 h postoperatively, when drainage was less than 50 mL per 24 h. The capsule was repaired, and the wound was closed in layers.

Posterolateral approach protocol

A curved incision measuring 8 to 12 cm was made centered over the tip of the greater trochanter, extending from the posterior superior iliac spine toward the greater trochanter and following the direction of the femoral shaft. Subcutaneous tissue was exposed through layered dissection. The fascia latae was incised and extended into the gluteus maximus muscle. The tensor fasciae latae was divided. A Hoffman retractor was used to retract the gluteus medius and quadratus femoris muscles. The bursa surrounding the greater trochanter was resected. The external rotator muscles and the posterior capsule were transected. Femoral neck osteotomy and prosthesis implantation were performed using the same technique as in the DAA group. Similarly, a closed-suction drain was placed deep to the fascia latae prior to wound closure and was managed with the same removal criteria. The external rotator muscles were subsequently repaired, and the wound was closed in layers.

Both patient groups received identical perioperative management protocols. Tranexamic acid (2.0 g) was administered intravenously 30 min prior to surgery. Starting on postoperative Day 1, low-molecular-weight heparin sodium (4,000 IU) was injected subcutaneously. Upon discharge, oral rivaroxaban (10 mg once daily) was prescribed for thromboprophylaxis, with a total anticoagulation duration of 15 days. Ambulation with a walker was initiated on the first day after surgery. Patients were gradually weaned from the walker, until full weight-bearing on the affected limb was achieved.

Data collection

Epidemiological data were documented, including age, sex, height, body weight, BMI, underlying comorbidities, diagnosis, symptom duration, and affected side. Laboratory parameters consisted of fasting blood glucose, Hct, serum albumin concentration, and Hb level. Clinical records encompassed the American Society of Anesthesiologists (ASA) classification, operative time, intraoperative blood loss, postoperative drainage volume, length of hospital stay, and follow-up period. Perioperative transfusion events and postoperative complications were also recorded.

Calculation of blood loss

Patient height and weight were measured preoperatively to calculate BMI. Intraoperative blood loss was determined by two components: the first was the net weight gain of surgical sponges and gauzes (with 1 g equivalent to 1 mL), and the second was the volume of fluid in the suction container minus the volume of saline irrigation used during the procedure.

Total blood loss (L) was calculated using the following formula:

TBL = Patient's blood volume (PBV) × (Preoperative Hct-Hct on postoperative Day 3)/Average of preoperative and postoperative Day 3 Hct.[15]

The patient's blood volume (L) was estimated as follows:

PBV = K1 × height^3 (m^3) + K2 × weight (kg) + K3.[16]

For males: K1 = 0.3669, K2 = 0.03219, K3 = 0.6041;

For females: K1 = 0.3561, K2 = 0.03308, K3 = 0.1833.

Visible blood loss was defined as the sum of intraoperative blood loss and postoperative drainage volume.

HBL was calculated as:

HBL = TBL-VBL + volume of transfused red blood cells.

Statistical analysis

Statistical analysis was performed using the IBM SPSS version 27.0 software (IBM Corp., Armonk, NY, USA). Continuous variables were presented in mean ± standard deviation (SD) or median (min-max), while categorical variables were presented in number and frequency. Intergroup comparisons were performed using independent t-tests for continuous variables and chi-square tests for categorical variables. A p value of < 0.05 was considered statistically significant.

RESULTS

Nearly 22% of the patients had comorbid diabetes mellitus. The most common indication for THA was hip osteoarthritis (approximately 49%). No significant differences were observed in demographic characteristics between the two groups (Table I).

All surgical procedures were completed as planned, with no conversions from DAA to PLA or *vice versa* during the operations. The mean operative time was 120.4 ± 10.2 min in the DAA group and 117.7 ± 8.2 min in the PLA group, with no statistically significant difference ($p = 0.093$). Similarly, there were no significant differences in the ASA classification, intraoperative blood loss, postoperative drainage volume, length of hospital stay, or follow-up duration between the two groups ($p > 0.05$) (Table II).

Perioperative laboratory parameters and blood loss calculations are summarized in Table III. The primary difference in TBL between the two groups was attributable to a significantly higher HBL in the PLA group (318.9 ± 44.9 mL) compared to the DAA group (206.3 ± 40.4 mL; $p < 0.001$). Consequently, both the TBL and the Hb loss were also significantly greater in the PLA group (TBL: 477.0 ± 71.6 mL *vs.* 366.3 ± 54.3 mL; Hb loss: 15.2 ± 3.7 g/L *vs.* 10.5 ± 3.4 g/L; both $p < 0.001$).

In the DAA group, five patients required transfusion, one developed a surgical site infection, and two experienced deep vein thrombosis (DVT) in both lower limbs. In the PLA group, eight patients required transfusion, two had wound infections, and three developed bilateral DVT. No cases of pulmonary embolism occurred in either group. There were no statistically significant differences in transfusion rates, incision infection rates, or DVT incidence between the two groups ($p > 0.05$) (Table IV).

DISCUSSION

In the present study, we compared DAA and PLA in primary unilateral THA cases. This study identified two key findings regarding surgical approaches in THA: (1) compared to the DAA, the PLA was associated with significantly greater HBL and Hb reduction and (2) irrespective of the surgical approach, HBL accounted for the majority of TBL. These results underscore the need for standardized anemia management protocols in PLA cases, including rigorous postoperative Hb monitoring and targeted hemostatic interventions.

Previous studies have indicated that the surgical approach can reduce muscle injury and pain following THA, and is associated with accelerated rehabilitation.[17] However, it is also accompanied by drawbacks such as prolonged operative time and a steep learning curve.[18] In the present study comparing clinical data between this approach and the conventional PLA, we observed that the DAA was associated with lower mean

TABLE I
Patients' demographics

	DAA		PLA		
Variables	n	Mean ± SD	n	Mean ± SD	*p*
Age (year)		69.2 ± 7.2		70.1 ± 8.1	0.462
Sex					
Male	25		38		
Female	38		33		
Height (m)		1.65 ± 0.06		1.64 ± 0.06	0.844
Weight (kg)		59.1 ± 7.0		60.1 ± 8.7	0.466
BMI (kg/m^2)		21.8 ± 2.0		22.2 ± 2.2	0.304
Underlying comorbidities					0.972
Hypertension	6		8		
DM	16		14		
CHD	4		8		
Diagnosis					0.161
Osteonecrosis of the femoral head (Ficat Stage III or IV)	21		27		
Hip osteoarthritis	28		38		
Developmental dysplasia (Crowe Stage III or IV)	14		6		
Symptom duration, months		17.9 ± 5.1		19.5 ± 6.2	0.102
Affected side					
Right	38		45		
Left	25		26		
Total	63		71		

DAA, direct anterior approach; PLA, posterolateral approach; SD, standard deviation; BMI, body mass index; DM, diabetes mellitus; CHD, coronary heart disease.

TABLE II
Comparison of intraoperative and postoperative parameters between the two groups

	DAA		PLA		
Variables	n	Mean ± SD	n	Mean ± SD	*p*
ASA classification					0.651
I	4		1		
II	47		57		
III	12		13		
Operative time (min)		120.4 ± 10.2		117.7 ± 8.2	0.093
Intraoperative blood loss (mL)		130.4 ± 19.1		131.1 ± 21.3	0.839
Postoperative drainage (mL)		37.5 ± 10.3		39.8 ± 7.5	0.146
Length of hospital stay (day)		8.0 ± 1.3		8.4 ± 1.3	0.079
Follow-up time (year)		2.2 ± 0.6		2.3 ± 0.7	0.427
Total	63		71		

DAA, direct anterior approach; PLA, posterolateral approach; SD, standard deviation; ASA, American society of Aneshesiologists.

TABLE III
Laboratory parameters and HBL-related parameters

	DAA		PLA		
Variables	n	Mean ± SD	n	Mean ± SD	*p*
Preoperative blood glucose (mmol/L)		6.3 ± 1.2		6.1 ± 1.3	0.220
Preoperative serum albumin (g/L)		34.4 ± 2.7		35.1 ± 1.8	0.071
Preoperative Hb (g/L)		129.0 ± 7.0		127.3 ± 6.3	0.142
Postoperative Hb (g/L)		118.5 ± 7.4		112.1 ± 5.9	< 0.001
Hb loss (g/L)		10.5 ± 3.4		15.2 ± 3.7	< 0.001
Preoperative Hct (%)		37.8 ± 3.1		37.1 ± 3.1	0.245
Postoperative Hct (%)		34.3 ± 2.8		32.9 ± 2.9	0.004
Hct loss (%)		3.4 ± 0.7		4.3 ± 0.9	< 0.001
PBV (L)		3.9 ± 0.5		4.0 ± 0.6	0.308
VBL (mL)		167.9 ± 21.5		170.8 ± 21.1	0.421
HBL (mL)		206.3 ± 40.4		318.9 ± 44.9	< 0.001
TBL (mL)		366.3 ± 54.3		477.0 ± 71.6	< 0.001
Total	63		71		

HBL, hidden blood loss; DAA, direct anterior approach; PLA, posterolateral approach; SD, standard deviation; Hb, hemoglobin; Hb loss, preoperative Hb - postoperative Hb; Hct, hematocrit; Hct loss, preoperative Hct - postoperative Hct; PBV, patient blood volume; VBL, visible blood loss; HBL, hidden blood loss; TBL, total blood loss.

TABLE IV
The postoperative blood transfusion rates and related complications of the two surgical approaches

	DAA	PLA	
Variables	n	n	*p*
Blood transfusion	5	8	0.519
Incision infection	1	2	0.634
Deep vein thrombosis	2	3	0.751
Pulmonary embolism	0	0	-

DAA, direct anterior approach; PLA, posterolateral approach.

intraoperative blood loss and VBL than PLA, although these differences were not statistically significant. This may be attributed to the fact that although DAA requires a longer operative time, which might contribute to increased bleeding, the use of an intermuscular plane minimizes soft tissue disruption, thereby potentially mitigating the VBL such that it does not differ significantly from that of PLA.

The principal driver of the observed difference in TBL was the significantly greater HBL in the

PLA group compared to the DAA group. This substantial disparity in HBL consequently led to a higher TBL and a clinically relevant, although not statistically significant, trend toward a higher transfusion rate in the PLA group (11.3% *vs.* 7.9%). These findings underscore that the reduction in perioperative blood loss associated with the DAA is primarily attributable to its capacity for minimizing HBL. The underlying mechanism may involve the intermuscular nature of DAA, which avoids muscle transection and results in less muscle trauma. Consistent with this, a study by Bender et al.[19] reported that PLA caused greater muscle damage, leading to elevated levels of blood biomarkers, particularly creatine kinase, which may contribute to erythrocyte membrane disruption and hemolysis. It is essential to acknowledge that the current literature presents conflicting findings regarding blood loss between surgical approaches. Several studies and meta-analyses, including a recent one focusing on Asian demographics by Manhas et al.,[20] have reported no significant difference in TBL between the DAA and PLA.[20] The divergence in results across studies may be attributed to several factors including heterogeneity in patient demographics (e.g., BMI, baseline Hb), surgical proficiency and the learning curve associated with each approach, variations in perioperative protocols (particularly the timing and route of TXA administration), and differences in the methodology used for calculating HBL. The specific emphasis on muscle preservation and meticulous vascular management in our DAA protocol might have contributed to the observed reduction in HBL.

Furthermore, during DAA procedures, the lateral circumflex femoral vessels are directly identified and reliably ligated. In contrast, during PLA, when managing the medial circumflex femoral vessels posteriorly, it is sometimes unavoidable to incompletely address certain vascular branches; for instance, when partially transecting the quadratus femoris muscle, which is highly vascularized and may not be fully amenable to intraoperative hemostasis.[21] Additionally, during postoperative rehabilitation, hip motion, particularly flexion, exerts less traction on anteriorly located vascular structures, whereas posteriorly located vessels may experience greater traction forces, potentially leading to rebleeding and subsequent increases in HBL.[22]

Compared to the DAA, clinicians should be aware that patients undergoing the PLA are associated with greater postoperative Hb reduction and HBL. While selecting a surgical strategy for THA, HBL may be incorporated into consideration alongside conventional factors such as hip stability. For high-risk patients, such as older adults, those with anemia, or individuals with cardiopulmonary comorbidities, DAA may represent a comparatively advantageous option, potentially mitigating HBL-related complications. Conversely, if PLA is indicated, vigilant perioperative monitoring for anemia remains warranted. Future studies should aim to validate HBL-reduction protocols and explore their association with long-term outcomes.

In the current study, HBL constituted a substantial portion of TBL throughout the perioperative period of THA and exerted a considerable influence on clinical outcomes. Therefore, HBL merits clinical attention, and strategies such as the administration of TXA should be implemented to reduce HBL.[23] Additionally, postoperative supplementation with iron and erythropoietin may be considered to prevent severe anemia.[24]

Nonetheless, there are several limitations to this study. First, the retrospective design and the limited number of patients, although sufficient to provide insightful preliminary evidence regarding the relationship between surgical approach (DAA *vs.* PLA) and HBL, limit the generalizability of the findings. Second, Hct and Hb measurements were assessed only at preoperative and postoperative Day 3 timepoints, with no extended monitoring for anemia, which could potentially result in an underestimation of HBL. Third, postoperative fluid resuscitation may have introduced hemodilution bias into the calculation of HBL.

In conclusion, perioperative HBL represents a critical clinical parameter requiring close attention in THA. Compared to the DAA, the PLA is associated with greater reductions in Hb and increased HBL, warranting heightened clinical vigilance. In the light of these data, recognition of its contribution to elevated HBL should prompt the implementation of protocol-driven blood conservation strategies to mitigate anemia-related sequelae.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: J.W.Z.: Wrote the draft of the manuscript, was a major contributor in design and revising; X.K.Y.: Critically reviewed and revised the manuscript for important intellectual content; X.C., Y.J.W., X.J.: Were involved in collecting data and design of the study. All authors approved the final manuscript and agree to be accountable for all aspects of the work.

Conflict of Interest: The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding: The authors received no financial support for the research and/or authorship of this article.

AI Disclosure: The authors declare that artificial intelligence (AI) tools were not used, or were used solely for language editing, and had no role in data analysis, interpretation, or the formulation of conclusions. All scientific content, data interpretation, and conclusions are the sole responsibility of the authors. The authors further confirm that AI tools were not used to generate, fabricate, or 'hallucinate' references, and that all references have been carefully verified for accuracy.

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