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ORIGINAL PAPER

Does the surgical approach in one stage bilateral total hip arthroplasty affect blood loss?

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Abstract
Purpose It is not clear whether type of surgical approach affects the amount of blood loss in one-stage bilateral total hip arthroplasty (THA). This study therefore aims to examine if type of surgical approach can affect peri-operative blood loss and allogeneic blood transfusion in patients undergoing one-stage bilateral THA.
Methods Records of 319 patients who underwent one-stage bilateral THA from January 2004 to June 2011 were retrospectively reviewed. Patients were divided into two groups: direct anterior (DA) approach (75 patients) and direct lateral (DL) approach (244 patients). Blood loss was calculated using a previously validated formula. Blood loss and need for allogeneic blood transfusion were compared between the two groups. Additionally, the effects of using cell saver and surgical approach were evaluated in a multivariate analysis.
Results Compared to the DL approach, calculated blood loss was significantly lower in the DA group (2,813.90±804.13 ml vs 3,617.03±1,148.47 ml) and a significantly lower per cent of patients needed allogeneic blood transfusion in the DA group (26.6 vs 52.4 %). Intra-operative cell saver was used in 36 patients. Compared to the non-cell saver group, mean blood loss was significantly higher in the cell saver group (4,061.0± 1,285.55 ml vs 3,347.71±1,083.85 ml), whereas the difference between the two groups regarding allogeneic blood transfusion was not statistically significant. The DA approach was an independent predictor of lower peri-operative blood loss and allogeneic blood transfusion while using cell saver was not.
Conclusions Our results may be explained by the lower extent of muscular dissection performed in the DA approach. Our findings also indicate that intra-operative cell salvage might not be justified in bilateral THA performed expeditiously.

Keywords Bilateral total hip arthroplasty · Direct anterior approach · Cell salvage · Blood loss · Transfusion

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Introduction

Although the majority of total hip arthroplasties (THAs) being performed are unilateral, bilateral osteoarthritis of the hip develops in 42 % of patients, necessitating replacement of both hips [1]. In spite of the existing controversy regarding the safety of one-stage bilateral THA, some surgeons prefer this approach in selected patients due to its benefits, which include faster recovery, easier rehabilitation, shorter hospital stay, lower procedure cost and one-session anaesthetic risk [2, 3].

Despite improvement in surgical and anaesthetic techniques, either one- or two-stage bilateral THAs are still associated with significant blood loss and a considerable portion of patients may require allogeneic blood transfusion [4, 5]. Allogeneic blood transfusion is associated with the risk of transmission of blood-borne infectious diseases and immunological risks such as haemolytic transfusion reactions, autoimmunisation, transfusion-related acute lung injury and immunomodulation [6]. In addition, it has been demonstrated that allogeneic blood transfusion increases the all-time mortality and the risk of subsequent surgical site infection and prolongs the length of the average hospital stay [5, 7].

Because of these untoward risks associated with blood transfusion, numerous strategies have been implemented to reduce the need for blood transfusion which include use of hypotensive regional anaesthesia [8], administration of erythropoietin and iron supplementation [9], use of tranexamic acid

[10, 11], preoperative autologous donation (PAD) [5, 6], application of blood salvage systems [12] and development of minimally invasive surgical procedures [13]. These strategies are particularly important for patients undergoing one-stage bilateral total joint arthroplasty due to the higher amount of blood loss.

The type of surgical approach and its influence on blood loss and subsequent need for allogeneic blood transfusion has been studied by various investigators previously [14, 15]. In recent years, the direct anterior (DA) approach for THA has been popularised mostly because of its intended muscle-sparing ability and potential for faster recovery [16, 17]. It is not known if the reduced soft tissue dissection and more expeditious closure in these patients may translate to a lower blood loss and subsequent need for blood transfusion. This study was designed to investigate this possible advantage of the DA approach compared to the traditional lateral approach to the hip in patients undergoing one-stage bilateral THA.

Methods

Upon approval from the Institutional Review Board, we retrospectively identified and reviewed a cohort of all patients who underwent one-stage bilateral THA by three surgeons at our institution between January 2004 and July 2011. After excluding patients with incomplete or illegible records, 319 patients were identified, consisting of 180 men (56 %) with an average age of 55 (range 17–78) and 139 women (44 %) with an average age of 59 (range 21–75).

These 319 patients were separated into two groups based on surgical incision type used: direct lateral (DL) group (76 %, 244 patients) and DA group (24 %, 75 patients). Surgical approach was selected based on surgeon pre-operative evaluation. We reviewed medical records to extract pertinent data including demographics, laboratory results and surgical data as well as details of blood loss, blood salvage system used, autologous donation and transfusion data (Table 1).

Patients undergoing THA at our institution are subjected to preoperative medical optimisation by an internist. All patients were offered the opportunity to donate blood pre-operatively. The criteria for autologous donors are not as stringent as those for allogeneic donors. Donors should have haemoglobin and haematocrit (Hct) levels be respectively no less than 11.0 g/dl and 33 % before each donation and that blood be donated about 30 days before surgery. There were no age or weight restrictions. The number of units donated was determined by patient decision and surgeon judgment [5]. All patients at our institution were screened for pre-operative anaemia and steps were taken to investigate previously unrecognised anaemia. Hypotensive regional anaesthesia was used on all patients, with all surgeries performed by or under the supervision of a fellowship-trained arthroplasty surgeon.

Surgical approach

The DL approach was performed using a modified Hardinge technique [18], similar to the technique described by Moskal and Mann [19], but with the patient in the supine position. This approach included division of the fascia lata by making the incision over the greater trochanter. Following division of the abductor mechanism approximately in the anterior two thirds of the gluteus medius, the approach was extended into the anterior aspect of the vastus lateralis and the anterior portion was retracted anteriorly. In order to facilitate reattachment at the time of closure, a small portion of the tendon was left attached to the greater trochanter. Hip dislocation and cutting of the femoral neck was performed after capsulotomy. Acetabular and femoral preparation was conducted following standard procedures [16].

For the DA approach, a regular operating table, which allows extension of the hip in the supine position, was used. The incision was placed slightly more anterior than the DL approach described above. The initial incision length was 8 cm. However, based on the need for proper surgical exposure, the incision could be lengthened. Following exposure of the tensor fascia lata the perimysium was divided. Blunt dissection between the sartorius and tensor fascia lata was performed to minimise the risk of injury to the lateral femoral cutaneous nerve. The femoral neck was exposed following anterior capsulectomy. To facilitate dislocation of the femoral head, double osteotomy was performed and a wedge of bone from the femoral neck was removed. The preparation of the acetabulum and the femoral neck was conducted in a

Table 1 Characteristics of patients in DA and DL groups

	DA ($n=75$)	DL ($n=244$)	p value
Age (years)	54.75±9.77	57.28±10.13	0.056
Gender (male)	48 (64 %)	132 (54.1 %)	0.14
BMI (kg/m^2)	26.20±3.46	28.20±4.81	<0.001
Units of allogeneic blood transfused (median, range)	0 (0–3)	1 (0–6)	<0.001
Units of donated autologous blood (median, range)	1 (0–2)	2 (0–3)	<0.001
Preoperative haemoglobin (mg/dl)	13.95±1.42	13.65±1.42	0.110
Operative time (min)	130.52±24.68	140.23±27.38	0.006

SD standard deviation, *BMI* body mass index

conventional manner. Exposure of the femoral canal involved selected soft tissue releases on the posterior aspect of the femoral neck. The DA approach required modified instruments for reaming of the acetabulum and femur. Uncemented femoral and acetabular components were used in all patients [16].

Blood loss calculation

Blood loss was calculated using the previously validated formulas as below [20]:

Total RBC loss (ml) = [uncompensated RBC loss] + [compensated RBC loss (ml)]
Uncompensated RBC loss (ml) = [initial RBC (ml) − final RBC (ml)
Initial RBC = [estimated blood volume (ml)] × [initial Hct level (%)] at day − 1
Final RBC = [estimated blood volume (ml)] × [final Hct level (%)] at day + 3
Compensated RBC loss = [sum of RBCs received from the various sources of transfusion]
Sum of various sources of transfusion = [allogeneic units × unit volume (ml) x unit Hct level (%)] + [autologous units × unit volume (ml) × donation Hct level (%)] + [CS reinfusion (ml) × 0.6]

Estimated blood volume (ml) needed to be calculated separately between men and women with the following formula:

Women: [body surface area (m^2)] × 2,430
Men: [body surface area (m^2)] × 2,530
Body surface area = 0.0235 × [height (cm)] 0.42246 × [weight (kg)] 0.51456
Total blood loss (ml) = 100 × [total RBC loss (ml)] / Hct %

Post-operative care

Venous thromboembolism prophylaxis was administered to all patients based on institutional protocol. Wound dressing and physical therapy were the same in both groups and have been previously described in detail [16]. Briefly, a few hours after the surgery, all patients were visited by a physical therapist and helped to sit in a chair and walk with assistance if possible. Wound dressing was also similar in both groups and incisional wounds were covered by a single large dressing.

Internist physicians were responsible for post-operative blood management. The protocol after THA included allogeneic transfusion for patients with haemoglobin of less than 8 g/dl or symptomatic patients with haemoglobin between 8 and 10 g/dl and past medical history of coronary artery disease. Symptoms triggering transfusion included persistent tachycardia (heart rate greater than 100), chest pain, dyspnoea, lassitude (inability to comply with physical therapy exercises) and hypotension.

Statistical analysis

Categorical variables were compared using Fisher's exact test, while the independent samples t test was used to compare continuous variables between the two groups. Using allogeneic blood transfusion as the end point, logistic regression analysis was performed to identify independent predictors of allogeneic blood transfusion. Multiple regression analysis was performed to determine predictors of peri-operative blood loss. In all statistical analyses, p values less than 0.05 were considered to be statistically significant.

Results

Calculated blood loss was significantly lower in the DA approach at 2,813.90±804.13 ml compared to the DL approach at 3,617.03±1,148.47 ml [difference between the two groups=803.12 ml, 95 % confidence interval (CI) 569.36–1,036.87, $p<0.001$]. Significantly, a lower per cent of patients needed allogeneic blood transfusion in the DA group (26.6 versus 52.4 %, $p<0.001$). However, there was no significant difference in the mean haemoglobin drop between the two groups (4.4 ±1.4 g/dl in DA versus 4.2± 1.6 g/dl in DL, $p=0.21$).

A cell salvage (CS) system was used in a total of 36 patients. The mean blood loss was significantly higher in the CS group at 4,061.0±1,285.55 ml compared to the non-CS group at 3,347.71±1,083.85 ml (difference between the two groups=713.297, 95 % CI 261.64–1,164.95, $p=0.002$), whereas the difference regarding allogeneic blood transfusion was not statistically significant (45.9 and 50 % in non-CS and CS groups respectively, $p=0.72$). It was the same regarding mean haemoglobin drop as it was higher (4.5±1.7 g/dl) but not statistically significant ($p=0.41$) after using CS compared to the non-CS group (4.2±1.9 g/dl).

Multivariate analysis indicated that the DA approach decreased the amount of peri-operative blood loss by 485.17 ml, whereas PAD reduced peri-operative blood by 390.07 ml. Prolonged operative time was also associated with increased blood loss (10.09 ml/min) (Table 2). Using allogeneic blood transfusion as the end point, logistic regression analysis demonstrated that the DA approach reduced the rate of allogeneic blood transfusion [odds ratio (OR) 0.31, 95 % CI 0.16–0.62, $p<0.001$], while women are at greater risk of allogeneic blood transfusion (OR 3.04, 95 % CI 1.67–5.54, $p<0.001$) following one-stage bilateral THA. Body mass index (BMI), operative time and pre-operative haemoglobin level were other predictors of allogeneic blood transfusion (Table 3).

Table 2 Results of multivariate analysis to identify predictors of peri-operative blood loss in study patients

	Estimate	Standard error	*t* statistic	*p* value
Intercept	−217.24	712.98	−0.30	0.76
Age (years)	8.44	5.61	1.50	0.13
Use of cell saver	270.12	190.50	1.41	0.15
Preoperative Hb (mg/dl)	98.02	39.28	2.49	0.01
Total PAD (units)	390.07	83.92	4.64	<0.001
Operative time (min)	10.09	2.21	4.55	<0.001
DA approach	−485.17	140.80	−3.44	<0.001

Hb haemoglobin, *PAD* preoperative autologous blood donation

Discussion

Various management strategies have been introduced to reduce peri-operative blood loss and the subsequent need for allogeneic blood transfusion in patients undergoing THA. In recent years improvements in anaesthesia and surgical techniques with the intention of minimising complications, reducing blood loss and improving overall outcome have gained much attention [5, 8]. The main purpose of this study was to investigate the influence of surgical approach on blood loss and need for blood transfusion in patients undergoing one-stage bilateral THA. We elected to investigate the bilateral THA patients as we believe these patients are at highest risk for blood transfusion and the complications that potentially ensue from receiving blood transfusions.

The study highlights some important findings. First, we noted that bilateral THA performed under one anaesthesia leads to substantial peri-operative blood loss. Using a validated formula [20] the amount of blood loss was calculated using pre-operative and post-operative Hct levels as well as other parameters that influence blood loss. The formula takes into account hidden blood loss into joint space and surrounding soft tissues as well as the post-operative blood loss. This method of determining blood loss overcomes the issues and limitations of using crude methods of blood loss estimation, which often cannot take into account post-operative blood loss.

Table 3 Predictors of allogeneic blood transfusion in patients who underwent simultaneous bilateral total hip arthroplasty

	OR	95 % CI	*p* value
BMI (kg/m^2)	0.90	0.85–0.96	0.002
Preoperative Hb (mg/dl)	0.63	0.50–0.81	<0.001
Operative time (min)	1.01	1.00–10.02	<0.001
DA approach	0.31	0.16–0.62	<0.001
Female	3.04	1.67–5.54	<0.001

OR odds ratio, *CI* confidence interval, *BMI* body mass index, *Hb* haemoglobin

Second, this study, and using multivariate analysis, demonstrated that the use of an intra-operative cell saver system did not confer any benefits in terms of reducing blood loss or the need for blood transfusion. This finding is in contrast to previous studies that have shown benefit for the use of an intra-operative blood salvage system [21, 22]. Multiple explanations exist for the latter finding. One of the most important factors may relate to the fact that all surgeries were done under regional anaesthesia, which is known to reduce blood loss per se, and using uncemented components that allowed surgery to be performed expeditiously. The use of an intra-operative blood salvage system may be beneficial during longer surgical procedures. Another reason for our failure to detect a benefit for the use of an intra-operative blood salvage system may relate to the specific type of cell saver system that we used. Over 800 mm of blood need to be shed and salvaged in order for this system to retrieve adequate blood for retransfusion. The major portion of blood loss in this cohort occurred post-operatively and in most cases an inadequate volume of blood was available for retransfusion.

Third, and perhaps the most important finding of this study, was that the use of a less invasive surgical approach, namely the DA approach, did lead to reduction in blood loss when compared to the DL approach. The reason for the latter may relate to the fact that in DL approach a larger degree of soft tissue dissection is carried out and particularly the abductor muscle is violated [17]. In addition, the operative time is usually longer, at least in our hands, when surgery is performed through the DL approach compared to the DA approach.

Previous studies have shown that using a minimally invasive approach may shorten length of hospital stay and post-operative pain as well as improve functional outcome of patients undergoing THA [16, 17, 23–26]. A randomised controlled trial carried out at our institution which recruited 100 patients undergoing unilateral THA (50 in each group) did not demonstrate any significant difference in blood loss, haemoglobin drop or allogeneic blood transfusion [16]. The use of estimated blood loss, as opposed to calculated blood loss, the smaller sample size and unilateral THA compared to bilateral THA in this study may have been some of the reasons for not recognising the beneficial effects of the DA approach in reducing peri-operative blood loss in our previous study. In contrast a study by Alecci et al. [23] demonstrated a significantly lower rate of allogeneic blood transfusion and haemoglobin drop in patients who underwent unilateral THA through the DA approach. However, that study did not report the amount of blood, but instead used drop in haemoglobin as a proxy for blood loss. In our study, we found a significant reduction in the amount of peri-operative blood loss and allogeneic blood transfusion but no difference in haemoglobin drop.

This study has a few limitations that need to be highlighted. We were not able to control change in the protocol of venous thromboembolic prophylaxis in our centre, in which some surgeons began using aspirin instead of coumadin in the latter years of the study. Another limitation was that patients in the DA group had lower mean BMI than those in the DL group, which might contribute to lower amounts of peri-operative blood loss and rate of allogeneic blood transfusion in this group. However, in the multivariate analysis controlling for the effect of confounder variables including BMI, the DA approach was still associated with lower amount of peri-operative blood loss and reduced risk of allogeneic blood transfusion. Therefore, we believe that higher mean BMI in the DL group could not affect our findings. Both groups were the same regarding level of pre-operative haemoglobin, which is the most important predictor of peri-operative blood transfusion.

In conclusion, this study indicated that peri-operative blood loss and rate of allogeneic blood transfusion are significantly lower in patients undergoing bilateral THA under regional anaesthesia using the DA approach compared to the DL approach. It also appears that an intra-operative blood salvage system, at least the type used in this cohort, does not seem to reduce the need for blood transfusion. We were cognisant of the numerous factors that influence blood loss during any surgery particularly bilateral procedures. All findings of this study were based on multivariate analysis that takes into account the influence of each confounding variable. Finally, as blood loss was elected to represent the primary end point for this study, we believe the use of a validated formula that calculates total blood loss, including post-operative loss, overcame some of the limitations that exist when crude methods for estimation of blood loss are used.

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