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Intra-operative blood salvage in total hip and knee arthroplasty

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ABSTRACT

Purpose. To review records of 371 patients who underwent total hip or knee arthroplasty (THA or TKA) with intra-operative blood salvage to determine the allogeneic blood transfusion rate and the predictors for allogeneic blood transfusion.
Methods. Records of 155 male and 216 female consecutive patients aged 17 to 95 (mean, 70) years who underwent primary THA or TKA by a single surgeon with the use of intra-operative blood salvage were reviewed.
Results. The preoperative haemoglobin level was <120 g/dl in 15% of THA patients and 5% of TKA patients; the allogeneic transfusion rate was 24% in THA patients and 12% in TKA patients. Despite routine use of intra-operative blood salvage, only 59% of THA patients and 63% of TKA patients actually received salvaged blood, as a minimum of 200 ml blood loss was required to activate blood salvage. In multivariable analysis, predictors for allogeneic blood transfusion were female gender (adjusted odds ratio [OR]=2.8, p=0.02), age >75 years (adjusted OR=5.9, p<0.001), and preoperative haemoglobin level <120 g/l (adjusted OR=30.1, p<0.001), despite the use of intra-operative blood salvage. Patients who received allogeneic blood transfusion had a longer hospital stay and greater complication rate.
Conclusion. Intra-operative blood salvage is not effective in preventing allogeneic blood transfusion in patients with a preoperative haemoglobin level <120 g/l. It should be combined with preoperative optimisation of the haemoglobin level or use of tranexamic acid.

Key words: *arthroplasty, replacement, hip; arthroplasty, replacement, knee; blood transfusion; operative blood salvage*

INTRODUCTION

Substantial peri-operative blood loss in total hip and knee arthroplasty (THA and TKA) may lead to postoperative anaemia and necessitate allogeneic blood transfusion, with the rate being 57% and 39%, respectively.[1] Total joint arthroplasty and fracture surgery account for most cases of allogeneic

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blood transfusion, compared with other surgical specialties.[2,3] Nonetheless, allogeneic blood transfusion is associated with risks of disease transmission, haemolytic reactions, immunomodulation, haemodynamic overload, acute lung injury, and coagulopathy.[4] Patients who receive allogeneic blood have an increased risk of postoperative infection, longer hospital stay, and mortality.[5–7] Various blood conservation strategies have been recommended. Nonetheless, preoperative autologous blood donation is not cost-effective and there is a high rate of unused blood.[8–10] The effectiveness of acute normovolaemic haemodilution is debatable.[11] Postoperative re-transfusion may result in transfusion reactions, as unwashed blood contains fibrin degradation products and other contaminants.[12,13]

Intra-operative blood salvage re-transfuses washed blood that is removed of biochemical, cellular, and non-cellular debris including activated clotting factors, fatty lipids, and bone, and results in minimal disruption to surgical workflow.[14,15] Intra-operative blood salvage has been reported to decrease the allogeneic blood transfusion rate varying from 57%[1] to 6%,[16] 8%,[17] and 15%[18] in THA, and from 39%[1] to 7%,[19] 11%,[20] and 16%[21] in TKA. This study reviewed records of 371 patients who underwent THA or TKA with intra-operative blood salvage to determine the allogeneic blood transfusion rate and the predictors for allogeneic blood transfusion.

MATERIALS AND METHODS

This study was approved by our hospitals' regional ethics committee. The proportion of patients who would require blood transfusion was assumed to be 20%, and thus 246 patients were required to obtain a 95% confidence interval (CI) with a maximum error of 0.05. Records of 155 male and 216 female consecutive patients aged 17 to 95 (mean, 70) years who underwent primary THA (n=135) or TKA (n=236) by a single surgeon from January 2010 to December 2011 (prior to the introduction of tranexamic acid) with the use of intra-operative blood salvage were reviewed.

THA was performed through an anterolateral approach with the patient in a lateral position. Uncemented acetabular and femoral components were used (Exceed acetabular cup Taperloc femoral stem, Biomet, Warsaw [IN], USA); no drain was used. TKA was performed through a standard medial para-patellar approach without tourniquet use. Computer navigation was used for alignment and preparation. Cemented femoral, tibial, and patellar components were used (Legion Primary, Smith and Nephew, Memphis [TE], USA). An intra-articular drain on low suction was removed on day 1. All patients received enoxaparin 40 mg daily for venous thromboembolic prophylaxis, commencing 4 hours postoperatively and continued for 14 days for TKA and 28 days for THA. Aspirin was continued throughout the peri-operative period if it was already prescribed.

Using the Haemonetics Cell Saver 5+ machine (Braintree [MA], USA), salvaged blood was washed and concentrated prior to re-transfusion in the recovery room. Haemoglobin level was checked on postoperative day 1. The transfusion trigger was patient-specific, based on the guidelines of the National Blood Authority of Australia. An absolute trigger was a haemoglobin level <80 g/l. Patients with symptomatic anaemia and significant comorbidities may be given transfusion at a haemoglobin level <100 g/l,[22] based on the surgeon's decision.

Binary variables were presented in proportion; normally distributed variables were presented as mean±standard deviation and compared using independent *t*-test; non–normally distributed variables were presented as median and inter-quartile range and compared using Mann-Whitney *U* test; discrete variables were presented as percentages and compared using Pearson Chi-squared test. Univariate and multivariate analyses were used to determine predictors for allogeneic blood transfusion, a p value of ≤0.10 and <0.05 was considered significant, respectively.

RESULTS

The preoperative haemoglobin level was <120 g/dl in 15% of THA patients and 5% of TKA patients; the allogeneic transfusion rate was 24% in THA patients and 12% in TKA patients (Table 1). Despite routine use of intra-operative blood salvage, only 59% of THA patients and 63% of TKA patients actually received salvaged blood, as a minimum of 200 ml blood loss was required to activate blood salvage. Only 9 patients who did not receive salvaged blood had blood loss >200 ml. Intra-operative blood loss was greater in patients who received salvaged blood than in those who did not (362.48 vs. 156.15 ml, p<0.001, Table 2).

Compared with patients who did not receive allogeneic blood transfusion, those who did had a lower preoperative haemoglobin level (139.61 vs. 122.76 g/l, p<0.001), less blood loss (290 vs. 245 ml, p=0.03), lower rate of re-transfusion of salvaged blood (64% vs. 48%, p=0.02), lower postoperative haemoglobin level (121.65 vs. 103.46 g/l, p<0.001),

Table 1
Patient characteristics and outcome*

Parameter	Total (n=371)	Total hip arthroplasty (n=135)	Total knee arthroplasty (n=236)
Female	216 (58)	86 (63)	130 (55)
Age >75 years	101 (27)	39 (29)	62 (26)
Age (years)	70 (17–95)	70 (17–91)	70 (47–95)
Body mass index (kg/m^2)	29.2 (15.7–52.2)	27.4 (15.7–43.8)	30.3 (18.5–52.2)
Body mass index (kg/m^2) category			
<20	4 (1)	3 (2)	1 (<1)
20–25	77 (21)	47 (35)	30 (13)
26–30	143 (39)	45 (33)	98 (42)
>30	147 (40)	40 (30)	107 (45)
Diagnosis			
Osteoarthritis	349 (94)	119 (88)	230 (97)
Inflammatory	6 (2)	2 (1)	4 (2)
Other	16 (4)	14 (10)	2 (1)
Preop haemoglobin (g/l)	137 (72–177)	134 (72–170)	138 (103–177)
Preop haemoglobin (g/l) category			
≥150	83 (22)	20 (15)	63 (27)
120–150	257 (69)	95 (70)	162 (69)
<120	31 (8)	20 (15)	11 (5)
Allogeneic blood transfusion	61 (16)	32 (24)	29 (12)
Whole blood loss (ml)	283 (50–1200)	271 (50–1200)	290 (100–950)
Re-transfusion of salvaged blood	228 (61)	79 (59)	149 (63)
Salvaged blood volume (ml)†	197 (10–890)	205 (40–890)	193 (10–650)
Haemoglobin drop until day 0 (g/l)	18.3 (-34–47)	17.7 (-34–40)	18.7 (-12–47)
Haemoglobin drop until day 1 (g/l)	28.4 (-29–56)	27.3 (-29–53)	29.1 (6–56)
Knee drain volume (ml)	-	-	209 (0–800)
Any complication	74 (20)	29 (21)	45 (19)
Length of hospital stay (days)	6 (3–30)	6 (3–16)	6 (3–30)

* Data are presented as no. (%) of patients or median (range)

† Only 79 and 149 total hip and knee arthroplasty patients actually received salvage blood, respectively

Table 2
Comparison of patients who did or did not receive intra-operative salvaged blood in terms of preoperative haemoglobin level and intra-operative blood loss

Parameter	Received salvaged blood (n=228)	Not received salvaged blood (n=143)	Mean difference (95% CI)	p Value
Preop haemoglobin (g/l)	137.40±14.03	135.85±12.76	1.6 (-1.4–4.5)	0.30
Intra-operative blood loss (ml)	362.48±136.69 (200–1200)	156.15±52.06 (50–350)	206.3 (182.8–229.8)	<0.001

longer hospital stay (5 vs. 6 days, p=0.01), and higher complication rate (15% vs. 48%, p<0.001) [Table 3].

In univariate analysis, main predictors for allogeneic blood transfusion were female gender (odds ratio [OR]=3.5, p<0.001), age >75 years (OR=5.2, p<0.001), THA (OR=2.3, p=0.004), and preoperative haemoglobin level <120 g/l (OR=44.4, p<0.001) [Table 4]. In multivariate analysis, predictors for allogeneic blood transfusion were female gender (adjusted OR=2.8, p=0.02), age >75 years (adjusted OR=5.9, p<0.001), and preoperative haemoglobin level <120 g/l (adjusted OR=30.1, p<0.001), despite the use of intra-operative blood salvage (Table 4). All 4 patients with a body mass index <20 kg/m^2 required allogeneic blood transfusion. THA was no longer a predictor for allogeneic blood transfusion, as this group had more percentage of patients with a preoperative haemoglobin level <120 g/dl and female gender.

DISCUSSION

Intra-operative blood salvage avoids problems with the storage of pre-donated autologous blood and allogeneic blood transfusion, and enables re-transfusion of more efficacious oxygen-carrying red blood cells that have a higher erythrocyte viability[23] and increased preservation of 2-3 diphosphoglycerate.[24] It also removes contaminants and concentrates the re-transfusion volume.

In our study, patients who underwent THA were

Table 3
Comparison of patients who did or did not receive allogeneic blood transfusion*

Outcome	Total (n=371)	Allogeneic blood transfusion (n=61)	No allogeneic blood transfusion (n=310)	Difference (95% CI)	p Value
Preop haemoglobin (g/l)	136.80±13.56	122.76±14.26	139.61±11.54	-16.9 (-13.5 to -20.2)	<0.001
Whole blood loss (ml)	283±150	245±156	290±148	-45.6 (-4.4 to -86.8)	0.03
Received salvaged blood	228 (61)	29 (48)	199 (64)	-16 (-3 to -30)	0.02
Salvaged blood volume (ml)	150 (135–250)	156 (130–270)	150 (135–250)	6	0.40
Haemoglobin drop until day 0 (g/l)	18.3±9.3	19.3±13.2	18.1±8.2	1.2 (-1.33 to 3.73)	0.38
Haemoglobin drop until day 1 (g/l)	28.4±10.1	28.4±16.2	28.5±8.4	-0.1 (-3.0–2.8)	0.95
Haemoglobin at day 1 (g/l)	118.46±14.14	103.46±11.04	121.65±12.60	-18.19 (-21.59 to -14.78	<0.001
Knee drain volume (ml)†	209±169	205±162	210±170	-4.8 (-73.4–63.7)	0.89
Length of hospital stay (days)	5 (5–7)	6 (5–8)	5 (5–7)	1	0.01
Any complication	74 (20)	29 (48)	45 (15)	33 (20–46)	<0.001

* Data are presented as mean±SD, no. (%), or median (interquartile range)

† In 27 and 197 total knee arthroplasty patients who did and did not receive allogeneic blood transfusion, respectively

Table 4
Univariate and multivariate analyses for predictors for allogeneic blood transfusion

Predictor	OR (95% CI)	p Value
Univariate analysis	Crude	
Female sex	3.5 (1.8–6.8)	<0.001
Age >75 years	5.2 (2.9–9.2)	<0.001
Total hip arthroplasty (vs. total knee arthroplasty)	2.3 (1.3–4.0)	0.004
Diagnosis of inflammatory condition (vs. osteoarthritis)	1.2 (0.1–10.1)	0.75
Diagnosis of other condition (vs. osteoarthritis)	4.62 (1.74–12.28)	0.002
Haemoglobin <120 g/l (vs. haemoglobin >150 g/l)	44.4 (12.8–154.3)	<0.001
Haemoglobin 120–150 g/l (vs. haemoglobin >150 g/l)	2.5 (0.8–7.3)	0.21
Body mass index (BMI) <20 kg/m^2 (vs. BMI 20–25 kg/m^2)*	-	-
BMI 25–30 kg/m^2 (vs. BMI 20–25 kg/m^2)	0.34 (0.17–0.67)	0.002
BMI >30 kg/m^2 (vs. BMI 20–25 kg/m^2)	0.23 (0.11–0.48)	<0.001
Multivariate analysis	Adjusted	
Female sex	2.8 (1.2–6.6)	0.02
Age >75 years	5.9 (2.9–12.1)	<0.001
Haemoglobin <120 g/l (vs. haemoglobin >150 g/l)	30.1 (7.5–121.6)	<0.001
Haemoglobin 120–150 g/l (vs. haemoglobin >150 g/l)	1.3 (0.4–4.1)	0.32

* All 4 patients with a BMI <20 kg/m^2 required allogeneic blood transfusion

more likely to require allogeneic blood transfusion, probably owing to a higher percentage of patients with preoperative haemoglobin level <120 g/l and lower percentage of patients actually received salvaged blood. Patients who received allogeneic blood transfusion had a longer hospital stay and higher complication rate. Those with a preoperative haemoglobin level <120 g/l were 30 times more likely to require allogeneic blood transfusion (despite the use of blood salvage), compared with patients with a preoperative haemoglobin level >150 g/l. Thus, preoperative optimisation of the haemoglobin level to a minimum of 120 g/l is essential.[11,25]

Our study had several limitations. It was retrospective and predisposed to recall and selection bias. A tourniquet was not used in TKA in order to avoid initial decrease in quadriceps strength, swelling, and postoperative pain.[26] Although tourniquet use decreases intra-operative blood loss, total blood loss is similar owing to decreased postoperative blood loss.[27] Patients did not receive any form of tranexamic acid; this eliminated the effect of tranexamic acid as a confounder of intra-operative blood salvage. Patients were allowed to continue taking aspirin during the peri-operative period, but this increases the risk of major bleeding.[28]

Allogeneic blood transfusion is associated with an increasing cost of blood banking. Intra-operative blood salvage combined with preoperative optimisation of haemoglobin level, use of tranexamic acid, and individualisation of the transfusion trigger is recommended.

CONCLUSION

Intra-operative blood salvage is not effective in preventing allogeneic blood transfusion in patients

with a preoperative haemoglobin level <120 g/l. It should be combined with preoperative optimisation of the haemoglobin level or use of tranexamic acid.

DISCLOSURE

No conflicts of interest were declared by the authors.

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