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Perioperative Transfusion in Total Hip Arthroplasty: Predictive Factors and Outcomes

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ABSTRACT

Background: Total hip arthroplasty is a common orthopedic procedure with significant hemorrhagic risks, often necessitating postoperative transfusions to treat anemia. Transfusions carry considerable costs and complications, including infection, necessitating judicious use. Identifying factors influencing transfusion rates in hip arthroplasty can improve perioperative management.

Patients and methods: Records of 3,865 patients who underwent primary total hip arthroplasty at a university center from 2002 to 2020 were retrospectively reviewed. Factors analyzed included age, sex, BMI, ASA physical status classification, surgical indication, operation duration, surgical approach, additional procedures, hospital stay duration, intraoperative complications, postoperative infections, anticoagulation, tranexamic acid use, anti-inflammatory use, and pre- and postoperative hemoglobin levels. Data were analyzed using descriptive, univariate, and multivariate analyses.

Results: The overall transfusion rate was 9.4%. Transfusion rates decreased from 28.5% (2002-2003) to 11.3% (2004-2012) and 4.3% (2013-2020). Multiple logistic regression showed that female sex, surgical indication, surgical approach, longer operative time, higher ASA scores, and greater postoperative hemoglobin drop significantly increased transfusion risk. Conversely, tranexamic acid and anti-inflammatory use, and higher body weight significantly decreased transfusion risk. Infection rates were higher among transfused patients (3%) compared to non-transfused patients (0.83%).

Conclusion: Reducing transfusion use is essential due to the scarcity of blood, associated costs, and complications, necessitating a standardized transfusion policy and perioperative care protocols. Optimizing preoperative hemoglobin, using controlled hypotension anesthesia, minimally invasive surgical approaches, consistent surgical techniques, perioperative tranexamic acid, and postoperative anti-inflammatory use are crucial to reducing transfusion risks. Transfusion is confirmed as an independent risk factor for postoperative infection.

Keywords: Total hip arthroplasty, transfusion, anemia, infection, tranexamic acid.

INTRODUCTION

Total hip arthroplasty (THA) is one of the most common orthopedic procedures with excellent outcomes[1]. Given the aging population in Western societies, its frequency is projected to increase significantly with a 176% rise by 2040 and a 659% rise by 2060 in the United States[2].

Given this anticipated increase, it is essential to address peri-operative complications, such as blood loss and the need for transfusions throughout the perioperative period[3]. THA is known for its hemorrhagic potential, due to the arterial network and bone osteotomies involved, which pose challenges for effective hemostasis[4].

Transfusions, while sometimes necessary to treat postoperative anemia, carry risks including infections, immuno-allergic reactions, transfusion overload,

coagulopathies, and significant costs[5-8]. They are also independently associated with increased risk of infectious complications, leading to greater patient morbidity and mortality, and burdening the healthcare system [9-12].

Reducing the risk of postoperative infections in THA by minimizing transfusions is crucial[13,14]. Blood-saving strategies are recommended to reduce the need for homologous blood transfusion, which requires the establishment of a clear transfusion policy[15,16].

Analyzing both patient-related factors and perioperative factors can help identify those most likely to require transfusion after THA[17,18]. Implementing a transfusion policy, using perioperative tranexamic acid (TXA), standardizing care, and selecting the appropriate surgical approach can lower transfusion rates[19-23].

This article aims to analyze these factors and propose an optimal management strategy to reduce the need for transfusions in THA patients, thereby decreasing the associated complications.

PATIENTS AND METHODS

Records of 3,865 patients who underwent THA performed by various surgeons at a university hospital in Belgium from 2002 to 2020 were retrospectively reviewed. The study protocol was approved by the university's ethics committee (reference N°B403201523492). Clinical information and laboratory test results were collected for analysis, including age, sex, body mass index (BMI), American Society of Anesthesiologists (ASA) physical status classification (ASA score), surgical indication, duration of surgery, surgical approach, associated procedures (e.g., hardware removal), length of hospital stay, perioperative complications, postoperative infections, postoperative anticoagulation, type of anesthesia, use of TXA, use of non-steroidal anti-inflammatory drugs (NSAIDs), preoperative and postoperative hemoglobin (Hb) levels, and the number of transfusions and units per transfused patient.

The primary outcome was early postoperative blood transfusion, defined as patients receiving allogeneic blood transfusions within 14 days of THA Transfusion indications evolved over time: autotransfusions (2002-2003), Hb < 8 g/dL (2004-2012) and, Hb < 7 g/dL or 8 g/dL with anemia symptoms (since 2013). The secondary outcome was infection within 90 days postoperatively.

Data were analyzed using descriptive, univariate, and multivariate analyses. Variables were expressed as mean ± standard deviation. Normal distribution of variables was assessed using QQ plots and Shapiro-Wilk tests. Spearman's rho and Cramer's V coefficients were used to test correlations between quantitative and qualitative variables, respectively. The Mann-Whitney U test and Chi-square tests were used to compare transfused and non-transfused patient groups.

Multivariate analyses involved successive logistic regression models to identify risk factors for transfusion. Variables with a correlation coefficient > 0.95 or a Variance Inflation Factor (VIF) > 5 were excluded to avoid multicollinearity. The final multiple logistic regression was performed based on variables selected from univariate analyses. The most accurate model was selected based on deviance and likelihood ratio tests (LRT).

All tests were two-sided with a significance threshold set at $p< 0.05$. Analyses were conducted using Sigmaplot 13 and SPSS software (v.28.0.1.1 (15), SPSS, Inc., Chicago, IL, USA).

RESULTS

Descriptive Statistics

We analysed records of 3,865 patients, with 59.3% female. The mean BMI was 26.81 kg/m² and 74.7% had an ASA physical status II (Table I). Almost all surgeries (99.61%) were under general anesthesia with an average operative time of 104.9 minutes (Table II). The average hospital stay was 7.37 days (Table III). Peroperative complications occurred in 1.2% of cases, and the postoperative infection rate was 1%. The mean difference in preoperative and postoperative Hb levels was 2.93 g/dL. The overall transfusion rate was approximately 9.4%.

Univariate Statistics

Univariate analysis showed that the year when the surgery was performed had a significant negative correlation with the length of hospital stay ($r = -0.755$, $p < 0.001$) and the duration of surgery ($r = -0.502$, $p < 0.001$). Surgery duration had a significant positive correlation with the length of hospital stay ($r = 0.460$, $p < 0.001$), and the number of transfused units was positively correlated with both times spent in hospital after surgery ($r = 0.266$, $p < 0.001$) and the duration of surgery ($r = 0.233$, $p < 0.001$).

Univariate Statistics

Quantitative Data with Non-Normal Distribution

Quantitative variables showed significant differences ($p < 0.001$) between transfused and non-transfused groups (Table IV). Transfused surgeries were

Table I. — Descriptive Demographic Statistics.

Variables (units)	Frequency (N)	Qualitative variables	Quantitative variables			
		Percentage (%)	Mean	Std dev	Min	Max
Sex	3865					
Male	1773	40,7				
female	2292	59,3				
BMI (cm/kg2)	3765		26,81	5,26	14,1	56,75
HTA	3864					
No	1987	51,4				
Yes	1877	48,6				
ASA score						
1	313	8,3				
2	2824	74,7				
3	626	16,6				
4	16	0,4				
The cohort is predominantly female, with a mean BMI indicating overweight. Nearly half have hypertension, and most are classified as ASA II, indicating mild systemic disease.						

Table II. — Descriptive Surgical Statistics.

Variables (units)	Frequency (N)	Qualitative variables	Quantitative variables			
		Percentage (%)	Mean	Std dev	Min	Max
Surgical Indication	3862					
coxarthrosis	2976	77,1				
osteonecrosis	359	9,3				
dysplasia	114	3				
fracture	297	7,7				
oncology	46	1,2				
orther	70	1,9				
Type anesthesia	3845					
general	3830	99,61				
rachi	15	0,39				
TXA	3836					
No	885	23,1				
Yes	2950	79,9				
Approach	3790					
Hueter	639	16,86				
Rottinger	1548	40,84				
Hardinge	1333	35,17				
Moore	264	6,97				
Per-op complication	3817					
No	3817	98,8				
Yes	47	1,2				
Surgical time	3778		104,86	39,92	27	360
The primary surgical indication was coxarthrosis. General anesthesia was used in nearly all cases, with the majority receiving tranexamic acid. The Rottinger and Hardinge approaches were most common, and perioperative complications were rare.						

Table III. — Descriptive Postoperative Condition Statistics.

Variables (units)	Frequency (N)	Qualitative variables	Quantitative variables			
		Percentage (%)	Mean	Std dev	Min	Max
Hospital stay (days)	3703		7,369	4,406	1	74
AINS	3855					
No	2272	58,9				
yes	1583	41,1				
anti	3739					
Fraxiparine®	3155	84,4				
Clexane®	487	13				
Sintrom®, xarelto®, others	97	2,6				
Hb (pre-post opératoire g/dl)	3781		2,933	1,307	0,2	13,6
Hct (pre-post opératoire %)	3753		8,457	3,905	0	29,6
Blood unit	3862		0,224	0,838	0	11
infection	3861					
No	3821	99				
Yes	40	1				
additional procedure	3861					
No	3750	97,1				
Yes	112	2,9				
Transfusion						
No	3863	90,6				
Yes	365	9,4				
Postoperatively, patients had an average hospital stay of over a week. NSAIDs and Fraxiparine® were commonly used. Hemoglobin levels typically decreased post-surgery. The infection rate was low, with few patients needing additional procedures or transfusions.						

Table IV. — Quantitative Data with Non-Normal Distribution - Mann-Whitney Tests.

	Z	p-value
Year	-10,86	<0,001
Hospital stay (days)	-16,07	<0,001
Surgical time (min)	-14,04	<0,001
BMI	-4,88	<0,001
Hb loss (pre-post)	-7,10	<0,001
Ht loss (pre-post)	-7,46	<0,001
Test results indicate significant differences between groups across multiple variables. Notably, the year of surgery, length of hospital stay, surgical time, BMI and hemoglobin loss all showed significant variations, with p-values less than 0.001 for each variable, indicating strong statistical significance.		

performed earlier (mean 2009 ± 5.4 years) than non-transfused ones (2012 ± 5.1 years) ($p < 0.001$). Transfusion rates declined from 28.69% (2002-2003) to 11.21% (2004-2012) and 4.87% (2013-2020), correlating with changing transfusion indications (Figures 1).

The time spent in hospital after surgery was significantly longer in the transfused group (11 ± 6 days) compared to the non-transfused group (7 ± 4 days) ($p < 0.001$) (Figure 2).

Categorical Data

Variables like sex, surgical indication, surgical approach, laterality, stem type, anticoagulant dose, additional procedures, postoperative infections, ASA score, and TXA and NSAID administration showed

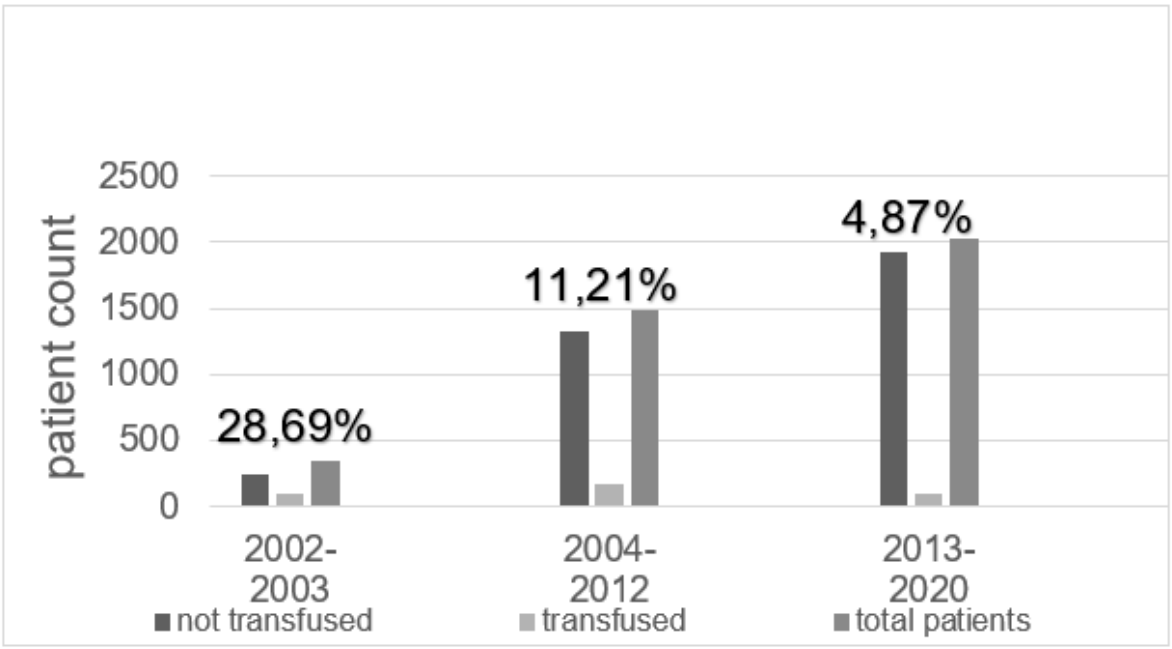

Fig. 1 — Percentage of Transfusions Based on the date of Surgery.
Transfusion rates decreased over time. In 2002-2003, the rate was 28.69%. This dropped to 11.21% in 2004-2012 and further to 4.87% in 2013-2020, indicating improved management and practices over the years.

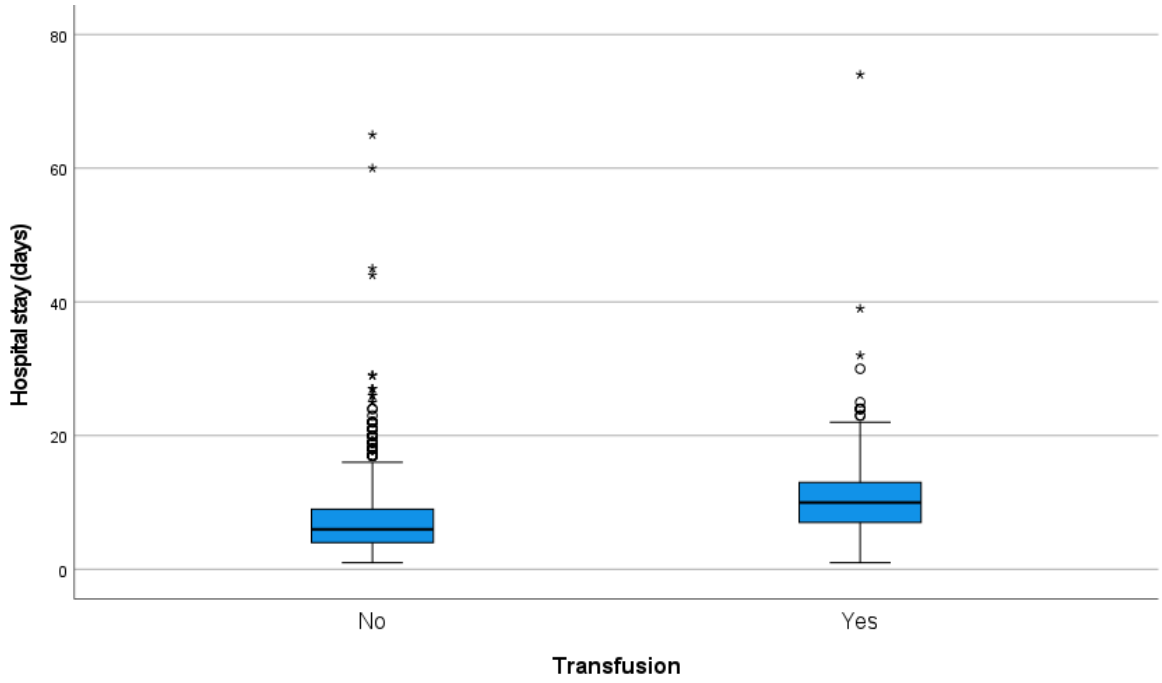

Fig. 2 — Comparison of Hospital Stay Duration Between Transfused and Non-Transfused Patients.

significant differences between the transfused and non-transfused groups ($p < 0.001$) (Table V).

Multivariate Statistics – Logistic Regression (Sigmaplot)

Several variables were excluded to avoid multicolinearity: the year due to its retrospective nature, the length of hospital stay as it could depend on the transfusion rather than the reverse, lost hematocrit as it is equivalent to lost Hb, and the anticoagulant dose due to differing units.

Multiple logistic regression revealed an increased transfusion risk with female sex, surgical indication, surgical approach, longer operative time, higher ASA score, and greater postoperative Hb drop. On the other hand, TXA administration, NSAID use, and higher

Table V. — Categorical Data - Chi-Square Tests.

	X^2	df	p-value
Sex	14,17	1	<0,001
Indication	240,77	8	<0,001
Surgical approach	164,38	5	<0,001
Additional procedure	99,75	1	<0,001
complication per-op	0,08	1	0,780
infection post-op	15,37	1	<0,001
anticoagulant type	1,43	2	0,489
anticoagulant dose	24,47	7	<0,001
Anesthesia type	0,19	2	0,909
TXA	93,62	2	<0,001
AINS	36,16	1	<0,001
HTA	0,63	1	0,429
ASA score	108,79	4	<0,001

Significant associations were found for sex, surgical indication, surgical approach, additional procedures, postoperative infection, anticoagulant dose, TXA use, NSAID use, and ASA score, all with p-values < 0.001. No significant associations were found for perioperative complications, type of anticoagulant, type of anesthesia, and hypertension.

BMI significantly reduced the likelihood of blood transfusion (Table VI).

Infection rates were higher among transfused patients (3%) compared to non-transfused (0.83%). Patients receiving TXA had a 7% transfusion rate, while not receiving TXA had a 17.9% transfusion rate. NSAID use also correlated with lower transfusion rates (5.8% vs. 12%) (Table VII).

Osteoarthritis patients had the lowest transfusion rate at 6.8% (Table VIII). The Hueter and Rottinger surgical approaches had fewer transfusions (3% and 4.6%, respectively) (Table IX). Higher ASA scores were associated with increased transfusion rates (Table X).

DISCUSSION

Blood loss in THA patients inevitably reduces Hb levels, often necessitating allogeneic blood transfusions to counteract anemia. However, several studies have shown that transfusions increase the risk of postoperative complications, mortality, inpatient duration, and costs[7,9-12]. Identifying high-risk patients and implementing preventive measures can help reduce transfusion rates.

Our analysis found a perioperative transfusion incidence of 9.4% and 4.87% for the more recent period. The transfusion rate observed in the most recent period of our cohort (approximately 4–5%) is consistent with contemporary reports from high-volume centers applying restrictive transfusion thresholds and modern blood management strategies[25-27]. In parallel, recent observational work suggests that, in the "tranexamic acid era" and with optimized perioperative pathways, transfusion has become uncommon in elective THA when preoperative haemoglobin is adequate[28-29]. Importantly, while many previous studies have analyzed limited time windows, the present work provides a longitudinal, real-world overview across major institutional transitions (transfusion triggers, adoption of tranexamic acid, and evolution of surgical practice), enabling a unified analysis of patient-related and modifiable practice-related determinants of transfusion[26].

Independent risk factors for early postoperative blood transfusion included lower weight, female sex, longer operative duration, greater intraoperative blood loss, absence of TXA and NSAIDs, higher ASA scores, lower preoperative Hb, and posterolateral or Hardinge surgical approaches. Conversely, THA for primary osteoarthritis was associated with a lower transfusion risk, likely due to better preoperative preparation, fewer comorbidities and less complex surgery. Our findings confirm well-established predictors of allogeneic transfusion after total hip arthroplasty, including higher ASA grade, lower preoperative haemoglobin/haematocrit and greater perioperative haemoglobin decrease[30]. These determinants are consistent with recent series emphasizing that baseline anaemia and physiological reserve strongly condition the probability of transfusion, even in modern pathways[27,28]. Beyond confirming these associations,

Table VI. — Multiple Logistic Regression.

	CR	95%IC		p-value
Sex	1,54	1,10	2,17	0,013
Indication	1,21	1,10	1,32	<0,001
Surgical approach	1,43	1,18	1,74	<0,001
additional procedure	0,99	0,52	1,90	0,978
infection post-op	4,29	1,64	11,24	0,003
Surgical time (min)	1,01	1,01	1,01	<0,001
TXA	0,43	0,33	0,57	<0,001
AINS	0,69	0,51	0,93	0,014
BMI	0,96	0,94	0,99	0,006
ASA score	2,97	2,3	3,82	<0,001
Hb (pre-post)	1,30	1,19	1,43	<0,001

Significant associations were found for sex, surgical indication, surgical approach, additional procedures, postoperative infection, anticoagulant dose, TXA use, NSAID use, and ASA score, all with p-values < 0.001. No significant associations were found for perioperative complications, type of anticoagulant, type of anesthesia, and hypertension.

Table VII. — Description of Factors Found Significant After Multiple Logistic Regression.

	Non transfused	Transfused	Total patients
Infection + number %	354 97%	11 3%	365 100%
Infection - number %	3469 99,17%	29 0,83%	3498 100%
TXA + number %	2744 93%	206 7%	2950 100%
TXA - number %	727 82,1%	158 17,9%	885 100%
NSAIDs + number %	1491 94,2%	92 5,8%	1583 100%
NSAIDs - number %	1999 88%	273 12%	2272 100%

Transfusion rates were higher in patients with infections, those not receiving TXA, and those not using NSAIDs. Specifically, infections, lack of TXA, and lack of NSAID use were significant factors associated with increased transfusions.

our analysis refines current knowledge by integrating patient-level risk factors with modifiable practice-related variables within a single multivariable framework, thereby supporting transfusion as a quality indicator reflecting the degree of implementation of structured perioperative blood management[26].

An underexplored finding of the present study is the association between postoperative NSAID use and a lower likelihood of transfusion. This could be due to NSAIDs reducing pain and associated hypertension peaks, thereby minimizing blood loss. However, known hypertensive patients from our cohort did not show a significant difference in transfusion rates. Historically, concerns were raised regarding increased operative blood loss with perioperative NSAIDs, largely attributed to platelet inhibition with non-selective agents[31]. However, more recent evidence across surgical fields suggests that NSAIDs are unlikely to meaningfully increase clinically significant postoperative bleeding outcomes, including transfusion, when used appropriately[32]. Furthermore, contemporary procedure-specific recommendations for THA incorporate NSAIDs or COX-2 selective inhibitors as part of multimodal analgesia when not contraindicated, reflecting their integration into ERAS-type pathways[26,33]. In this context, NSAID use in our cohort may represent a surrogate marker of protocolized multimodal analgesia and broader ERAS implementation rather than a direct causal protective effect; prospective studies differentiating NSAID classes (non-selective versus COX-2 selective), timing, and co-interventions (tranexamic acid,

Table VIII. — Description of Transfusions Based on Surgical Indication.

		Transfusion		
		NO	YES	Total
Coxarthrosis	count	2772	202	2974
	% within indication	93,2 %	6,8 %	100 %
Osteonecrosis	count	321	38	359
	% within indication	89,4 %	10,6 %	100 %
Dysplasia	count	101	13	114
	% within indication	88,6 %	11,4 %	100 %
Fracture	count	231	66	297
	% within indication	77,8 %	22,2 %	100 %
Oncology	count	28	18	46
	% within indication	60,9 %	39,1 %	100 %
Arthritis	count	4	4	8
	% within indication	50 %	50 %	100 %
Pseudarthrosis	count	19	22	41
	% within indication	46,4 %	53,7 %	100 %
Rhumatoïd arthritis	count	17	1	18
	% within indication	94,4 %	5,6 %	100 %
Periprosthétic fracture	count	2	1	2
	% within indication	66,7 %	33,3 %	100 %
TOTAL	count	3495	365	3860
	% within indication	90,5 %	9,5 %	100 %

Transfusion rates varied by surgical indication. Coxarthrosis had the lowest transfusion rate, while oncology and fracture patients had the highest rates. Overall, 9.5% of patients required transfusions, with significant variation depending on the underlying condition.

Table IX. — Description of Transfusions Based on Surgical Approach.

		Transfusion		
		0 NO	1 yes	Total
Hueter	count	620	19	639
	% within surgical approach	97,0 %	3 %	100 %
Rottinger	count	1471	73	1548
	% within surgical approach	95,3 %	4,7 %	100 %
Hardinge	count	1143	188	1331
	% within surgical approach	85,9 %	14,1 %	100 %
Moore	count	205	59	264
	% within surgical approach	77,7 %	22,3 %	100 %
Trochanterotomy	count	4	1	5
	% within surgical approach	80 %	20 %	100 %
TOTAL	count	3448	340	3788
	% within surgical approach	91 %	9 %	100 %

Transfusion rates varied significantly by surgical approach. The Hueter approach had the lowest transfusion rate, while the Moore approach had the highest. Overall, 9% of patients required transfusions, with the rate depending on the surgical technique used.

Table X. — Transfusions Based on ASA Score.

		Transfusion		
		NO	YES	Total
ASA I	count	300	13	313
	% within ASA score	95,67 %	4,33 %	100 %
ASA II	count	2607	217	2824
	% within ASA score	92,3 %	7,7 %	100 %
ASA III	count	504	122	626
	% within ASA score	80,5 %	19,5 %	100 %
ASA IV	count	10	6	16
	% within ASA score	62,5 %	37,5 %	100 %
TOTAL	count	3421	358	3779
	% within ASA score	90,5 %	9,5 %	100 %

Transfusion rates increased with higher ASA scores. Patients with ASA I had the lowest transfusion rate, while those with ASA IV had the highest. Overall, 9.5% of patients required transfusions, with the rate rising significantly in patients with greater surgical risk (higher ASA scores).

transfusion thresholds) are warranted to clarify causal mechanisms and identify the safest analgesic-blood management combinations[25,33].

We observed higher transfusion rates with lateral and posterior surgical approaches, likely due to their use during a period of autotransfusion policy and in more complex surgeries. To our knowledge, only one study compares the blood transfusion rate in different surgical approaches of the hip. It is reported that using a direct anterior approach is less likely to require blood transfusion (transfusion rate 4.14%) than an lateral approach (transfusion rate 11,29%)[24]. Those rates are comparable with our findings 3% for anterior approach and 14.1% for the lateral approach. The association between surgical approach and transfusion risk should be interpreted with caution, as approach selection is often intertwined with surgeon experience, case-mix, and time-period effects. Comparative data suggest that the direct anterior approach may be associated with lower transfusion rates when controlling for confounders, yet the magnitude of this effect can diminish within modern standardized pathways[24,26]. Future studies restricted to contemporary periods or using propensity score methods would be useful to better isolate the independent contribution of surgical exposure from concurrent perioperative changes.

Consistent with Frisch et al.[5], our study confirmed a higher infection rate in transfused patients (3%) compared to non-transfused patients (0.83%). Although we did not record postoperative mortality, Browne et al. (34) have demonstrated that transfusions are associated with higher postoperative complications and mortality, potentially due to heart failure or lung injuries[35]. Additionally, transfused patients had longer hospital stays, averaging four days more than non-transfused patients, corroborating previous findings[34-36].

We know that the length of patient admission impacts cost[37]. Complications related to transfusions also increase the total cost. Moreover, blood products represent a direct cost, and their use depletes reserves, which are already in shortage for some blood types. Given the costs and complications associated with transfusions, their application demands careful and judicious implementation.

Our institution adopted a policy of transfusing patients with Hb < 7 g/dL or < 8 g/dL with symptoms. We also standardized care to optimize preoperative Hb levels, minimize intraoperative blood loss, use TXA, and adopt less invasive surgical approaches.

The widespread adoption of tranexamic acid is widely recognized as a cornerstone of contemporary blood conservation in total joint arthroplasty, with consistent evidence showing reduced perioperative blood loss and transfusion requirements[38]. Real-world observational data further support that combining tranexamic acid with standardized fast-track/ERAS pathways is associated with very low transfusion rates in routine practice. In our cohort, the temporal decline in transfusion likely reflects this cumulative shift towards structured perioperative pathways rather than the effect of a single isolated change, which is an important message for institutions currently implementing ERAS programs. From a practical perspective, our results support the view that sustained reductions in transfusion after THA are achieved through a multimodal institutional strategy rather than isolated measures. Key components

include preoperative identification and treatment of anaemia, adoption of restrictive transfusion thresholds (commonly ~8 g/dL in orthopedic surgery, adjusted to symptoms and comorbidity), and routine antifibrinolytic therapy. These elements align with ERAS pathways emphasizing standardization, early recovery, and reduction of avoidable complications; in this context, monitoring transfusion rates can serve as a pragmatic institutional performance metric when implementing or updating ERAS/PBM protocols[39].

Our study has limitations, including its retrospective, monocentric design, which may introduce biases. The cohort includes all primary THA procedures, regardless of the primary indication, including complex tumor surgeries.

The small sample size of the transfused patient group limits our ability to draw definitive conclusions about the relationship between transfusion volumes and postoperative infectious complications. While we observed an increased infection rate in transfused patients, this group often included more fragile patients undergoing extensive and prolonged surgeries. Multicentric prospective studies are needed to better elucidate these findings.

CONCLUSION

Hip arthroplasty surgery often results blood loss, sometimes necessitating the allogeneic blood transfusions, which carry additional costs and complications, notably infections. Therefore, it is essential to limit their use. This can be achieved by defining a clear transfusion policy, standardizing perioperative anesthetic and surgical care, and utilizing TXA and possibly NSAIDs.

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