RESEARCH

The impact of preoperative anemia on red blood cell transfusion in primary and revision hip arthroplasty: A retrospective analysis

Oliver Poole, MD,[1] André Bernard, MD,[1] Blaine Kent, MD,[1] Paul Brousseau, BEd, RRT(A)[1]

1. Department of Anesthesia, Pain Management, and Perioperative Medicine, Dalhousie University, Halifax NS, Canada

Abstract

Rationale: Lower extremity joint arthroplasty can lead to significant blood loss, and the need for blood transfusion. The use of blood products is associated with a variety of adverse outcomes including infection, circulatory overload, and transfusion reaction. Objectives: The objective of this quality improvement study is to identify the prevalence of preoperative anemia at our institution, and elucidate its impact on perioperative transfusion in elective patients undergoing primary or revision hip arthroplasty. Methods: Data for this study was collected from four databases at our institution. Elective patients undergoing primary or revision hip arthroplasty were selected. Transfusion was defined as the receipt of a red blood cell transfusion on the surgical day through to postoperative day five. The primary outcome was the effect of preoperative anemia on transfusion rates. Results: The overall transfusion rate was 7.6%. Transfusion rates for primary and revision arthroplasty were 5.8% and 18.7% respectively. Patients with a preoperative hemoglobin between 100 and 120 g/L were 4.5 times more likely to be transfused than those with a hemoglobin between 121 and 140 g/L, and 15.4 times more likely than those greater than 140 g/L. Preoperative anemia was common, with 11.5% of all patients having a preoperative hemoglobin of 120 g/L or less. Conclusion: Preoperative anemia was common and was significantly associated with higher transfusion rates. These findings reinforce the need to optimize hip arthroplasty patients prior to surgery, where possible. As a quality control study, these findings may help direct policy regarding the deferral of elective hip arthroplasty patients who are anemic preoperatively.

Introduction

Lower extremity joint arthroplasty can lead to significant blood loss, and the need for blood transfusion[6]. Primary hip arthroplasty is associated with a transfusion rate between 18 – 68%[1-2,9-10]. IIn a recent study of over nine thousand total hip arthroplasty surgeries, Hart et al reported a transfusion rate of 22.2% within 72 hours of surgery[6]. Numerous blood conservation strategies have been implemented for joint arthroplasty including preoperative autologous donation, cell saving, erythropoietin, and tranexamic acid[11-13]. TThe use of blood products is associated with a variety of adverse outcomes including infection, circulatory overload, and transfusion reaction[6]. Restrictive transfusion protocols have been shown to be appropriate in both critical care, and following hip surgery[4,7]. Preoperative anemia has been associated with an increased incidence of perioperative transfusion[3,6,8] and a higher rate of prosthetic joint infection[5]. The Hart et al. study found preoperative anemia carried an odds ratio of 3.6 for red cell transfusion within 72 hours[6]. The aim of this quality improvement study is to identify the prevalence of preoperative anemia at our institution, and elucidate its impact on perioperative transfusion rates in patients undergoing elective primary or revision hip arthroplasty.

Methods

After obtaining approval from the institutional research ethics board, we began by creating a transfusion database by linking data from various existing sources at our institution. Data for this study was collected from four databases:

1. The intraoperative anesthesia information system (AIMS) contains all recorded intraoperative data including intraoperative procedures, physiologic data (vital signs, gas monitoring, among others), and all medications and therapies administered to patients during the course of intraoperative anesthetic care. (AIMS (Innovian® Anesthesia, Drager Medical Inc, Telford, PA))
2. The laboratory reporting system (Millennium Laboratory Information System, Cerner, Kansas City, MO) contains all laboratory and transfusion data within the Central Zone of the Nova Scotia Health Authority.
3. The perioperative surgical manager (Horizon Surgical Manager (HSM), McKesson, San Francisco, CA) contains perioperative nursing care notes, and documented surgical procedures performed.
4. The institution's admission, discharge and transfer registration system (STAR system) contains all registration data associated with a medical encounter within Central Zone, Nova Scotia Health Authority. This includes the patient's planned disposition post-operatively,

whether as an outpatient or as a same day admission.

This data was linked by the senior database analyst and the quality improvement and safety officer for the Department of Anesthesia, Pain Management, and Perioperative Medicine. This was performed using medical record numbers and/or encounter numbers and subsequently assigning a unique, anonymous study ID with the original medical record and encounter numbers removed. The data elements collected from the aforementioned databases are described in Table 1.

The Innovian database was searched for all elective surgeries between January 1st 2011 and June 30th 2015. Same day admission patients undergoing hip arthroplasty were selected and identified as undergoing primary or revision surgery. Transfusion for the purpose of this study was defined as the receipt of a red blood cell transfusion on the surgical day through to post-operative day number five. The degree of pre-operative anemia was assessed using preoperative complete blood count collected between pre-operative day 1 – 20. Patients without this blood work were excluded, however as all of the same day admission patients are seen in pre-operative anesthesia clinic, very few patients were excluded for this reason.

Statistical Analysis

The primary outcome was the effect of preoperative anemia on transfusion rates. This was analyzed using logistic regression. First, a set of univariate binary regressions were run to examine the effect of each of the predictors. Then a multivariate regression was used to examine the effect of each predictor while controlling for the others. As the primary predictor (preoperative hemoglobin) was a numerical variable, Kendall's Tau testing was used. When the predictor was a dichotomous categorical variable such as Primary or Revision surgery, or TXA use vs no TXA use, Mann-Whitney U tests were used. The dataset was also characterized using descriptive statistics to examine transfusion rates.

Table 1. Data elements collected and the institutional database source.

Data category	Data element	Database(s)
Demographic	Age, sex, height, weight, operative procedure, medical record number (required for linking)	HSM[1]
Type of surgical admission	Designation as "same day admit" (SDA) surgery (to enable exclusion of ambulatory surgical/day surgery cases)	STAR
Medications and blood products	Type, dosage, timing	Innovian[2], Millenium[3]
Lab results	Preoperative and postoperative hemoglobin (Hgb) and hematocrit (HCT), date, time	Millenium[3]
Surgical variables	Procedure, type, anesthesia type (general, neuraxial, regional/peripheral nerve block), date, time	Innovian[2], HSM[1]

[1]HSM (Horizon Surgical Manager (HSM), McKesson, San Francisco, CA); [2]Innovian (Innovian® Anesthesia, Drager Medical Inc, Telford, PA); [3]Millenium Laboratory Information System, Cerner, Kansas City, MO

Results

1727 patients were included in the analysis. The overall transfusion rate was 7.6%. The transfusion rate for primary and revision arthroplasty was 5.8% and 18.7% respectively as shown in Table 2. Revision surgery (vs Primary) was a predictor of transfusion in univariate analysis (OR 3.712, P <.001), however this effect was not preserved in the multivariate analysis (OR 1.773, 95% CI 0.963; 3.264, P = 0.066).

There was an inverse relationship between preoperative hemoglobin level and transfusion risk with an OR of 1.10 (p<0.001) as shown in Table 3. Thus, for every one unit increase in preoperateive hemoglobin, patients were 10% more likely to not require a transfusion.

Transfusion rates were indirectly related to the degree of preoperative anemia, as shown in Figure 1. Patients with a preoperative hemoglobin between 100 and 120 g/L were 4.5 times more likely to be transfused than those with a preoperative hemoglobin between 121 and 140 g/L, and 15.4 times more likely than those with a hemoglobin greater than 140 g/L. Though the data visualization in Figure 2 suggests that there is a slight trend towards more transfusions in the revision group, the magnitude of the preoperative hemoglobin effect does not vary across Primary vs. Revision group.

Table 2. Descriptive statistics split by primary vs reivsion surgery.

Numerical variables		
Variable	Primary median (IQR)	Revision median (IQR)
Transfusion amount (mL)	297 (71.25)	294 (66)
Length of stay (days)	5.50 (2)	9 (10)
Preoperative hemoglobin (g/L)	121.5 (17)	120 (25)
Procedure duration (min)	80 (31)	154 (72)
Categorical variables		
	Primary N (%)	Revision N (%)
Transfused (yes)	99 (5.8%)	50 (18.7%)
TXA (yes)	681 (40.2%)	173 (64.8%)

Table 3. Binary logistic regression results when predicting transfusion (yes/no)

			95% CI for odds ratio	
	p	Odds ratio	Lower	Upper
Univariate				
No TXA vs TXA	0.018	1.529	1.077	2.172
Primary vs revision	<0.001	3.712	2.568	5.366
Preoperative hemoglobin	<0.001	0.907	0.893	0.921
Procedure duration	<0.001	1.013	1.009	1.017
Multivariate				
No TXA vs TXA	<0.001	4.171	2.487	6.996
Primary vs revision	0.066	1.773	0.963	3.264
Preoperative hemoglobin	<0.001	1.10	1.09	1.13
Procedure duration (min)	<0.001	1.020	1.014	1.027

This is supported by a non-significant interaction effect (Odds Ratio = 1.02, p = .20).

Preoperative anemia was common in our study population, with 11.5% of all patients having a preoperative hemoglobin of 120 g/L or less (as shown in Table 4). The percentage of primary and revision arthroplasty patients with a hemoglobin of 120 g/L or less was 10.4% and 18.0% respectively. Men were more often anemic than women with 38.5% of men having a preoperative hemoglobin of 140 g/L or less, whereas 17.4% of women had a preoperative hemoglobin of 120 g/L or less.

There was no relationship between degree of anemia and transfusion volume in either the primary or revision groups. The majority of patients received 1-2 units of blood if transfused, this is shown in Figure 3.

Tranexamic acid (TXA) use had a statistically

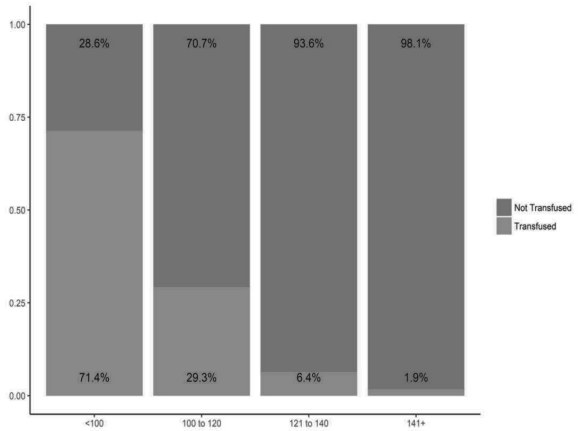

Figure 1. Comparison of transfusion rate by preoperative hemoglobin group.

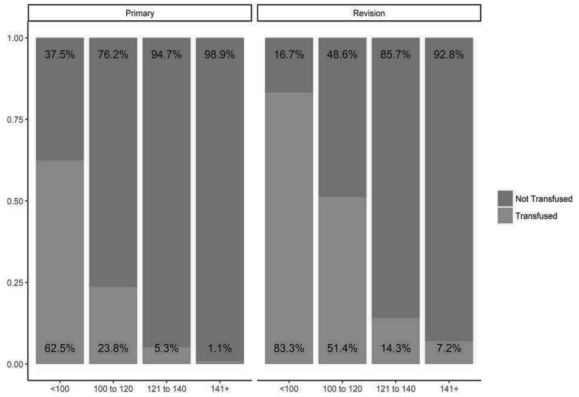

Figure 2. Bar plot comparing transfusion rate and preoperative hemoglobin, grouping into preoperative hemoglobin groups, splitting by Primary vs. Revision.

significant effect on transfusion risk. Patients who did not receive TXA had an odd ratio of 4.171 of requiring transfusion (OR 4.171, 95% CI 2.487,6.996, P < .001). Procedure duration was a predictor of transfusion risk in both the univariate (OR 1.013, 95% CI 1.009,1.017, P < .001) and multivariate logistic regression (OR 1.020,

Table 4. The frequency of patients in each preoperative hemoglobin group.

Group	Preoperative hemoglobin (g/L)	Frequency	Percent (%)	Cumulative percent (%)
All	<100	14	0.8	0.8
	100 to 120	184	10.7	11.5
	121 to 140	886	51.3	62.8
	141+	643	37.2	100
	Total	1727		
Female	<100	14	1.5	1.5
	100 to 120	149	15.9	17.4
	121 to 140	616	66.0	83.4
	141+	155	16.6	100
	Total	934		
Male	<100	0	0	0
	100 to 120	35	4.4	4.4
	121 to 140	270	34.1	38.5
	141+	488	61.5	100
	Total	793		
Primary	<100	8	0.5	0.5
	100 to 120	147	9.9	10.4
	121 to 140	774	52.0	62.4
	141+	560	37.6	100
	Total	1489		
Revision	<100	6	2.5	2.5
	100 to 120	37	15.5	18.0
	121 to 140	112	47.1	65.1
	141+	83	32.9	100
	Total	238		

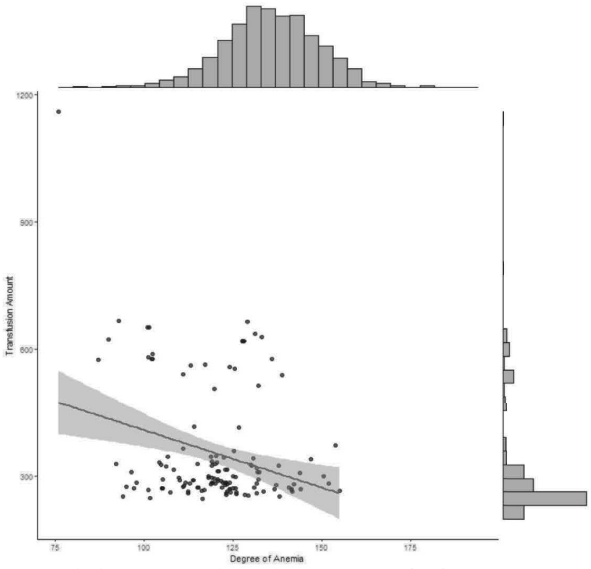

Figure 3. Scatterplot of transfusion amount (mL) and preoperative hemoglobin in g/L.

95% CI 1.014,1.027, P < .001).

Discussion

Despite only including elective, same day admission patients in our analysis, preoperative anemia was common. The rates of preoperative anemia of 120g/L or lower were high in all groups, but were especially high in the revision arthroplasty group.

Preoperative anemia had a significant impact on transfusion rates, which suggests that preoperative optimization of patients undergoing hip arthroplasty is essential. The data from this study provides an opportunity to evaluate the pre-anesthetic assessment process at our institution. The results of this study, as well as others in the literature suggest a strong relationship between preoperative anemia and transfusion rates, yet a significant number of elective patients in this study entered the operating room anemic. Transfusion rates were significantly higher in patients with preoperative anemia, but we were not able to analyze the impact of these transfusions on significant outcomes such as prosthetic joint infection, or mortality. The literature to date has however presented a convincing case for the relationship between preoperative anemia, transfusion, and prosthetic joint infection[5].

The data in this study is from 2011-2015, during which time there was a movement towards blood conservation strategies in joint surgery. The use of TXA has been increasing over the past decade, and this is not reflected in our data. The current analysis has not attempted to track transfusion rates over time to elucidate the impact of blood conservation strategies such as TXA use. There was considerable heterogeneity in the tranexamic dosing in our data, with some patients receiving infusions, and some boluses of varying amount. We were also not aware of the context of the TXA use. It is likely that many patients received prophylactic bolus dosing, while others may have received TXA reactively when bleeding was encountered. It is due to this heterogeneity that we decided to include TXA as a binary variable in the analysis. Future study may attempt to analyze the impact of TXA dosing on transfusion rates in joint arthroplasty.

The preoperative hemoglobin value was defined as the closest hemoglobin measurement to the surgical day. We used preoperative day 20 as a cut off for preoperative hemoglobin value, as the majority of patients are seen in pre-anesthetic clinic within 3 weeks of their surgery. It is not known whether patients with preoperative anemia received any non-transfusion intervention prior to surgery, such as iron supplementation. It is possible that an anemic patient seen in clinic on preoperative day 20 may have a received corrective treatment and actually presented to the operating room with a hemoglobin higher than reported in our analysis.

Transfusion was defined as receiving packed red blood cells on the surgical day through postoperative day five. It is unclear for any of the transfused patients in the analysis what the transfusion trigger was. It is possible that patients were transfused unnecessarily, or at hemoglobin triggers higher than recommended in the literature[7], which may create a misleading transfusion rate. The data we collected was not capable of elucidating the decision making process for transfusion, which is a limitation. We do not feel there was a significant degree of unnecessary transfusion, given the transfusion rates reported in the study are lower than those reported in literature[1-2, 9-10], suggesting a restrictive transfusion attitude.

This study shows that preoperative anemia is common in elective hip arthroplasty patients at our institution, and has a significant impact on transfusion rates. Transfusion rates were predicted by the degree of preoperative anemia. From a quality control perspective, our data provides valuable insight into the perioperative impact of anemia at our center, and may help guide quality improvement strategies for elective arthroplasty patients. Future research should examine the clinical impact of this higher transfusion rate with respect to outcomes such as prosthetic joint infection, and mortality.

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