

Association of pre-operative anemia and cell saver usage with red blood cell transfusion in total joint replacement surgery patients

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ABSTRACT

BACKGROUND: Pre-operative (pre-op) anemia contributes to the risk of transfusion in total joint replacement patients. This study 1) evaluated blood usage among total joint replacement patients, 2) determined the estimated hemoglobin (Hb) decline, and 3) reviewed cell saver usage. A proposed guideline for an anemia management program was reviewed as a strategy to minimize transfusion risks for these patients.

STUDY DESIGN AND METHODS: A total of 254 patients who underwent primary total joint replacement surgeries at this facility between January 1 and July 18, 2013 were evaluated. Data included patient demographics, type of joint, autologous blood pre-donation, cell saver use, pre- and post-op Hb, and number of allogeneic red blood cell units transfused.

RESULTS: Pre-op anemia was more prevalent in transfused patients (57.9%) compared to the non-transfused patients (10.4%) ($p < 0.0001$). Pre-op Hb in the transfused group was 1.8 g/dL lower than the non-transfused group. The mean Hb delta was 3.0 g/dL. Cell saver usage did not decrease transfusion rates nor increase post-op Hb values.

CONCLUSION: This facility has a low transfusion rate for total joint replacement surgery patients, though pre-op anemia was more prevalent in the transfused patient group. The mean post-op Hb decline can be used in conjunction with pre-op values to predict blood usage and target pre-op treatment. A higher transfusion rate among patients who used a cell saver suggests a need for further investigation into the efficacy of its usage. Establishing a pre-op anemia management program could further decrease transfusions and costs, and improve patient outcomes.

INTRODUCTION

Pre-operative (pre-op) anemia is associated with higher blood transfusion rates among patients undergoing total joint replacement surgery and other major orthopedic surgeries.¹ Blood transfusions carry a variety of risks including post-operative (post-op) infections, poorer outcomes, increased length of stay and increased mortality.¹ The implementation of a pre-op anemia management program can mitigate the risk of transfusion in total joint replacement patients and thereby improve outcomes.²

This study evaluated blood usage among total joint replacement patients to determine the estimated hemoglobin (Hb) decline post-op for predicting transfusion needs. Cell saver usage was evaluated for correlation to allogeneic (allo) red blood cell (RBC) transfusion. A proposed guideline was reviewed as a strategy to minimize transfusion risks as part of an anemia management program for patients undergoing major orthopedic surgeries.

MATERIAL AND METHODS

Patients

A total of 254 patients who underwent primary total joint replacement surgeries at this facility between January 1 and July 18, 2013 were evaluated. No joint replacement revision surgeries were included in this study. This study was approved by the facility's Institutional Review Board.

Data Collection

Laboratory data was collected using Siemens Soarian Health Information System software (Munich, Germany). These data included pre-op Hb from a sample collected up to 21 days prior to surgery, number of allo RBC units transfused intra-operatively (intra-op) and up to 30 days post-op, and next available post-op Hb (typically collected the morning after the procedure). Hb was analyzed on the Sysmex XE-2100 Hematology analyzer (Kobe, Japan). Post-op Hb values for transfused patients were collected but not analyzed, since these Hb values could be elevated due to the transfusion and not accurately reflect post-op Hb decline. Patient data collected from chart review included age, gender, use of perioperative cell saver technology, and surgery type (knee or hip).

The current practices of this facility are that few patients undergoing such surgeries pre-donate autologous (auto) units. Only one patient pre-donated 2 auto units and the units were not transfused. Therefore, this data was not included in this study.

Hb Reference Range and Transfusion Trigger

WHO defines anemia as Hb <12.0 g/dL in a female and <13.0 g/dL in a male.³ However, this facility has a defined reference range for Hb of 12.0-16.0 g/dL for females and 12.0-17.5 g/dL for males. To stay consistent with literature, this study used the commonly defined Hbs for anemia of <12.0 g/dL for females and <13.0 g/dL for males. For orthopedic surgery patients, this facility's transfusion guidelines dictate that patients with active bleeding and/or Hb \leq 7.0 g/dL require RBC transfusion.

Statistical Analysis

Chi-square analysis was calculated to assess associations between pre-op Hb and RBC transfusions, and between cell saver usage and RBC transfusions. Differences were considered significant at p values of less than 0.05.

RESULTS

Of the 241 patients evaluated, 111 had hip replacements and 130 had knee replacements. The majority of joint replacements were unilateral though 6 bilateral joint replacements were noted with no significance to the results discussed in this study. The mean age was 67 years (range 23-88 years). Table 1 shows the patient demographics that included 141 females (58.5%) and 100 males (41.5%). The cell saver was used in 55 cases (22.8%). Pre-operatively, the mean Hb was 13.6 g/dL (range 9.0-16.9 g/dL). Post-op Hb was not analyzed as some patients in this group were transfused intra-op and/or post-op. A total of 33 patients (13.7%) were anemic (Hb ranges 9.0-11.8 g/dL for females and 9.4-12.9 g/dL for males) prior to their surgery. Thirteen patients were excluded for lack of laboratory data (12 were missing pre-op laboratory values and one was missing post-op values).

Of the 241 patients, 222 (92.1%) patients were not transfused. One-hundred and two patients in this subset had hip replacements and 120 had knee replacements. The mean age was 67 years (range 23-88 years). There were 131 females (59.0%) and 91 males (41.0%). The cell saver was used in 51 (22.3%) patients. Pre-operatively, the mean Hb was 13.8 g/dL (range 9.0-16.9 g/dL). Post-operatively, the mean Hb was 10.8 g/dL (range 8.2-15.3 g/dL). The mean drop in Hb from pre-op to post-op was 3.0 g/dL.

There was virtually no difference in the mean drop in Hb between males and females. The Hb decline for hip replacements was higher at 3.3 g/dL compared to knee replacements at 2.7 g/dL. Of the 222 non-transfused patients, 24 (10.8%) were anemic (Hb ranges 10.9-11.8 g/dL for females and 11.5-12.9 g/dL for males) prior to their surgery.

Of the 19 patients who were transfused, nine had hip replacements and 10 had knee replacements. The mean age was 71 years (range 57-87 years). There were 10 females (52.6%) and nine males (47.4%). The cell saver was used in six patients (31.6%) all of whom received allo units as well. The mean pre-op Hb was 12.0 g/dL (range 9.0-15.3 g/dL). Post-op Hb was not analyzed as all patients in this group were transfused intra-op and/or post-op. A total of 30 allo RBC units were transfused to these 19 patients, 3 units being transfused intra-op and 27 post-op. Of the 19 transfused patients, 11 (57.9%) were anemic (Hb ranges 9.0-11.6 for females and 9.4-12.7 g/dL for males) prior to their surgery.

With regard to blood transfusion in total joint replacement patients, similarities and differences should be assessed to help better predict blood usage (Table 1). Patients were slightly older in the transfused group (71 years) compared to the non-transfused group (67 years). The gender ratio in the two groups was virtually the same; there were more females than males in both groups.

Pre-op anemia was more prevalent in the transfused patients (57.9%) compared to the non-transfused patients (10.4%) ($p < 0.0001$). The pre-op Hb in the transfused group was 1.8 g/dL lower compared to non-transfused group (Table1). The mean Hb drop in

non-transfused patients was 3.0 g/dL, with a larger drop in hip replacements over knee replacements (Table 2).

Cell saver was used in the surgeries of 57 of 241 (23.7%) patients (Table 3), and the usage was slightly higher in the transfused group (31.6%) compared to the non-transfused group (22.3%). Of the patients who used the cell saver, six (10.5%) were transfused with allo RBC units. Of the 184 patients who did not use the cell saver, 13 (7.1%) were transfused with allo RBC units ($p = 0.397$). The two groups had virtually the same post-op mean Hb, when excluding transfused patients, at 10.7 g/dL for those who used cell saver and 10.8 g/dL for those who did not.

DISCUSSION

It has been well established that pre-operatively anemic orthopedic patients are more likely to require transfusions. Jans et al reported that a much larger proportion of transfused patients were anemic pre-operatively when compared to non-transfused patients.⁴ Spahn et al also illustrated that lower pre-operative Hb levels in patients appear to “trigger” blood transfusions.⁵ Beirbaum et al found a correlation between blood transfusion and a pre-operative Hb <13 g/dL.¹ Callaghan and colleagues cited that pre-operative Hb level and anemia are major contributing factors in predicting transfusion in total joint replacement patients.⁶ Similarly, data in this study showed a correlation between pre-operative anemia and blood transfusion in total joint replacement surgery patients. There was a much higher incidence of anemia in the transfused patient group. Additionally, this study showed a decrease in pre-operative Hb of 1.8 g/dL among

transfused patients (mean 12.0 g/dL) compared to non-transfused patients (mean 13.8 g/dL).

However, this facility showed a lower transfusion rate (7.9%) for total joint replacement patients compared with another study that reported 14.5% of the 449 patients who underwent total joint replacement surgeries were transfused with red blood cells.⁷ This can be attributed to the work of a blood management consulting group and the revamping of transfusion education and guidelines throughout this facility. This consulting group reviewed transfusion data and compared this facility's transfusion practices with the best practices. They also provided physician continuing education regarding blood transfusion management. Finally, the consulting group refined this facility's transfusion guidelines.

Similar to the overall lower transfusion rate, this facility's auto pre-donation rate and cell saver usage rate were 0.4% and 22.8%, respectively, which were lower than the respective rates of 30.3% and 76.8% reported in the 2013 study by Perazzo et al.⁸ These findings can also be attributed to effective education of medical staff. The mean Hb delta of 3.0 g/dL at this facility was consistent with values reported in the study by Callaghan.⁶

Of note, the three patients excluded for missing data were transfused with a total of 10 RBC units (2 intra-op and 8 post-op), which accounted for 25.0% (10/40) of the total units transfused in the original patient set. This may indicate that lack of pre-operative Hb evaluation may lead to higher transfusion rates.

There are conflicting practices regarding the use of cell saver technology in total joint replacement surgeries. Previous reports have shown infusion of shed blood (i.e. cell saver use) decreases the likelihood of allo transfusions in total joint replacement

patients.^{5,8,9,10} Moonen reported a 0.4 g/dL increase in post-op day one Hb for those who used cell saver compared to those who did not.⁹ However, a recent report shows that the use of cell saver did not decrease the incidence or quantity of allo transfusions in total joint replacement patients. Rather, the use of cell saver increased costs and extended length of stay.¹¹ This facility showed a higher frequency of transfusion in patients who used the cell saver compared to patients who did not, indicating that the use of cell saver did not reduce the need for transfusion but instead increased the incidence of transfusion. At this facility, the post-op Hb values were virtually the same for the patients who used the cell saver and the patients who did not.

The mean drop in Hb from pre-op to post-op can help forecast which patients could be at higher risk for transfusion based on lower pre-op values. Managing a patient's anemia prior to surgery could reduce allo transfusions.⁶ This study showed a mean 3.0 g/dL decrease in Hb post-op for total joint replacement patients. Combined with the Hb transfusion trigger of 7.0 g/dL at this facility, it can be assumed that the large majority of patients with a pre-op Hb <10.0 g/dL will require transfusion. Results of this study revealed that four of four (100%) patients with a pre-op Hb of <10.0 g/dL required allo RBC transfusion.

One strategy to manage pre-operative anemia and the risks associated with transfusion and blood exposure is a pre-operative anemia management program, which has the potential to provide more effective blood usage and cost savings while also improving patient outcomes.¹ One such comprehensive pre-operative anemia management strategy was proposed by Goodnough (Fig. 1.)² In a study comparing transfusion rates among patients managed pre-operatively for their anemia vs. those not

managed, no patients in the anemia management program were transfused allo RBCs while 27.4% of patients in the control group were transfused.¹² Data from this study will contribute to the development and implementation of a pre-operative anemia management program at this facility.

The target pre-operative Hb levels for an anemia management program should be above the WHO thresholds for anemia to decrease transfusion risks, as the majority of transfused patients in our study were anemic pre-operatively. The program should include the evaluation of pre-operative anemia and bleeding risk through laboratory studies and also exclude the use of anti-platelet and anticoagulant drugs prior to surgery.⁶ If anemia is detected, additional tests should be performed to determine cause due to nutritional deficiencies (iron studies), chronic renal insufficiency (serum creatinine and glomerular filtration rate) or chronic inflammation. Anemias of unknown cause should also be investigated as secondary to another condition.² A recommendation from the Circular of Information is to treat anemias that can be corrected by iron, vitamin B12, folic acid and erythropoietin with such hematinic medications in lieu of blood.¹³ Anemias detected at least 28 days prior to surgery may allow more sufficient time for erythropoiesis.¹³

For this facility, future research needs related to pre-operative anemia and transfusion management in total joint replacement patients should include the investigation into the current use of the cell saver in total joint replacement surgeries to determine its appropriateness and efficacy. Another area for investigation should include a review of this facility's data following the implementation of a pre-operative anemia

management program. Comparative data of this type would be useful in validating the benefit of a pre-operative anemia management program at this facility.

In conclusion, the results of this study were consistent with previous reports that pre-operatively anemic total joint replacement patients require more blood transfusions. A patient with a pre-op Hb of <10.0 g/dL will likely require transfusion. The facility-defined transfusion trigger of a 7.0 g/dL Hb combined with a 3.0 g/dL mean decline in Hb resulted in 100% patients with a <10.0 g/dL Hb requiring allo transfusion, but an anemia management program has the power to mitigate pre-operative anemia and improve patient outcomes.

REFERENCES

1. Bierbaum BE, Callaghan JJ, Galante JO, Rubash HE, Tooms RE, Welch RB. An analysis of blood management in patients having a total hip or knee arthroplasty. *J Bone Joint Surg Am* 1999;81:2-10.
2. Goodnough LT, Maniatis A, Earnshaw P, Benoni G, Beris P, Bisbe E, Fergusson DA, Gombotz H, Habler O, Monk TG, Ozier Y, Slappendel R, Szpalski M. Detection, evaluation, and management of pre-operative anaemia in the elective orthopaedic surgical patient: NATA guidelines. *Br J Anaesth* 2011;106:13-22.
3. WHO. Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity. *VMNIS* 2011;11.1:1-6.
4. Jans O, Jørgensen C, Kehlet H, Johansson PI. Role of pre-operative anemia for risk of transfusion and post-operative morbidity in fast-track hip and knee arthroplasty. *Transfusion* 2013;54:717-26.
5. Spahn DR. Anemia and patient blood management in hip and knee surgery: a systematic review of the literature. *Anesthesiology* 2010;113:482-95.
6. Callaghan J, Spitzer A. Blood management and patient specific transfusion options in total joint replacement surgery. *The Iowa Orthopedic Journal* 2000;20:36.
7. Thimmaiah R, Peter V. Blood transfusion in hip and knee joint replacement surgery. *Internet J of Ortho Surg* 2009;17:1.
8. Perazzo P, Viganò M, de Girolamo L, Verde F, Vinci A, Banfi G, Romagnoli S. Blood management and transfusion strategies in 600 patients undergoing total

- joint arthroplasty: an analysis of pre-operative autologous blood donation. *Blood Transfus* 2013;11:370-6.
9. Moonen AFCM, Knoors NT, van Os JJ, Verburg AD, Pilot P. Retransfusion of filtered shed blood in primary total hip and knee arthroplasty: a prospective randomized clinical trial. *Transfusion* 2007;47:379-84.
 10. Muñoz M, Ariza D, Campos A, Martín-Montañez E, Pavía J. The cost of post-operative shed blood salvage after total knee arthroplasty: an analysis of 1,093 consecutive procedures. *Blood Transfus* 2013;11:260-71.
 11. So-Osman, C, Nelissen, RGHH, Koopman-van Gemert, AWMM, Kluyver, E, Poll, RG, Onstenk, R, Can Hilten, JA, Jansen-Werkhoven, TM, van den Hout, WB, Brand, R, Brand, A. Patient blood management in elective total hip-and knee-replacement surgery (Part 1). *Anesthesiology* 2014;120:839-51.
 12. Moráis S, Ortega-Andreu M, Rodríguez-Merchán EC, Padilla-Eguiluz NG, Pérez-Chrzanowska H, Figueredo-Zalve R, Gómez-Barrena E. Blood transfusion after primary total knee arthroplasty can be significantly minimised through a multimodal blood-loss prevention approach. *International Orthopedics* 2014; 38(2):347-54.
 13. Guidance for Industry: An Acceptable Circular of Information for the use of Human Blood and Blood Components. Revised November 2013. [Available at <http://www.fda.gov/downloads/BiologicsBloodVaccines/GuidanceComplianceRegulatoryInformation/Guidances/Blood/UCM364593.pdf> (accessed June 10, 2014).]

Table 1: Age, gender, use of cell saver, and pre-op Hb between non-transfused and transfused patients.

	Age (mean)	Gender		Cell Saver (% used)	Mean Pre- op Hb (g/dL)	Pre-op Anemia (%)
		Female (%)	Male (%)			
All Patients (241)	67	58.5	41.5	22.8	13.6	13.7
Non-transfused (222)	67	49.0	41.0	22.3	13.8	10.8
Transfused (19)	71	52.6	47.4	31.6	12.0	57.9

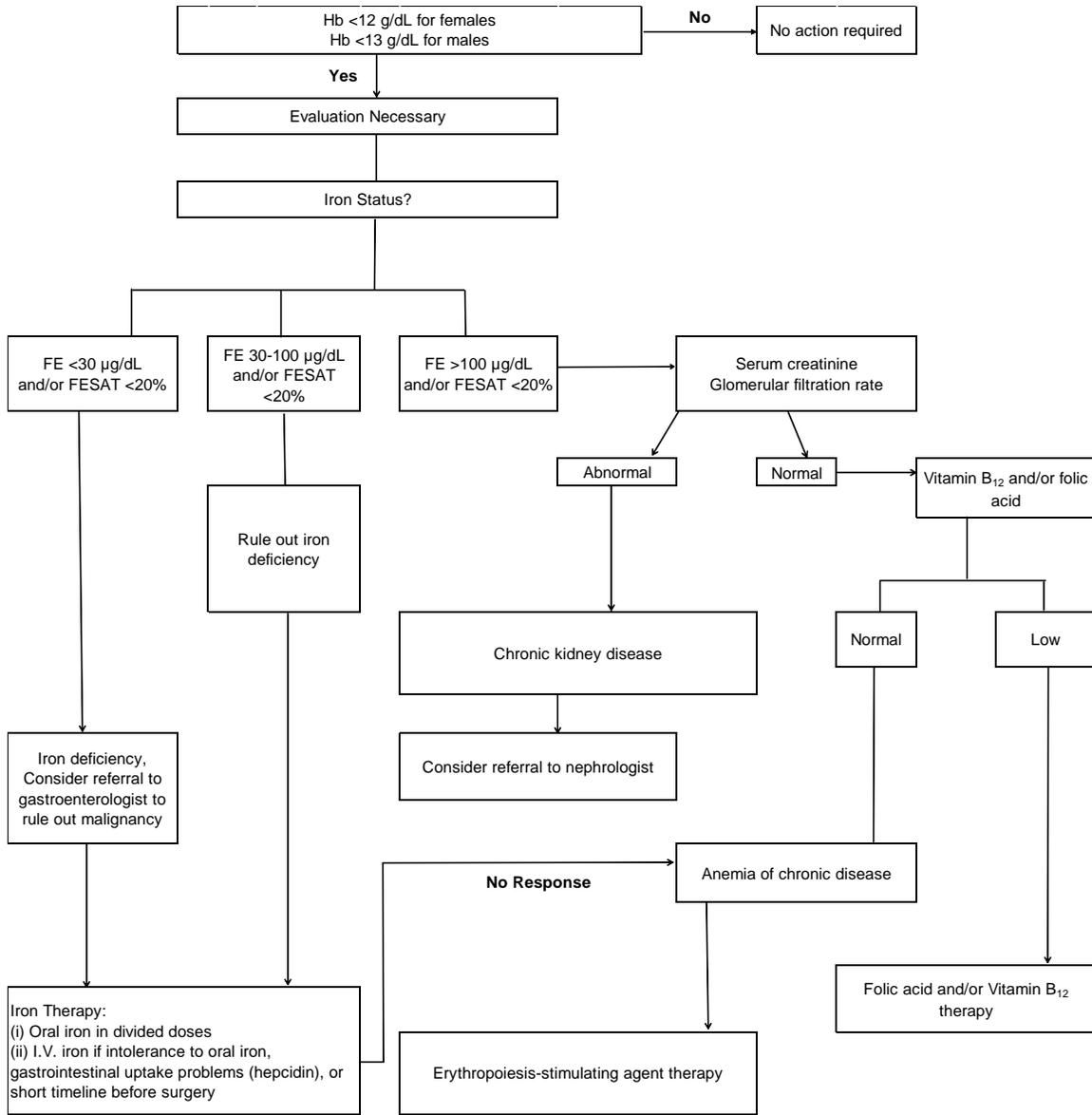
Table 2: Pre- and post-op Hb delta values in non-transfused patients.

	Delta Mean Hb (g/dL)
All Patients	3.0
Females	3.0
Males	3.0
Knee Surgery	2.7
Hip Surgery	3.3

Table 3: Transfusions and post-op Hb relevant to cell saver usage.

	Patients		# Units Transfused			Patients Transfused		Post-op Hb (g/dL)
	#	%	Intra-op	Post-op	Total	#	%	
Used Cell Saver	57	23.7	2	9	11	6	10.5	10.7
No Cell Saver	184	76.3	1	18	19	13	7.1	10.8

Fig 1: Proposed algorithm for the detection, evaluation and management of pre-operative anemia.²



FE = serum iron
FESAT = iron saturation