HSSJ (2011) 7: 141–144
DOI 10.1007/s11420-011-9200-9

ORIGINAL ARTICLE

Nonanemic Patients Do Not Benefit from Autologous Blood Donation Before Total Knee Replacement

Stephen Kim, MD · Eric Altneu, BS · Jad Bou Monsef · Elizabeth A. King, BS · Thomas P. Sculco, MD · Friedrich Boettner, MD

Received: 11 July 2010/Accepted: 22 February 2011/Published online: 14 June 2011

Abstract A retrospective analysis of 221 patients undergoing unilateral total knee arthroplasty between January 2007 and April 2008 was performed to look at rates of total transfusions, allogenic transfusions, and autogenic transfusions. Two senior surgeons performed all the surgeries. During that period, patients in group A (129 patients) all donated one unit of autologous blood and patients in group B (92 patients) did not donate. Within both groups, patients were further divided by preoperative hemoglobin level as either anemic or non-anemic. A hemoglobin of 12.5 g/dL was used as the cutoff. Ninety-eight patients in group A (76%) required autologous blood. Patients in group A received a higher total number of transfusions (0.93 per patient) than those in group B (0.33 per patient; $p<0.001$). The rate of allogenic transfusion was lower for group A (14%) than for group B (25%; $p<0.033$). The reduction of allogenic transfusions associated with preoperative autologous blood donation was confined to anemic patients (29% in group A vs 72% in group B; $p=0.0006$). There was no difference in allogenic blood transfusions in non-anemic patients between group A (8%) and group B (9%; $p=0.91$). Limiting autologous blood donation to anemic patients decreased cost compared to routine autologous blood donation (US $256.63/patient versus US $511.44/patient) without exposing patients to increased allogenic blood transfusions. Targeted blood management in total knee replacement surgery decreases transfusion rates and reduces cost.

Keywords primary total knee replacement · autologous blood · transfusion · blood management

Introduction

Total knee arthroplasty (TKA) is associated with a significant perioperative blood loss and can require blood transfusion to treat postoperative anemia [1]. While allogenic transfusion is widely regarded as a safe alternative with modern blood bank protocols, the potential risks of blood-borne diseases, transfusion reaction, allergic reaction, and postoperative infection still exist [1, 4, 17, 18]. Preoperative autologous blood donation (PABD) is currently the gold standard to reduce the incidence of allogenic transfusion. Unfortunately, donation of autologous blood is costly, creates logistical challenges, and can result in phlebotomy-induced anemia, which may actually increase the risk of needing a transfusion [1, 4, 18]. Furthermore, use of autologous blood may not eliminate all the risks of transfusion, including fluid overload, increased hospital stay, and administrative errors [1, 2, 4, 6, 11, 14, 15].

With these potential disadvantages, several studies have questioned the efficacy of routine PABD in reducing the need for allogenic blood [1, 6, 11, 14, 15], as well as its cost-effectiveness [3, 9, 12]. In a study by Forgie et al [11], patients who donated autologous blood had lower hematocrit levels immediately prior to surgery than patients who did not donate blood. While the rate of allogenic transfusion was somewhat lower in this group, the total transfusion rate was higher and many autologous units were wasted [11]. As a result, the efficacy of autologous blood in anemic patients has been questioned [5, 8].

The current study investigates (1) whether routine donation of one unit of autologous blood prior to primary TKA reduces exposure to allogenic blood compared to a protocol in which autologous blood is not utilized, (2) whether anemic and/or non-anemic patients benefit from

Each author certifies that he or she has no commercial associations (e.g., consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted article.

Each author certifies that his or her institution has approved the reporting of this case and that all investigations were conducted in conformity with ethical principles of research.

S. Kim, MD · E. Altneu, BS · J. B. Monsef · E. A. King, BS · T. P. Sculco, MD · F. Boettner, MD (✉)
Hospital for Special Surgery,
535 East 70th Street, New York, NY 10021, USA
e-mail: boettnerf@hss.edu

PABD, (3) whether PABD increases the overall number of blood transfusions, (4) what percentage of autologous blood is wasted, and (5) the difference in cost between the two blood management protocols.

Materials and Methods

The two senior attending surgeons at the author's institution (surgeons A and B) performed primary TKAs utilizing a standardized minimally invasive midline approach under hypotensive regional anesthesia. During the study period, the two surgeons utilized different standard blood management protocols. Surgeon A routinely attempted to send patients for preoperative donation of one unit of autologous blood, whereas surgeon B did not routinely advise preoperative autologous blood donation. After approval was obtained from our Institutional Review Board, retrospective chart reviews were performed for all patients who underwent primary TKA performed by the two surgeons between January 2007 and April 2008. Gender, age, body mass index (BMI), preoperative hemoglobin, date of preoperative hemoglobin measurement, date of autologous blood donation, intraoperative blood pressure, preoperative co-morbidities, American Society of Anesthesiologists score, number of autologous transfusions, number of allogenic transfusions, time of transfusion, vital signs during the postoperative period, postoperative hemoglobin levels until date of discharge, and in-hospital complications were recorded. Patients were excluded if their charts noted blood dyscrasias, significant coronary artery disease, and/or simultaneous bilateral knee replacement. Patients whose actual blood management deviated from the standard protocol of their attending surgeon were excluded from analysis.

During the study period, surgeon A performed 140 unilateral TKAs in patients eligible for study inclusion. Eleven patients did not donate autologous blood, leaving 129 patients in group A who donated one unit prior to surgery. During the study period, surgeon B performed 97 unilateral TKAs in patients eligible for study inclusion. Four patients requested to donate one unit of autologous blood, and one patient was transfused outside the normal criteria (hemoglobin above 10.0 g/dL, stable vital signs, and no attempt of a fluid bolus), leaving 92 patients in group B. Patients in both groups were further divided by preoperative hemoglobin level, utilizing 12.5 g/dL as the cutoff. Patients with a hemoglobin level above 12.5 g/dL were considered non-anemic.

Patients received allogenic transfusions if the hemoglobin level dropped below 8.0 g/dL, and they displayed clinical symptoms of anemia. The decision to transfuse autologous blood in the post-anesthesia care unit was initiated at the discretion of the anesthesiologist, and strict transfusion guidelines were not always enforced.

The two groups were similar in terms of age, BMI, and diagnosis. Group A included 54 male and 75 female patients (n=129) with mean age 70 years (range, 39 to 88 years), mean BMI 29.0 kg/m^2 (range, 18.6 to 53.4 kg/m^2), and 129 patients with a diagnosis of osteoarthritis. Group B included 27 male and 65 female patients (n=92) with mean age 67 years (range, 43 to 86 years), mean BMI 30.4 kg/m^2 (range, 17.4 to 46.5 kg/m^2), and 90 patients with a diagnosis of osteoarthritis, one with a diagnosis of avascular necrosis, and one with a diagnosis of psoriatic arthritis.

The cost benefits were calculated considering the average cost of an autologous/allogenic unit of blood of US $250, a type and cross fee of US $100, and a transfusion fee of US $100. Insurance reimbursement for preoperative donation or transfusion was not considered for this protocol.

Data were analyzed using a standard t test with two tails in Microsoft Excel (Microsoft Corporation, Redmond, WA, USA, Microsoft Office 2008 Version 12.1.4 for Macintosh). A p value of less than 0.05 was considered statistically significant.

Results

In group A, 76% of patients received autologous transfusions (Table 1), whereas no patients in group B received autologous blood. As a result, patients in group A received a higher total number of transfusions (0.93 per patient) than those in group B (0.33 per patient; p<0.001; Table 1). However, the overall rate of allogenic transfusion was lower for group A (14%) than for group B (25%; p=0.03).

Overall, 74% of the patients in group A and 73% of the patients in group B had a preoperative Hgb of greater than 12.5 g/dL. In both groups, non-anemic patients had fewer total blood transfusions per patient than did anemic patients (Table 1; p<0.001). The rate of allogenic transfusion for non-anemic patients in group A (8%) was similar to the rate of

Table 1 Blood utilization in the two different treatment groups

	Number of patients	Number patients who received autologous blood transfusions	Number of patients who received allogenic blood transfusions	Total number of transfusions
Group A (1 unit autologous blood)	129 (100%)	98 (76%)	18 (14%)	0.93
Group B (no preoperative donation)	92 (100%)	0 (0%)	24 (25%)	0.33
Group A preop Hgb≤12.5 mg/dL	34 (26%)	31 (91%)	10 (29%)	1.29
Group B preop Hgb≤12.5 mg/dL	25 (27%)	0 (0%)	18 (72%)	0.96
Group A preop Hgb>12.5 mg/dL	95 (74%)	67 (71%)	8 (8%)	0.80
Group B preop Hgb>12.5 mg/dL	67 (73%)	0 (0%)	6 (9%)	0.09

allogenic transfusion for non-anemic patients in group B (9%). This difference was not statistically significant (p=0.91).

Subgroup analysis revealed that the reduction of allogenic transfusion associated with PABD was confined to anemic patients with baseline Hgb≤12.5 g/dL. The 29% rate of allogenic transfusion for anemic patients in group A was lower than the 72% rate of allogenic transfusion for anemic patients in group B (p=0.006).

In group A, 98 (76%) autologous units were transfused and 31 (24%) were wasted. However, in the anemic subset of group A, 31 (91.2%) autologous units were transfused and only 3 (8.8%) were wasted. The two blood management protocols did not differ with regards to discharge Hgb, which was 10.1 g/dL (range, 8.2–13.2 g/dL) in group A and 10.1 g/dL (range, 8.3–13.3 g/dL) in group B (p=0.94). There was no difference between anemic and non-anemic patients with regard to age (group A 72.4 vs. 69.0 years, p=0.27; group B 68.9 vs. 66.2 years, p=0.27) and BMI (group A 28.7 vs. 28.9 years, p=0.86; group B 29.7 vs. 30.7 years, p=0.51).

Cost analysis revealed increased cost with routine PABD (group A) compared to patients not donating autologous blood (group B): US $511.44/patient versus US $217.83/patient ($p$<0.0001). There was no difference in cost for anemic patients between both protocols: US $613.24/patient (group A) versus US $464.00/patient (group B; p=0.08). If preoperative autologous blood donation is only utilized for anemic patients but not for non-anemic patients, using a cutoff hemoglobin of 12.5 g/dL, the overall cost remains similar to group B: US $256.63 USD/patient versus US $217.83/patient.

Discussion

The present retrospective study evaluates the efficacy of a selective preoperative autologous blood donation protocol in primary total knee replacement (TKR) surgery. The study confirms that routine PABD decreases the overall need for allogenic blood. However, the reduction is confined to anemic patients only. There was no difference in allogenic blood transfusions in non-anemic patients between groups.

The current study is limited by several factors. While strict transfusion guidelines were enforced for allogenic blood, autologous blood was transfused at the discretion of the covering anesthesiologist in the post-anesthesia care unit rather than a standardized protocol. Also, the outcomes are not applicable to all patients, as those with preexisting conditions that might put them at risk for a transfusion were excluded from the study. Spinal epidural anesthesia and minimally invasive surgical technique were utilized by both surgeons, which may limit the applicability of our results to centers where these techniques are not employed. Some insurance plans reimburse for PABD or costs associated with type and cross, transfusion procedures, or discarded blood. These revenues have not been considered for the calculation of blood management expenses.

The correlation between low preoperative hemoglobin and the need for postoperative transfusions in TKR has been previously shown in a study by Bong et al. [4]. With this in mind, some studies have criticized routine autologous blood donation for increasing the need for transfusions due to the low preoperative hemoglobin caused by the preoperative donation process [6]. This is supported by a prospective randomized trial on patients undergoing elective total hip replacement in which Billote and coworker [3] concluded that PABD may be detrimental for non-anemic (Hgb levels above 120 g/L) patients because despite increased health care costs, it did not eliminate the use of allogenic blood. Keating et al. [19] showed that in patients with a hemoglobin greater than 13 g/dL, the use of a universal autologous donation protocol resulted in 66% of the blood being wasted. Likewise, Hatzidakis et al. [14] found that in young, non-anemic patients who generally did not require transfusion after primary joint replacement surgery, 83% of the autologous donated blood was discarded. These high rates of wasted autologous blood reinforce the importance of selecting an appropriately targeted group for an autologous donation protocol. The current study shows that limiting PABD to anemic patients reduces wasted autologous blood.

Literature shows that routine autologous blood donation increases cost [3, 19]. In the current study, routine PABD is associated with higher cost compared to not donating autologous blood (Table 2). However, if preoperative autologous blood donation is only utilized for anemic patients, using a cutoff hemoglobin of 12.5 g/dL, the overall cost per patient remains similar to a group without a PABD protocol: US $256.63/patient versus US $217.83/patient. While routine PABD is costly, limiting PABD to anemic patients only reduces the overall need for allogenic blood and only marginally increases cost.

The current study results support the use of autologous blood donation in anemic patients undergoing primary TKA; however, the best method to minimize allogenic blood exposure in anemic patients undergoing TKA remains uncertain. Our data support the efficacy of one

Table 2 Cost in US dollar per patient for each protocol

Protocol	Average cost in USD per patient with Hgb≤12.5 mg/dL	Average cost in USD per patient with Hgb>12.5 mg/dL	Average cost in USD per patient	Average number of blood transfusions
Routine donation of one unit of autologous blood (group A)	613.24	463.16	511.44	0.93
No preoperative donation of autologous blood (group B)	464.00	131.34	217.83	0.33
Routine donation of autologous blood for all patients with Hgb≤12.5 mg/dL (algorithm)	613.24	131.34	256.63	0.40

unit PABD in this population. Faris and coworkers [10] demonstrated that erythropoietin administered before elective orthopedic surgery can reduce allogenic transfusions. Other studies have shown that erythropoietin may reduce the need for allogenic blood, raise preoperative hemoglobin, and decrease the need for autologous blood donation [5, 12, 13, 16]. Cushner et al. [7] retrospectively compared PABD to epoetin alpha in anemic patients undergoing total knee arthroplasty and found similar allogenic transfusion rates in both groups, despite the average preoperative Hgb level being significantly higher in patients that underwent epoetin alpha treatment versus patients that donated autologous blood. Reinfusion drains were used in all patients in their study [6] and add to the reduction in allogenic blood transfusions.

Conclusion

The current study confirms that PABD is a cost-effective method to lower allogenic blood exposure in anemic patients undergoing primary TKA. Abandoning PABD for non-anemic patients (Hb>12.5 g/dL) does not increase the need for allogenic blood, but reduces overall cost. Targeted blood management based on preoperative hemoglobin reduces cost and decreases the overall transfusion rate and is therefore recommended.

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(1): 2–10.
2. Biesma DH, Marx JJ, van de Wiel A. Collection of autologous blood before elective hip replacement. A comparison of the results with the collection of two and four units. *J Bone Joint Surg Am*. 1994;76(10):1471–1475.
3. Billote DB, Glisson SN, Green D, Wixson RL. A prospective, randomized study of preoperative autologous donation for hip replacement surgery. *J Bone Joint Surg Am*. 2002; 84-A(8):1299–1304.
4. Bong MR, Patel V, Chang E, Issack PS, Hebert R, Di Cesare PE. Risks associated with blood transfusion after total knee arthroplasty. *J Arthroplasty*. 2004;19(3):281–287.
5. Couvret C, Laffon M, Baud A, Payen V, Burdin P, Fusciardi J. A restrictive use of both autologous donation and recombinant human erythropoietin is an efficient policy for primary total hip or knee arthroplasty. *Anesth Analg*. 2004;99(1):262–271.
6. Cushner FD, Hawes T, Kessler D, Hill K, Scuderi GR. Orthopaedic-induced anemia: the fallacy of autologous donation programs. *Clin Orthop Relat Res*. 2005;(431):145–149.
7. Cushner FD, Lee GC, Scuderi GR, Arsht SJ, Scott WN. Blood loss management in high-risk patients undergoing total knee arthroplasty: a comparison of two techniques. *J Knee Surg*. 2006;19(4):249–253.
8. Deutsch A, Spaulding J, Marcus RE. Preoperative epoetin alfa vs autologous blood donation in primary total knee arthroplasty. *J Arthroplasty*. 2006;21(5):628–635.
9. Etchason J, Petz L, Keeler E, Calhoun L, Kleinman S, Snider C, Fink A, Brook R. The cost effectiveness of preoperative autologous blood donations. *N Engl J Med*. 1995;332(11):719–724.
10. Faris PM, Ritter MA, Abels RI. The effects of recombinant human erythropoietin on perioperative transfusion requirements in patients having a major orthopaedic operation. The American Erythropoietin Study Group. *J Bone Joint Surg Am*. 1996;78 (1):62–72.
11. Forgie MA, Wells PS, Laupacis A, Fergusson D. Preoperative autologous donation decreases allogenic transfusion but increases exposure to all red blood cell transfusion: results of a meta-analysis. International Study of Perioperative Transfusion (ISPOT) Investigators. *Arch Intern Med*. 1998;158 (6):610–616.
12. Green WS, Toy P, Bozic KJ. Cost minimization analysis of preoperative erythropoietin vs autologous and allergenic blood donation in total joint arthroplasty. *J Arthroplasty*. 2010;25(1): 93–96.
13. Hardwick ME, Morris BM, Colwell CW, Jr. Two-dose epoetin alfa reduces blood transfusions compared with autologous donation. *Clin Orthop Relat Res*. 2004;(423):240–244.
14. Hatzidakis AM, Mendlick RM, McKillip T, Reddy RL, Garvin KL. Preoperative autologous donation for total joint arthroplasty. An analysis of risk factors for allogenic transfusion. *J Bone Joint Surg Am*. 2000;82(1):89–100.
15. Lee GC, Cushner FD. The effects of preoperative autologous donations on perioperative blood levels. *J Knee Surg*. 2007;20 (3):205–209.
16. Martinez V, Monsaingeon-Lion A, Cherif K, Judet T, Chauvin M, Fletcher D. Transfusion strategy for primary knee and hip arthroplasty: impact of an algorithm to lower transfusion rates and hospital costs. *Br J Anaesth*. 2007;99(6):794–800.
17. Slappendel R, Dirksen R, Weber EW, van der Schaaf DB. An algorithm to reduce allogenic red blood cell transfusions for major orthopedic surgery. *Acta Orthop Scand*. 2003;74(5):569–575.
18. Walsh M, Preston C, Bong M, Patel V, Di Cesare PE. Relative risk factors for requirement of blood transfusion after total hip arthroplasty. *J Arthroplasty*. 2007;22(8):1162–1167.
19. Keating EM, Meding JB, Faris PM, Ritter MA. Predictors of transfusion in elective knee surgery. Clin Orthop Relat Res. 1998;357:50–59.