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

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Abstract To avoid the potential risks of allogeneic transfusion during total hip arthroplasty (THA), the use of preoperative autologous blood donation (PABD) has been utilized. We performed a retrospective chart review of 283 patients undergoing THA that either donated 1 U of autologous blood (188 patients) or did not donate autologous blood before surgery (95 patients) in order to investigate the difference in postoperative transfusion rate (autologous and allogeneic), the incidence of allogeneic transfusion, and the difference in cost of each protocol. In addition, the study compared transfusion rates in patients with and without preoperative anemia (hemoglobin (Hb) $\leq$ 12.5 g/dL). At 0.75 transfusions per patient versus 0.22 transfusions per patient, the PABD patients had a significantly higher overall transfusion rate. PABD significantly reduced the need for allogeneic blood in anemic patients (Hb $\leq$ 12.5 g/dL) from 52.6% to 11.8%. PABD did not have the same affect in nonanemic patients (allogeneic trans-

fusion rate 5.7% versus 4.0%). The study demonstrated that nonanemic patients undergoing THA do not benefit from PABD, but it is effective for anemic patients.

Keywords transfusion · allogeneic · autologous · blood management · total hip arthroplasty · total hip replacement

Introduction

Blood loss in total hip arthroplasty (THA) can result in severe or symptomatic anemia, requiring blood transfusion. Preoperative autologous blood donation (PABD) is commonly used to reduce the incidence of allogeneic transfusion and the associated risks of blood-borne diseases, transfusion and allergic reactions, and postoperative infection [1, 4, 17, 18]. Unfortunately, donation of autologous blood is costly, creates logistical challenges, and can result in phlebotomy-induced anemia [1, 4, 18], which may actually increase the risk of needing a transfusion. Furthermore, use of autologous blood may not eliminate all the risks of transfusion [1, 2, 4, 6, 11, 14, 15], including fluid overload, increased hospital stay, and administrative errors.

Several studies have questioned the efficacy of autologous blood in reducing the need for allogeneic blood [1, 6, 11, 14, 15], as well as its cost-effectiveness [3, 9, 12]. In one study [11], patients who donated autologous blood had lower hematocrit (Hct) levels immediately prior to surgery than patients who did not donate blood. The rate of allogeneic transfusion was somewhat lower in this group, but the total transfusion rate was higher and many autologous units were wasted [11]. In anemic patients, the efficacy of autologous blood has been questioned [5, 8].

The current study investigates whether routine donation of 1 U of autologous blood prior to primary THA reduces the need for allogeneic blood transfusion following THA compared to a protocol in which autologous blood is not

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Each author certifies that his or her institution has approved the reporting of these cases, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participating in the study was obtained. Institutional Review Board Approval, IRB# 28103.

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utilized. In addition, we wished to assess whether anemic patients would benefit from PABD as compared to non-anemic patients. We also sought to assess whether PABD increases the overall number of transfusions and what percentage of autologous blood is wasted, and finally, we assessed the difference in cost between the two blood management protocols.

Materials and methods

After obtaining approval from our institutional review board, a retrospective chart review of the hospital records of patients undergoing primary THA utilizing a standardized minimally invasive posterior approach under hypotensive spinal–epidural anesthesia by the two senior authors (TPS, FB) was performed. The study encompassed surgeries performed between January 2007 and March 2008. During the study period, the two surgeons utilized different standard blood management protocols. Surgeon A (TPS) routinely sent patients for preoperative donation of 1 U of autologous blood, whereas surgeon B (FB) did not routinely advise preoperative autologous blood donation. Patients sent for preoperative blood donation were scheduled for donation based on the blood bank's scheduling availability, but not at a standard preoperative time period.

Gender, age, body mass index (BMI), preoperative hemoglobin (Hb), date of preoperative hemoglobin measurement, date of autologous blood donation, intraoperative blood pressure, preoperative comorbidities, American Society of Anesthesiologists score, number of autologous transfusions, number of allogeneic transfusions, time of transfusion, vital signs, 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 bilateral hip replacement. Patients whose actual blood management deviated from the standard protocol of their attending surgeon were noted and excluded from analysis.

During the study period, surgeon A performed 188 unilateral THAs in patients eligible for study inclusion. Fourteen patients did not donate autologous blood, leaving 174 patients in group A. During the study period, surgeon B performed 95 unilateral THAs in patients eligible for study inclusion. One patient donated 1 U of autologous blood, leaving 94 patients in group B. Patients received allogeneic transfusions if the hemoglobin level dropped below 8.0 g/dL, and they displayed clinical symptoms of anemia (increased heart rate, lower blood pressure, orthostatic reaction) despite an intravenous fluid bolus. The decision to transfuse autologous blood was initiated at the discretion of the anesthesiologist, and strict transfusion guidelines were not always enforced. Autologous blood was considered wasted if a patient predonated autologous blood but never received the autologous transfusion.

The two groups were similar in terms of male/female ratio, age, BMI, and degree of intraoperative hypotension achieved. Group A included 77 male and 97 female patients ($n=174$) with mean age 66 years (range, 19 to 89 years),

mean BMI 27.9 kg/m² (range, 18.3 to 51.5 kg/m²), and average intraoperative mean arterial pressure of 77.2 mmHg (range, 55 to 110 mmHg). Group B included 35 male and 59 female patients ($n=94$) with mean age 61 years (range, 25 to 91 years), mean BMI 27.8 kg/m² (range, 18.1 to 50.2 kg/m²), and average intraoperative mean arterial pressure of 75.0 mmHg (range, 60 to 90 mmHg).

The cost of PABD and allogeneic transfusion was calculated considering average cost of an autologous/allogeneic unit of blood of US \$300, 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.

Patients were further divided by preoperative hemoglobin level, utilizing 12.5 g/dL as the level below which preoperative anemia was defined. Patients with a hemoglobin level above 12.5 g/dL were considered nonanemic. Preoperative hemoglobin levels were measured before PABD.

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

The overall rate of allogeneic transfusion was lower for patients who donated autologous blood (group A, 6.9%) than for patients who did not donate blood (group B, 13.8%; $p=0.03$). In group A, 67.2% 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 (0.75 per patient) than did those in group B (0.22 per patient; $p<0.001$; Table 2). Nonanemic patients had fewer total blood transfusions per patient than did anemic patients (Table 1; $p<0.001$).

Overall, 80% of the patients in each group had a preoperative Hb of greater than 12.5 g/dL. Subgroup analysis revealed that the reduction of allogeneic transfusion associated with PABD was confined to anemic patients with baseline Hb ≤ 12.5 g/dL. The rate of allogeneic transfusion for nonanemic patients in group A (5.7%) was similar to the rate of allogeneic transfusion for nonanemic patients in group B (4.7%; $p=0.62$). The 11.8% rate of allogeneic transfusion for anemic patients in group A (PABD) was lower than the 52.6% rate of allogeneic transfusion for anemic patients in group B (no PABD; $p<0.001$). The two blood management protocols did not differ with regard to discharge Hb, which was 10.8 g/dL (range, 8.2–13.7 g/dL) in group A and 10.6 g/dL (range, 7.7–13.6 g/dL) in group B ($p=0.25$).

The mean cost per patient was higher in group A (US \$507.20) than in group B (US \$188.00). The cost per patient in both groups decreases for nonanemic patients and increases for anemic patients. If nonanemic patients are treated without autologous blood donations and anemic

Table 1 The number of allogeneic transfusions was less in groups with a higher hemoglobin level (group A: PABD, group B: no PABD; anemic ≤ 12.5 g/dL, nonanemic >12.5 g/dL)

Study group	Number of patients	Patients requiring allogeneic blood transfusions Number (%)	Total number of allogeneic blood transfusions Number (Average)	Patients requiring autologous blood transfusions Number (%)	Total number of transfusions (average transfusions per patient)
Group A	174	12 (6.9)	13 (0.08)	117 (67.2)	130 (0.75)
Group B	94	13 (13.8)	21 (0.22)	0 (0)	21 (0.22)
Group A with Hb >12.5 g/dL	140 (80%)	8 (5.7)	9 (0.07)	87 (62.1)	96 (0.69)
Group B with Hb >12.5 g/dL	75 (80%)	3 (4.0)	7 (0.09)	0 (0)	7 (0.09)
Group A with Hb ≤ 12.5 g/dL	34 (20%)	4 (11.8)	4 (0.12)	30 (88.2)	34 (1.00)
Group B with Hb ≤ 12.5 g/dL	19 (20%)	10 (52.6)	14 (0.74)	0 (0)	14 (0.74)

patients donate 1 U of autologous blood preoperatively, the cost of blood management per patient is US \$218.40 and only 5.6% of patients would require allogeneic transfusions (Table 3).

Discussion

The routine use of PABD in total hip arthroplasty has been questioned. Historic data supporting the use of PABD in THA [1] were never definitive and may not apply in the setting of modern surgical and anesthetic techniques. At the authors' institution, minimally invasive techniques and hypotensive anesthesia are routinely utilized. The current retrospective study evaluated whether routine autologous blood donation was beneficial prior to THA. We focused on the impact of PABD on allogeneic blood transfusions, overall transfusions, unused autologous blood, and cost of blood management. The study also analyzed whether the cost and efficacy of PABD differed between anemic and nonanemic patients.

The current study is limited by its retrospective nature. While strict transfusion guidelines were enforced for allogeneic blood, autologous blood was transfused at the discretion of the covering anesthesiologist. Patients with preexisting conditions that might put them at risk for a transfusion were excluded from the study. Hypotensive spinal 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. Furthermore, although the same surgical technique was used, having two surgeons could introduce bias. 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.

In an analysis of blood management in patients undergoing unilateral primary total hip arthroplasty, Bierbaum and coworkers found that 36% of patients that donated an average of 1.8 U of autologous blood before surgery did not receive any blood back, while 9% of patients that donated autologous blood before surgery still needed allogeneic blood [1]. A prospective, randomized trial of elective THA patients by Billote and coworkers compared PABD to no donation in patients with baseline hemoglobin levels above 12.0 g/dL. The authors concluded that PABD may be detrimental for nonanemic total hip replacement patients because despite increased health-care costs, PABD did not eliminate the use of allogeneic blood [3]. The current study also showed no benefit of PABD in nonanemic patients.

Forgie and coworkers conducted a meta-analysis of previously published studies and data (not specific to orthopedic surgery) to determine if autologous blood donation reduced the risk of allogeneic blood use. The researchers found that patients who donated autologous blood before surgery were less likely to receive allogeneic blood but were overall more likely to need a transfusion of

Table 2 The average total number of transfusions was higher in group A (group A: PABD, group B: no PABD; anemic ≤ 12.5 g/dL, nonanemic >12.5 g/dL)

Study group	Average autologous blood transfusions per patient	Average allogeneic blood transfusion per patient	Average total blood transfusions per patient	Cost per patient in USD
Group A	0.67	0.08	0.75	\$507.20
Group B	0	0.22	0.22	\$188.00
Group A with Hb >12.5 g/dL	0.62	0.07	0.69	\$497.00
Group B with Hb >12.5 g/dL	0	0.09	0.09	\$136.00
Group A with Hb ≤ 12.5 g/dL	0.88	0.12	1.00	\$548.00
Group B with Hb ≤ 12.5 g/dL	0	0.74	0.74	\$396.00

Table 3 The cost-effectiveness of the blood management protocol depends on several factors, including preoperative autologous blood donation and autologous blood wastage

Preoperative donation scenario	Percentage of patients requiring allogeneic blood	Cost per patient in USD
Cost if all patients donate 1 U of autologous blood	6.9	\$507.20
Cost if all patients do not donate autologous blood	13.8	\$188.00
Only patients with preoperative hemoglobin ≤ 12.5 g/dL donate 1 U of autologous blood	5.6	\$218.40

either allogeneic or autologous blood [11]. In the current study, patients who donated autologous blood had a higher total number of transfusions and higher average number of transfusions per patient than patients who did not donate.

Donating autologous blood before surgery can result in a high percentage of unused autologous blood. The percentage of wasted autologous blood reportedly ranges from 25% to 46% [1, 11]. In the current study, 32.8% of PABD patients wasted autologous blood.

Specific protocols targeting patients at risk for postoperative transfusion might reduce the need for allogeneic blood and overall costs. In a retrospective analysis of consecutive total joint arthroplasty patients, Hatzidakis and coworkers attempted to identify risk factors for allogeneic transfusions. Autologous donation not only significantly decreased allogeneic blood use but also significantly reduced preoperative hemoglobin level [14]. Bierbaum et al. found that the best predictors for allogeneic blood use were low baseline Hb levels and a lack of donated autologous blood [1]. Our findings support the notion that preoperative anemia is a strong risk factor for postoperative transfusion.

The current study results do not support the routine use of autologous blood donation in nonanemic patients undergoing primary THA. The best method to minimize allogeneic blood exposure in anemic patients undergoing THA remains controversial. Our data support the efficacy of 1 U PABD in this population. Faris and coworkers demonstrated that erythropoietin administered before elective orthopedic surgery can reduce allogeneic transfusions as well [10]. Other studies have shown that erythropoietin may reduce the need for allogeneic blood, raise preoperative hemoglobin, and decrease the need for autologous blood donation [5, 12, 13, 16]. Cushner retrospectively compared PABD to epoetin alpha in anemic patients undergoing total knee arthroplasty. The average preoperative Hb level was significantly higher in patients that underwent epoetin alpha treatment versus patients that donated autologous blood, but allogeneic transfusion rates were similar in both groups [7]. Couvret and coworkers conducted a prospective observational studies of THA and TKA patients and concluded that utilizing erythropoietin or limited preoperative autologous blood donation for anemic patients ($Hct \leq 39\%$) resulted in a 72% relative transfusion rate reduction [5]. Our study did not specifically compare the efficacy of PABD to the use of erythropoietin. Nevertheless, our data confirm that PABD is an effective method to lower allogeneic blood exposure for anemic THA patients with Hb levels ≤ 12.5 g/dL.

Abandoning PABD for nonanemic patients does not increase the need for allogeneic blood. PABD reduces the need for allogeneic blood transfusion in anemic patients. Target blood management offers significant cost savings and reduces the overall number of transfusions. A protocol that implemented selected preoperative autologous blood donation for anemic patients reduces the overall cost of blood management from US \$507.20 to US \$218.40 per patient. The current study recommends limiting PABD to patients undergoing primary THA with Hb ≤ 12.5 g/dL.

References

1. Bierbaum BE, Callaghan JJ, Galante JO, Rubash HE, Tooms RE, Welch RB (1999) An analysis of blood management in patients having a total hip or knee arthroplasty. *J. Bone Jt. Surg. Am.* 81 (1):2–10
2. Biesma DH, Marx JJ, van de Wiel A (1994) Collection of autologous blood before elective hip replacement. A comparison of the results with the collection of two and four units. *J. Bone Jt. Surg. Am.* 76(10):1471–1475
3. Billote DB, Glisson SN, Green D, Wixson RL (2002) A prospective, randomized study of preoperative autologous donation for hip replacement surgery. *J. Bone Jt. Surg. Am.* 84-A(8): 1299–1304
4. Bong MR, Patel V, Chang E, Issack PS, Hebert R, Di Cesare PE (2004) Risks associated with blood transfusion after total knee arthroplasty. *J. Arthroplast.* 19(3):281–287
5. Couvret C, Laffon M, Baud A, Payen V, Burdin P, Fuscicardi J (2004) A restrictive use of both autologous donation and recombinant human erythropoietin is an efficient policy for primary total hip or knee arthroplasty. *Anesth. Analg.* 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, Arshat SJ, Scott WN (2006) Blood loss management in high-risk patients undergoing total knee arthroplasty: a comparison of two techniques. *J. Knee Surg.* 19(4):249–253
8. Deutsch A, Spaulding J, Marcus RE (2006) Preoperative epoetin alfa vs autologous blood donation in primary total knee arthroplasty. *J. Arthroplast.* 21(5):628–635
9. Etchason J, Petz L, Keeler E, Calhoun L, Kleinman S, Snider C, Fink A, Brook R (1995) The cost effectiveness of preoperative autologous blood donations. *N. Engl. J. Med.* 332 (11):719–724
10. Faris PM, Ritter MA, Abels RI (1996) The effects of recombinant human erythropoietin on perioperative transfusion requirements in patients having a major orthopaedic operation. The American Erythropoietin Study Group. *J. Bone Jt. Surg. Am.* 78 (1):62–72
11. Forgie MA, Wells PS, Laupacis A, Fergusson D (1998) Preoperative autologous donation decreases allogeneic 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.* 158 (6):610–616
12. Green WS, Toy P, Bozic KJ, Cost minimization analysis of preoperative erythropoietin vs autologous and allogeneic blood donation in total joint arthroplasty. *J Arthroplast.* 2009 (in press)
 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 (2000) Preoperative autologous donation for total joint arthroplasty. An analysis of risk factors for allogeneic transfusion. *J. Bone Jt. Surg. Am.* 82(1):89–100
 15. Lee GC, Cushner FD (2007) The effects of preoperative autologous donations on perioperative blood levels. *J. Knee Surg.* 20(3):205–209
 16. Martinez V, Monsaingeon-Lion A, Cherif K, Judet T, Chauvin M, Fletcher D (2007) Transfusion strategy for primary knee and hip arthroplasty: impact of an algorithm to lower transfusion rates and hospital costs. *Br. J. Anaesth.* 99(6):794–800
 17. Slappendel R, Dirksen R, Weber EW, van der Schaaf DB (2003) An algorithm to reduce allogeneic red blood cell transfusions for major orthopedic surgery. *Acta Orthop. Scand.* 74(5):569–575
 18. Walsh M, Preston C, Bong M, Patel V, Di Cesare PE (2007) Relative risk factors for requirement of blood transfusion after total hip arthroplasty. *J. Arthroplast.* 22(8):1162–1167