AN ORIGINAL STUDY

Patient Factors Affecting Autologous and Allogeneic Blood Transfusion Rates in Total Hip Arthroplasty

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ABSTRACT

Factors that place patients undergoing total hip arthroplasty (THA) at increased risk of receiving an allogeneic or autologous blood transfusion may aid in determining which patients should predonate blood. The records of 354 consecutive patients undergoing THA were retrospectively reviewed to determine patient factors related to transfusion requirement. The risk of transfusion requirement was most strongly correlated with low preoperative hemoglobin level, but also with older age, higher American Society of Anesthesiologists physical status rating, female sex, cemented arthroplasty, and revision surgery. These patients were also least likely to predonate blood, likely because of their comorbid status.

Total hip arthroplasty (THA) is a common elective procedure that may lead to substantial blood loss. It has been documented that 70% to 90% of patients undergoing this procedure require blood transfusion.[1,2] The risk of contracting a serious transfusion-transmitted disease is approximately 3 in 10,000.[3] The risk of viral transmission is estimated at 1 in 63,000 for hepatitis B, 1 in 103,000 for hepatitis C, and 1 in 493,000 for human immunodeficiency virus.[4] The fatality rate from allogeneic transfusion has been reported as 1 in 435,000 units transfused, with the majority of problems caused by clerical or laboratory errors.[5]

Pre-THA blood donation has been shown to decrease the requirement for banked blood transfusion.[1,2,6–8] Other techniques have been shown to be effective in reducing the incidence of allogeneic blood transfusion, such as the cell saver and postoperative collection and reinfusion.[9] These techniques are costly and may not be required if autologous blood is available.[10]

Autologous blood donation is costly for the institution. The price of transfusion of a unit of autologous blood has been estimated at slightly more than 1.5 times the cost of the transfusion of an allogeneic unit.[11] The overall cost per unit transfused is even greater if the donated blood is not used, as it cannot be saved for use in other patients. There are no clear guidelines as to how many units patients should donate before surgery. Further, despite the benefits of autologous blood donation before surgery, not all patients are interested in participating. Patients who must travel a great distance often do not want to make an extra trip to donate blood. Other patients are unwilling to accept the discomfort and time required to predonate their own blood.

Factors that place patients at increased risk of receiving an allogeneic or autologous blood transfusion may aid in determining which patients should predonate their blood. Previous work in this area has analyzed autologous donors and nondonors together[6,12] or hip and knee replacements together[6,13] or has excluded patients who had donated autologous blood.[14] Other investigations examined the effect of patient variables on estimated blood loss, but not on transfusion requirement.[15] The goal of our study was to identify patient variables that affect the rate of autologous and allogeneic transfusion in patients undergoing elective THA, both in those who donated autologous blood and in those who did not.

MATERIALS AND METHODS

All patients who underwent THA by the senior author over a 2-year period were included in the study. They were retrospectively reviewed to determine patient factors related to transfusion requirements. The patients were divided into 2 groups, those who predonated their own blood before surgery and those who did not. Patients who did not predonate blood either refused to

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Table 1. Patient Variables in Predonation and No-Predonation Groups

Patient Variable	Predonation Group	No-Predonation Group	Difference Between Groups
Total patients	214	140	
Primary surgery	176	94	
Revision surgery	38	46	Revision or primary surgery, $P < .001$
Male	100	43	
Female	114	97	Sex, $P < .005$
Diagnosis of inflammatory arthritis	14	23	
Diagnosis of noninflammatory arthritis	200	117	Diagnosis, $P < .005$
Mean age (y)	60.3	67.2	Age, $P < .001$
Mean preoperative hemoglobin (g/L)	132.2	126.7	Preoperative hemoglobin, $P < .001$
Received allogeneic transfusion	8	43	
Received autologous transfusion	144	0	
No transfusion	62	97	
Cemented femoral component	106	55	
Uncemented femoral component	108	85	Cemented femoral component, $P = .058$
General anesthesia	177	114	
Spinal or epidural anesthesia	37	26	Anesthesia, $P = .76$
ASA rating= 1	54	10	
ASA rating= 2	144	90	
ASA rating= 3	16	39	
ASA rating= 4	0	1	ASA rating, $P < .001$

ASA=American Society of Anesthesiologists.

do so or were unable to because of anemia or medical disorders. Patients involved in the predonation program gave 2 units before primary THA and 3 units before revision surgery, if possible. The decision to transfuse patients was based on age, comorbidity, symptoms, and patient acceptability in each case. There was no specific hemoglobin level at which patients were transfused. No intraoperative salvage techniques were used.

Patient variables examined included age, diagnosis, preoperative hemoglobin level, sex, whether cement was used for the femoral component, American Society of Anesthesiologists (ASA) physical status rating, type of anesthesia, and whether the procedure was a primary THA or a revision. There are 4 ASA classes that apply to patients undergoing elective THA: 1 (no organic, physiologic, biochemical, or psychiatric disturbance), 2 (mild to moderate systemic disturbance that may or may not be related to the disorder requiring surgery), 3 (severe systemic disturbance that may or may not be related to the disorder requiring surgery), and 4 (severe systemic disturbance that is life-threatening with or without surgery).[16] We did not examine the effect of cementing the acetabular component because the cementless variety was used almost without exception. The lowest hemoglobin level while in hospital was recorded to provide a reference for the threshold for transfusion.

Characteristics of the patients are shown in Table 1. Univariate analyses using categorical and continuous techniques (χ^2 and t tests, respectively) were performed to determine the significance of each independent variable separately on the outcome. Before performing multivariable analyses, the association between independent risk factors was assessed to ensure that highly correlated independent variables would not be entered into the model together (χ^2 test was used if both variables were binary, point biserial correlation was used if one variable was continuous and the other binary, and the Pearson correlation coefficient was used when both variables were continuous). Variables meeting a 30% level of significance at the univariate stage were entered into a multiple regression model. Multiple logistic regression was used to assess the association between the patient variables and transfusion. Variables were selected by their contribution to the likelihood function via the log likelihood ratio test statistic after other uncorrelated significant variables were entered into the model. Stepwise regression procedures were also used. Last, we assessed for interactions between the significant variables.

RESULTS

The patients who predonated had a mean lowest hemoglobin level while in hospital of 90.5g/L. One hundred forty-four of the patients who predonated received an autologous transfusion, and they were given an average of 1.94 U of blood per individual transfused (range, 1–2 U). Eight patients who predonated required an allogeneic blood transfusion, with an average of 2.5 U per individual (range, 1–4 U). Of the 176 patients undergoing a primary THA, 166 donated 2 U, and 10 donated 1 U. Of the 38 patients undergoing a revision procedure, 2 donated 1 U, 27 donated 2 U, and 9 donated 3 U. All patients who donated a single unit did so because they were unable to donate a second.

Table II. Univariate Analysis of Patient Variables Among Individuals Who Predonated Blood

Variable	Odds Ratio (95% CI)*	P Value
Sex	5.20 (2.80–9.97)	.0001√ +
Diagnosis	1.23 (0.39–4.60)	.73
Procedure	0.49 (0.20–1.10)	.08 √
Cement	1.72 (0.97–3.08)	.07 √
ASA rating	2.17 (1.14–4.13)	
	2.59 (0.74–9.04)	.05 √
Anesthesia	1.39 (0.65–3.18)	.41
Age	1.03 (1.02–1.06)	.004 √
Preoperative hemoglobin	0.92 (0.89–0.95)	.0001 √ +

CI = Confidence interval; ASA = American Society of Anesthesiologists.

*Odds ratio for each variable: sex (female/male), diagnosis (inflammatory arthritis/noninflammatory arthritis), procedure (primary/revision), cement (cemented femoral component/noncemented femoral component), ASA rating (2/1 and 3/1, respectively), anesthesia (spinal or epidural/general), age (continuous), preoperative hemoglobin level (continuous).

√ Entered into the multivariable model.

+Significant ($P \leq .05$) in the multivariable analysis.

Forty-three of the patients who did not predonate blood received allogeneic transfusions (average, 2.3 U; range, 1–9 U). The patients who did not predonate autologous blood had a mean lowest hemoglobin level while in hospital of 86.4 g/L.

The groups had statistically significant differences for several of the variables (Table I). Of note, the group that did not predonate had older patients, more female patients, lower mean preoperative hemoglobin levels, and a greater proportion of patients who had inflammatory arthritis and higher ASA ratings and who were undergoing revision surgery (Table I).

For autologous donors, the univariate analysis showed that female sex, high ASA rating, low preoperative hemoglobin level, and older age were statistically significant predictors of transfusion requirement ($P \leq .05$, Table II). In the multivariable analysis, only female sex and low preoperative hemoglobin level remained significant ($P \leq .05$).

Table III. Univariate Analysis of Patient Variables Among Individuals Who Did Not Predonate Blood

Variable	Odds Ratio (95% CI)*	P Value
Sex	1.43 (0.65–3.31)	.37
Diagnosis	1.96 (0.77–4.89)	.16 √
Procedure	0.49 (0.23–1.03)	.06 √
Cement	0.49 (0.24–1.02)	.06 √ +
ASA rating	1.93 (0.46–13.2)	
	2.52 (0.55–18.07)	.49
Anesthesia	0.62 (0.21–1.61)	.34
Age	1.01 (0.98–1.04)	.30 √ +
Preoperative hemoglobin	0.95 (0.92–0.97)	.0001 √ +

*Odds ratio for each variable: sex (female/male), diagnosis (inflammatory arthritis/noninflammatory arthritis), procedure (primary/revision), cement (cemented femoral component/noncemented femoral component), ASA rating (2/1 and 3/1, respectively), anesthesia (spinal or epidural/general), age (continuous), preoperative hemoglobin level (continuous).

√ Entered into the multivariable model.

+Significant ($P \leq .05$) in the multivariable analysis.

This was at least in part due to the fact that these variables were collinear—that is, they were associated with each other.

For the patients who did not predonate blood, preoperative hemoglobin level was the only variable that was a statistically significant predictor of transfusion in the univariate analysis ($P \leq .05$, Table III). Revision surgery and use of a cemented femoral component were strong predictors, but they did not achieve statistical significance ($P = .06$ for both, Table III). The multivariable analysis showed that older age, low preoperative hemoglobin level, and cemented femoral components were all associated with transfusion requirement ($P \leq .05$). No interactions were significant at the .05 level.

DISCUSSION

We reviewed the records of patients who underwent THA to determine which variables were associated with an increased rate of blood transfusion. The 2 groups of patients studied were inherently different because the patients who did not predonate were medically unable or unwilling to do so. These differences are highlighted by the fact that the group that did not donate blood was older, had higher ASA ratings, had lower preoperative hemoglobin levels, and had a greater proportion of patients who were undergoing revision surgery. Further, the availability of autologous blood has been shown to increase the rate of transfusion.[17] The groups can therefore not be compared because of these differences. However, by studying the 2 groups separately in a single surgeon's practice, we were able to identify criteria that may aid in predicting which patients would most benefit from autologous blood predonation.

It was our practice not to give patients their autologous blood after surgery if they were asymptomatic and their hemoglobin was not below 100 g/L. Thus, only 144 of the 214 patients who predonated blood were given their predonated units. This wastage of predonated blood increases the cost of each transfused unit. We were unable to study predictors of allogeneic transfusion among the patients who predonated because only 8 of these patients received allogeneic blood.

For the autologous donors, low preoperative hemoglobin level, female sex, older age, and higher ASA rating were associated with increased transfusion requirement ($P \leq .05$) in the univariate analyses. Only preoperative hemoglobin level and female sex remained significant in the multivariable analysis. For the patients who did not predonate, low preoperative hemoglobin level was the only significant predictor of transfusion in the univariate analysis, but, in the multivariable analysis, older age and cemented femoral component joined low preoperative hemoglobin level as significant predictors. For both patients who predonated blood and those who did not, preoperative hemoglobin level was the strongest predictor of transfusion requirement.

Female sex was associated with an increased risk of transfusion among the autologous donors, likely because female sex and low preoperative hemoglobin level were very highly correlated in this group. Preoperative hemoglobin level was more likely responsible for this increased rate of transfusion, but it is possible that there is an unrecognized association between sex and transfusion requirement in our patient sample. Age was an important predictor in both groups, probably reflecting the fact that the treating physician was more likely to transfuse an elderly patient with a low hemoglobin level o reduce the risk of an ischemic cardiac or cerebral event. The same logic applies to ASA rating, which was a significant predictor for the autologous donors, as this variable is influenced directly by comorbidity. Cemented femoral implant was a significant predictor in the group that did not predonate, which is likely due to the fact that this variable was highly correlated with age ($P = .0001$) and preoperative hemoglobin level ($P = .05$). These associations were due to the fact that the treating surgeon tended to use cemented prostheses for older, female, lower-demand patients.

Female patients who were 80 years old or older and who did not predonate blood were given transfusions in 39% of cases (9/23). Twelve of 20 women (60%) who were 70 years old or older had a preoperative hemoglobin level <125 g/L, and did not have autologous blood available required transfusion. Of the women in this age group who had autologous blood available, all (17/17) were given a transfusion of their own blood if their preoperative hemoglobin level was below 125 g/L, and 95% (36/30) required autologous transfusion if their preoperative hemoglobin level was below 140 g/L.

Elderly patients who undergo revision surgery and who have significant comorbidity with a low preoperative hemoglobin level will have the highest transfusion requirement. These patients will therefore benefit the most from predonation of blood to decrease their risk of exposure to allogeneic blood. The cost-effectiveness of autologous donation would be increased in these patients, as the number of donated units transfused per donated unit would be maximized. However, their general medical condition and/or difficulty with travel to and from the hospital may prohibit predonation. This is illustrated by the fact that the patients who did not predonate were older, had higher ASA ratings, had a higher proportion of cases that were revisions, and had lower preoperative hemoglobin levels (all statistically significant differences, $P < .05$). Although we did not use preoperative recombinant erythropoietin in this series, it may be a useful option for patients who are unable to donate their own blood.[18]

Hatzidakis and colleagues also found age, revision surgery, and low preoperative hemoglobin level to be correlated with transfusion requirement in patients undergoing hip and knee replacement.[13] Unfortunately, sex was not evaluated as a predictor of transfusion in this study, and it is unclear if female sex was associated with low hemoglobin levels among their patients.

Limitations of this study include the fact that it was not randomized, and therefore it is possible that the group that did not predonate included patients who may have been distinguished by their unwillingness or inability to predonate blood (ie, ill health, potentially noncompliant). That a single surgeon performed all the THAs limits our ability to generalize the conclusions. As well, our transfusion rate was lower than others previously reported.[1,2] Our low transfusion rate was likely related to our criteria for transfusion, which were also conservative compared with those of other studies.[19] The decision to transfuse each patient was based on clinical grounds and is therefore a possible source of variability.

Patients who are anemic, elderly, or female, who have significant comorbidity (ie, higher ASA rating) or who are undergoing revision surgery are most likely to require transfusion after THA. Interestingly, these patients are the ones least likely to predonate blood. Other investigators have also shown that elderly patients are less likely to predonate blood.[13]

Women who are 70 years old or older and who have a preoperative hemoglobin level of <120 g/L are at greatest risk of requiring a transfusion after surgery. Although the health and decreased mobility of these patients often complicate predonation, a concerted effort should be made on behalf of the healthcare team to allow these individuals the opportunity to predonate blood prior before THA.

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COMMENTARY

This is a timely, useful, practical article that attempts to provide guidelines for predicting the need of blood transfusion in total hip arthroplasty patients. Obviously, if we know some criteria that would predetermine which patients require transfusion, then we can proactively encourage preoperative autologous blood donation. The authors note that only 144 of their 214 (67%) patients who did donate autologous blood actually received their blood postoperatively. The economic ramifications are obvious: one third of patients could have avoided the expense of autologous blood collection and storage. The authors note that 100% (17 of 17 patients) who met the following criteria were administered their autologous blood: females 70 years or older and preoperative hemoglobin level less than 125 g/L. Ninety-five percent of females who were 70 years or older and had preoperative hemoglobin level less than 140 g/L received their autologous blood. Unfortunately, no such strong statements can be made for the rest of the patients in this study, other than that patients who were anemic, elderly, female, and with significant comorbidities were more likely to require blood transfusion. It has been estimated nationally that the overall discarded rate for autologous blood approaches 50% in total joint arthroplasty patients. Besides trying to refine our indications for obtaining autologous blood, the medical community needs to find a way to use autologous blood that would otherwise be discarded.

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