PREOPERATIVE HEMOGLOBIN LEVELS AND THE NEED FOR TRANSFUSION AFTER PROSTHETIC HIP AND KNEE SURGERY

ANALYSIS OF PREDICTIVE FACTORS

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Background: Several studies have established a relationship between the preoperative hemoglobin level and the need for postoperative blood transfusion. We analyzed the relationship between preoperative hemoglobin levels, as well as other factors such as age, gender, weight, height, type and duration of the total joint replacement surgery, and the need for postoperative blood transfusion.

Methods: A retrospective study of 296 patients treated with 370 procedures (209 total hip arthroplasties [56.5%] and 161 total knee arthroplasties [43.5%]) from 1994 to 1998 was carried out. A univariate analysis was performed to establish the relationship between all independent variables and the need for postoperative transfusion. Variables that were determined to have a significant relationship were included in a multivariate analysis.

Results: The univariate analysis revealed a significant relationship between the need for postoperative blood transfusion and preoperative hemoglobin levels ($p = 0.0001$), duration of surgery ($p = 0.0001$), weight ($p = 0.002$), height ($p = 0.019$), and gender ($p = 0.0056$). However, the multivariate analysis identified a significant relationship only between the need for transfusion and the preoperative hemoglobin level ($p = 0.0001$) and weight ($p = 0.011$); height ($p = 0.776$) and gender ($p = 0.122$) were discounted as significant factors. Patients with a preoperative hemoglobin level of <130 g/L had a four times greater risk of having a transfusion than did those with a hemoglobin level between 130 and 150 g/L and a 15.3 times greater risk than did those with a hemoglobin level of >150 g/L.

Conclusions: The preoperative hemoglobin level ($p = 0.0001$) and weight of the patient ($p = 0.011$) were shown to predict the need for blood transfusion after hip and knee replacement.

Major blood loss usually occurs in both hip and knee replacement, frequently leading to the need for blood transfusion. Transfusion is associated with a number of problems, including the risk of transmission of infectious diseases (AIDS, hepatitis, and so on)[1-3] as well as minor problems such as fever, urticaria, and hemodynamic overload. In addition, some patients refuse to have a blood transfusion because of religious beliefs or other reasons.

In order to minimize these disadvantages, alternatives[3-7] to both autologous and allogenic blood transfusion, such as preoperative hemodilution, anesthetic hypotension, intraoperative and postoperative blood recovery, and, more recently, treatment with human recombinant erythropoietin[8-13], have been tried.

Several studies have established a relationship between the preoperative hemoglobin level and the need for postoperative blood transfusion[10,14-16]. In the present study, we analyzed the relationship between preoperative hemoglobin levels, as well as other factors such as age, gender, weight, height, and type and duration of surgery, and the need for transfusion after hip and knee arthroplasty. Our purpose was to establish risk criteria to enable us to predict preoperatively which patients would be candidates for blood transfusion.

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TABLE I Demographic Analysis

Variable	Transfusion*		
	Yes	No	P Value
Duration of surgery *(min)*	95.8 ± 22.3 (60-180)	87.4 ± 17.6 (50-180)	0.0001†
Age *(yr)*	67.0 ± 8.8	66.7 ± 8.0	0.74
Hemoglobin level *(g/L)*	135 ± 12 (101-164)	148 ± 12 (114-185)	0.0001†
Weight *(kg)*	71.6 ± 9.0 (53-95)	75.9 ± 8.7 (56-105)	0.002†
Height *(cm)*	154 ± 0.07 (140-173)	157 ± 0.08 (136-174)	0.019†
Gender *(no. of procedures)*			
Female	100	155	0.0056†
Male	28	87	0.0056†

*The values are given as the mean and the standard deviation, with the range in parentheses. †The p value was found to be significant in the univariate analysis.

Materials and Methods

A retrospective study involving 603 total or partial hip and total knee arthroplasties, performed between 1994 and 1998 in 529 patients, was carried out. The study was approved by our Institutional Review Board, and all patients provided informed consent. Patients were excluded from the study if they were undergoing surgery for a hip fracture; were undergoing revision surgery; had a hematological disease; were being treated with chronic dicumarol therapy for anticoagulation; had a chronic liver impairment; had had any type of hemorrhagic complication, such as gastrointestinal hemorrhage, during the postoperative period; or received a transfusion even though the pretransfusion hemoglobin level was >85 g/L.

A total of 370 procedures (296 patients) met the study criteria and were included in the study group. There were 203 women (68.6%) and ninety-three men (31.4%). The mean age was 66.9 years (range, thirty-five to eighty-nine years), the mean weight was 74.5 kg (range, 53 to 105 kg), and the mean height was 156 cm (range, 136 to 174 cm). There were 209 total hip arthroplasties and 161 total knee arthroplasties. The preoperative diagnosis was degenerative arthritis in 337 cases and rheumatoid arthritis in thirty-three. The average duration of the surgical procedures was 90.2 minutes (range, fifty to 180 minutes). The mean preoperative hemoglobin level was 144 g/L (range, 101 to 185 g/L), and the mean preoperative hematocrit was 43% (range, 30.4% to 53.2%). Although sixty-seven patients had more than one operation (sixty had two and seven had three), none had the procedures performed simultaneously. The mean interval between the procedures was 25.7 months (range, six to sixty months). The age and weight of the patient at the time of each procedure were used for the statistical calculation.

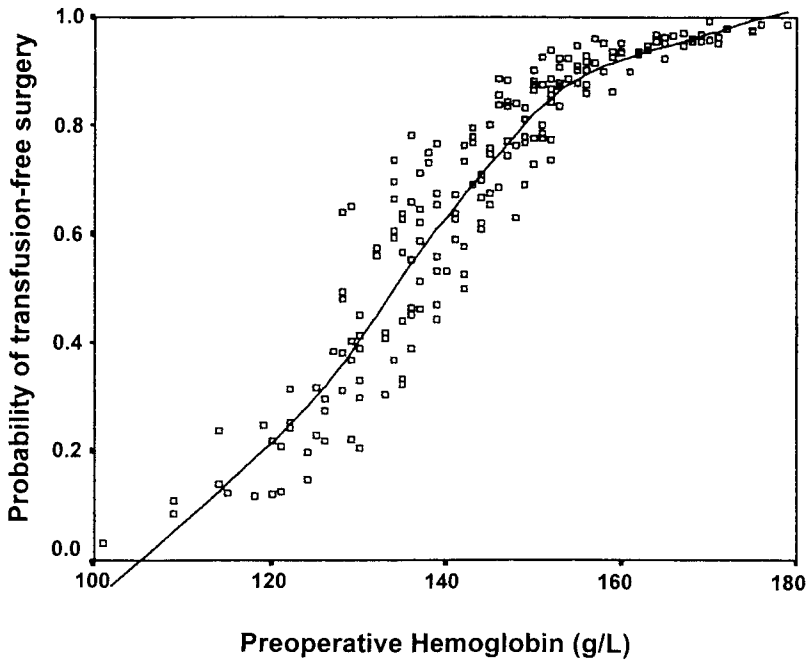

Fig. 1
Logistic regression analysis of the relationship between the preoperative hemoglobin level and the probability of surgery without transfusion.

The parameters that were evaluated included the preoperative hemoglobin level, gender, age, type of surgical procedure, weight, height, need for transfusion, and number of units of packed red blood cells transfused.

All patients were given antithromboembolic prophylaxis with low-molecular-weight heparin (nadroparin calcium; Sanofi Winthrop, Paris, France). Patients who weighed <70 kg received 0.3 mL (3075 IU) subcutaneously twelve hours before surgery, followed by 0.3 mL/day for the first three days after surgery and 0.4 mL (4100 IU)/day from the fourth day to a maximum of two months after surgery. Patients who weighed ≥70 kg received 0.4 mL preoperatively, followed by the same daily dose for three days and then a dose of 0.6 mL (6150 IU)/day up to two months after surgery. (This schedule has not been approved by the United States Food and Drug Administration.)

The statistical analysis consisted of a univariate analysis of all independent variables (hemoglobin level, age, gender, weight, height, and type and duration of surgery) to establish their relationship with the need for postoperative transfusion. Variables that were seen to have a significant relationship were included in a multivariate analysis by logistic regression.

The adjustment was performed backward by the likelihood of model –2LL0 (procedure RV of SPSS, version 9; Hispanoportuguesa SPSS, Madrid, Spain).

Results

Transfusion was required in 117 patients (128 procedures). Allogenic blood was used in all instances. An average of 2.5 units (range, one to six units) of packed red blood cells, with each unit equivalent to 300 mL of red-blood-cell concentrate, was given to the patients who received a transfusion. The average duration of the hip arthroplasties was 89.5 minutes (range, fifty to 180 minutes), and the patients undergoing those procedures had a mean preoperative hemoglobin level of 145 g/L (range, 101 to 179 g/L). Transfusion was required after 39.2% (eighty-two) of the hip arthroplasties (in seventy-four patients). The average duration of the knee arthroplasties was 91.1 minutes (range, fifty to 180 minutes), and the patients undergoing those procedures had an average preoperative hemoglobin level of 142 g/L (range, 114 to 185 g/L). Transfusion was required after 28.6% (forty-six) of the knee arthroplasties (in forty-three patients). The multivariate analysis revealed no relationship between the type of procedure (hip or knee) and the need for transfusion ($p = 0.73$)

A chi-square test showed no significant difference in the need for transfusion between patients who had had more than one joint replacement and those who had been operated on once ($p = 0.76$). Therefore, the patients who had a reoperation were considered new patients.

A univariate analysis including all of the independent variables (Table I) established a significant relationship between the need for postoperative transfusion and the preoperative hemoglobin level ($p = 0.0001$), duration of surgery ($p = 0.0001$), weight ($p = 0.002$), height ($p = 0.019$), and gender ($p = 0.0056$). However, no relationship was found between the age of the patient and the need for transfusion ($p = 0.74$).

Although the duration of surgery had a significant relationship with the need for transfusion in the univariate analysis, it was not included in the multivariate analysis because it was a postoperative variable and did not have predictive value.

The multivariate analysis revealed two significant variables: preoperative hemoglobin level ($p = 0.0001$) and weight ($p = 0.011$), with odds ratios of 2.51 (95% confidence interval, 1.83 to 3.44) and 1.05 (95% confidence interval, 1.01 to 1.09), respectively. The logistic regression equation for the probability (p) of no transfusion being required with use of these variables was $p = 1/1 + e^{-(-16.04 + 0.092 \times \text{hemoglobin level} + 0.05 \times \text{weight})}$, where $e = 2.72$. This means that for each ten grams per deciliter of increase in the preoperative hemoglobin level, the probability that the patient will not need a transfusion increases 2.5 times

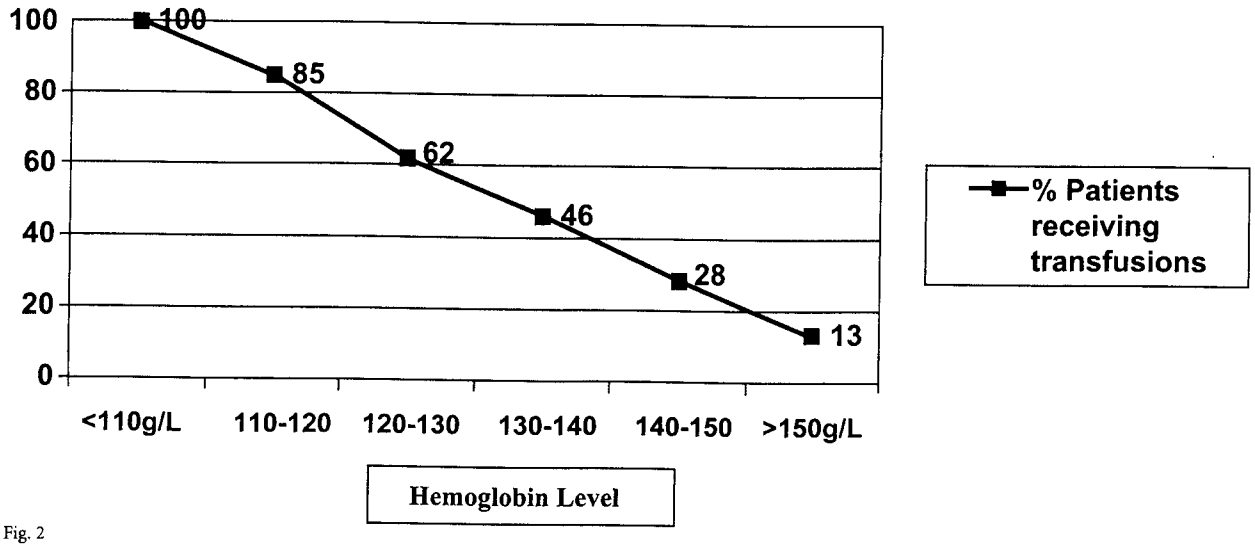

Fig. 2

Relationship between the preoperative hemoglobin levels and the percentage of patients who received a blood transfusion. Note the inverse relationship.

(Fig. 1). In addition, for each kilogram of increase in the weight of the patient, the probability of no transfusion increases by 1.05 times. Although weight is significant, preoperative hemoglobin levels have a greater influence on the need for transfusion. All procedures were classified with use of the above equation, and prediction was accurate for 89.3% (216) of the procedures without transfusion, 53.1% (sixty-eight) of those with transfusion, and 76.8% (284) of all procedures. Greater than 75% is considered to be good prediction.

Depending on the preoperative hemoglobin values, the sample was divided into three groups: Group 1 (<130 g/L), Group 2 (130 to 150 g/L), and Group 3 (>150 g/L). Transfusion was required after 69% (forty-five) of the procedures performed in patients with a hemoglobin level of <130 g/L, 36% (sixty-eight) of the procedures performed in patients with a level between 130 and 150 g/L, and 13% (fifteen) of the procedures performed in patients with a level of >150 g/L (Fig. 2). The risk of transfusion in Group 1 was four times greater than that in Group 2 and 15.3 times greater that that in Group 3.

Discussion

Blood transfusion does not effectively restore hemoglobin levels to preoperative levels[17]. Also, it entails a risk of transmitting diseases such as hepatitis and AIDS[2,3], which has led to the use of preoperative self-donation as an alternative[18]. Furthermore, identification errors can occur during the handling of blood units, which can be a source of medical problems and legal liability. In addition, a patient may refuse a transfusion, particularly for religious reasons. Hence, it is important to predict *a priori* the target population at a higher risk of requiring blood transfusion and to establish the appropriate prophylactic measures.

Various studies have demonstrated a relationship between preoperative hemoglobin levels and the need for blood transfusion[10,14,16,19-22]. It seems clear that the most important factor in the prediction of the need for blood transfusion is the preoperative level of hemoglobin[1,10,14-16,19,21,22], although other factors, such as weight[11] and volume of blood loss[19] (which are directly related to each other), are involved.

The criterion for determining whether a transfusion is indicated is not a static value; the clinical status of the patient must be taken into account[2,16,23]. A hemoglobin level of approximately 80 to 90 g/L is accepted by most as a relative indication for transfusion[2,16]. For this reason and to standardize our sample, a hemoglobin level of <85 g/L was established as the criterion for transfusion, despite the fact that we are aware of the importance of clinical factors[2].

The univariate analysis showed a significant relationship between postoperative transfusion and the preoperative hemoglobin level ($p = 0.0001$), weight ($p = 0.002$), height ($p = 0.019$), gender ($p = 0.0056$), and duration of surgery ($p = 0.0001$). However, the multivariate analysis revealed a significant relationship only with the preoperative hemoglobin level ($p = 0.0001$) and weight ($p = 0.011$), with odds ratios of 2.51 and 1.05, respectively.

On the basis of the results obtained in this study, with multivariate analysis showing no significant differences regarding the need for transfusion between hip and knee surgery, it was possible to establish an equation, based on the preoperative hemoglobin level (in grams per liter) and weight (in kilograms), for calculating the probability of a patient not requiring a transfusion: $p = 1/1 + e^{-(-16.04 + 0.092 \times \text{hemoglobin level} + 0.05 \times \text{weight})}$. This formula should be applicable to patients with a hemoglobin level and weight within the range of our study group (hemoglobin range, 101 to 185 g/L, and weight range, 53 to 105 kg). The formula is not valid for patients who meet any of the exclusion criteria stated in the Materials and Methods section of this paper. Furthermore, it is not valid for patients who receive a transfusion because of complications that occur after the surgical procedure (for example, gastrointestinal bleeding). The values obtained with use of this formula fall between 0 and 1, with 0 corresponding to 0% and 1 corresponding to 100% (the percentages represent the probability of each particular patient not requiring a transfusion). In addition to its clinical importance, we believe that this information could also be useful in blood bank forecasts.

The hemoglobin level, the most important prognostic factor, could be classified into three distinct groups: <130 g/L (Group 1), 130 to 150 g/L (Group 2), and >150 g/L (Group 3). Blood transfusion was required after 69% (forty-five) of the procedures performed in Group-1 patients, and this risk was four times greater than the risk for Group-2 patients and 15.3 times greater than the risk for Group-3 patients. These results are consistent with those of Faris et al.[19], who stated that patients with a preoperative hemoglobin level between 100 and 130 g/L had an increased risk of requiring blood transfusion. Sculco and Gallina[21] reported that preoperative hemoglobin levels were inversely proportional to the need for a transfusion. We found, as did Bierbaum et al.[1], that the prevalence of blood transfusion after hip surgery is higher than that after knee surgery, although this difference was not significant. The prevalence of transfusions in patients with a preoperative hemoglobin level of >130 g/L in our series was lower than that in the study by Sculco and Gallina. This difference may be explained by the fact that patients who received a transfusion even though the pretransfusion hemoglobin level was >85 g/L were excluded from our study but were not excluded from the study by Sculco and Gallina. ■

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