Predictive factors for perioperative blood transfusion in surgeries for correction of idiopathic, neuromuscular or congenital scoliosis

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OBJECTIVE: To evaluate the association of clinical and demographic variables in patients requiring blood transfusion during elective surgery to treat scoliosis with the aim of identifying markers predictive of the need for blood transfusion.

METHODS: Based on the review of medical charts at a public university hospital, this retrospective study evaluated whether the following variables were associated with the need for red blood cell transfusion (measured by the number of packs used) during scoliosis surgery: scoliotic angle, extent of arthrodesis (number of fused levels), sex of the patient, surgery duration and type of scoliosis (neuromuscular, congenital or idiopathic).

RESULTS: Of the 94 patients evaluated in a 55-month period, none required a massive blood transfusion (most patients needed less than two red blood cell packs). The number of packs was not significantly associated with sex or type of scoliosis. The extent of arthrodesis ($r = 0.103$), surgery duration ($r = 0.144$) and scoliotic angle ($r = 0.004$) were weakly correlated with the need for blood transfusion. Linear regression analysis showed an association between the number of spine levels submitted to arthrodesis and the volume of blood used in transfusions ($p = 0.001$).

CONCLUSION: This study did not reveal any evidence of a significant association between the need for red blood cell transfusion and scoliotic angle, sex or surgery duration in scoliosis correction surgery. Submission of more spinal levels to arthrodesis was associated with the use of a greater number of blood packs.

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INTRODUCTION

Arthrodesis, which is used as a definitive surgical treatment for scoliosis, is a major procedure with considerable risk of intraoperative bleeding. Losses of up to 4.5 liters are well-documented in the literature (1,2), as is the need for transfusion of up to eight units of red blood cell concentrate to support such procedures (3-5).

Recent studies have attempted to predict the risk of bleeding in arthrodesis by the posterior route for correction of idiopathic scoliosis in adolescents. Some risk factors, such as the curve angle, were associated with a higher risk of bleeding in a study carried out in China by Yu et al. (6), confirming the previous findings of a similar study carried out in Canada by Miyanji et al. (7). The Chinese study also associated the extent of arthrodesis with bleeding (6). Another recent study carried out in the United States by Ialenti et al. (8) revealed links among bleeding, the sex of the patient and surgery duration.

However, there is still no clearly defined protocol for determining the quantity of red blood cell concentrates that should be reserved for use in spinal surgery. This figure is grossly overestimated and there is evidence that blood packs are being wasted due to this lack of standardization (9).

To confirm their external validity, it would be interesting to verify whether the factors that have been associated with bleeding in the abovementioned studies are also associated with bleeding in similar surgeries in the Brazilian population. Our objective was to assess whether there is any correlation between these risk factors and bleeding, as inferred by the quantity of red blood cell concentrates transfused, in patients with different types of scoliosis with the aim of adding more reliable criteria for surgical planning for these patients.

No potential conflict of interest was reported.

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MATERIALS AND METHODS

The medical charts of consecutive patients admitted with scoliosis of idiopathic, neuromuscular and congenital types who were operated on at the Instituto de Ortopedia e Traumatologia of the Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo (IOT-HCFMUSP) between January 2009 and July 2013 were evaluated. We considered neuromuscular scoliosis to be that caused by either neuropathy or myopathy and congenital scoliosis to be that caused by congenital vertebral anomalies. All the medical charts investigated were from patients operated on by the same team of spine surgeons and anesthetized by the same team of anesthetists. Since 1999, the team has included only two anesthetists working with the same protocol for transfusion indication.

For inclusion in the study, the treatment carried out must have been arthrodesis by the posterior route with instrumentation with pedicular screws. Criteria for exclusion were as follows: patients operated on by other routes, patients with arthrodesis without instrumentation, surgeries with instrumentation other than pedicular screws (modular growth instrumentation, for example), revision surgeries and scoliosis of other types. A preoperative red blood cell level lower than 12 grams per deciliter of serum was a contraindication for surgery and therefore was considered an exclusion criterion for this study.

We investigated data on the sex of the patients, age (in years), curve angle (in degrees) before surgery, type of scoliosis (idiopathic, neuromuscular or congenital), surgery duration (in minutes) and number of fused levels. The scoliotic angle was measured by analyzing the preoperative radiographies using the Cobb method (10). The angle measured for analysis was the main scoliotic curve (larger and more rigid) in all cases.

The number of red blood cell (RBC) packs transfused in the perioperative period was also recorded. We defined the perioperative period as the time from surgery to the period shortly after hospital discharge (in case there was a need for postoperative transfusion by clinical decompensation). The team of anesthetists used homogenous, classical criteria for the indication for transfusion (11), based mainly on the patient's risks of developing complications due to inadequate oxygenation (indicated by serum hemoglobin levels).

The normality of the data was evaluated by the Kolmogorov-Smirnov test and analysis of the distribution histograms.

We analyzed the association of the risk factors with the data on blood transfusion. For the Gaussian distribution data, we used Pearson's correlation test and for the abnormal distribution data, we used Spearman's correlation test.

Finally, we evaluated whether the positive associations were maintained when the three types of scoliosis were evaluated separately. The associations were calculated by Pearson's or Spearman's correlation tests where appropriate, depending on the data distribution characteristics. The differences between the groups, in turn, were calculated by the Mann-Whitney and Kruskal-Wallis tests or Student's t and chi-square tests where appropriate, depending on the data distribution characteristics and the number of groups studied.

We also used multiple linear regression analysis to study associations between the need for transfusion and independent variables, such as surgery duration and the number of arthrodesis levels.

RESULTS

Of the 131 patient charts initially evaluated from patients submitted to surgery in the study period, 94 patients were included in the study and 37 were excluded. The main reasons for exclusion were as follows: non-instrumented arthrodesis, surgeries instrumented without pedicular screws and revision surgeries. No corrected osteotomies were performed in any of the patients in this sample.

Our sample included 27 male patients (28.7%) and 67 female patients (71.3%). We did not find any statistically significant differences between the sex of the patients and the number of transfusions, according to the chi-square test ($p = 0.111$) (Table 1). Mean transfusions of 0.69 and 1.34 RBC packs were found for males and females, respectively. The Kolmogorov-Smirnov test demonstrated an abnormal distribution and the Mann-Whitney test showed no significant differences between the sexes in terms of the need for transfusion ($p = 0.056$) (Table 2). The mean age of the patients was 15.60 years (Table 3) and no statistically significant differences were found in terms of age between the types of scoliosis ($p = 0.34$).

The patients were distributed by the type of scoliosis: there were 13 patients (13.8%) with congenital scoliosis, 23 (24.5%) with neuromuscular scoliosis and 58 patients (61.7%) with idiopathic scoliosis. We did not find any statistically significant differences in the preoperative population distribution between the types of scoliosis (Table 1; $p = 0.723$). Means of 0.54, 1.10 and 1.32 RBC packs were transfused in patients with congenital scoliosis, neuromuscular scoliosis and idiopathic scoliosis, respectively (Table 2). The Kolmogorov-Smirnov test showed abnormal distribution and the Kruskal-Wallis test showed no significant difference between the types of scoliosis in terms of bleeding ($p = 0.296$).

Measurement of the scoliotic curve angle by the Cobb method resulted in a mean preoperative value of 69.37 degrees (Table 3). No association was found between the preoperative Cobb angle and the number of blood packs transfused ($p = 0.95$, chi-square test). The Kolmogorov-Smirnov test showed a normal distribution for this parameter.

The number of levels submitted to arthrodesis was approximately 10.84 and the mean surgery duration was 332.99 minutes (Table 3). When we divided the number of fusions necessary in each patient into ≤ 10 or > 10 arthrodeses, we found a significant association: the individuals with a higher number of arthrodeses performed had a higher number of blood packs transfused ($p = 0.005$, chi-square test).

Table 1 - Population distribution by sex and type of scoliosis.

	Number of patients (%)	*p*-value
Male	27 (28.7%)	0.111
Female	67 (71.3%)	
Congenital scoliosis	13 (13.8%)	0.723
Neuromuscular scoliosis	23 (24.5%)	
Idiopathic scoliosis	58 (61.7%)	

Table 2 - Distribution of the number of blood packs used in the surgery by the sex of the patient and the type of scoliosis treated.

	Mean	Median	Min-max	95% CI
Male	0.69	0.00	0-4	0.56 (0.22-1.16)
Female	1.34	1.00	0-5	1.25 (0.98-1.71)
Congenital scoliosis	0.54	0.00	0-3	0.43 (0.01-1.07)
Neuromuscular scoliosis	1.10	0.00	0-5	0.04 (0.37-1.83)
Idiopathic scoliosis	1.32	1.0	0-4	1.24 (0.93-1.70)

CI = confidence interval

In the distribution analysis for transfusion and association with the different variables studied, we found the following data. The correlation between the number of levels submitted to arthrodesis and the quantity of RBC packs transfused was very low (Pearson's correlation test; R = 0.103). The correlation between surgery duration in minutes and the quantity of blood packs transfused was also very low (Pearson's correlation test; R = 0.144). Additionally, the correlation between the measurement of the curves prior to surgery by the Cobb method and the quantity of RBC packs transfused was very low (Pearson's correlation test; R = 0.004) (Figure 1).

The frequency of the use of blood packs per patient is shown in Table 4. The number of levels submitted to arthrodesis was significantly ($p = 0.001$) associated with the number of packs transfused based on regression analysis (Table 5).

DISCUSSION

Surgery is the first-line treatment for congenital and neuromuscular scoliosis and it plays an important role in the treatment of idiopathic scoliosis too. Surgery for extensive arthrodesis by the posterior route is, in itself, a treatment associated with high morbidity, particularly in patients with non-idiopathic scoliosis. The identification of predictive factors of bleeding can assist in the surgical planning for these patients, increasing the accuracy and safety of the treatment of this disease (12-14). In fact, we observed that the number of fused levels was higher than 10 per patient on average and that the average surgery duration was longer than five hours, indicating the high complexity and morbidity of these procedures. Multiple linear regression analysis showed that a one-level increase in arthrodesis required transfusion of 0.2 packs of RBCs.

The sample studied was in agreement with other samples described in the literature in terms of the prevalence of females and the average age (15). Additionally, the distribution of the types of scoliosis treated (13.8% with congenital scoliosis, 24.5% with neuromuscular scoliosis and 61.7% with idiopathic scoliosis) reflects the frequency of each type in the general population (14). The measurements of the angles by the Cobb method in our study are also compatible with the classic indications for surgical treatment of scoliosis based on the magnitude of the main curve (12-14).

Table 3 - Population distribution by age and clinical data. The 95% confidence interval is also provided (95% CI).

	Mean	Median	Min-max	95% CI
Age (years)	15.60	16.00	11-43	16.22 (15.66-17.53)
Pre-Cobb (degrees)	69.37	68.72	40-112	68.72 (64.84-73.89)
Arthrodesis (levels)	10.84	11.00	3-19	10.80 (10.17-11.50)
Surgery duration (minutes)	332.99	320	60-690	329.99 (307.95-358.02)

We evaluated whether the number of RBC packs was associated with the other variables. However, unlike Ialenti et al. (8), who studied only patients with idiopathic scoliosis and with different surgical approaches, we could not associate blood loss with sex ($p = 0.056$) in our sample. This may be because in our study, we combined three different types of scoliosis and only included patients operated on by the posterior approach. Indeed, we believe that there is no clinical justification for the difference between the sexes.

Regarding the type of scoliosis in relation to the quantity of RBC packs transfused, we found an abnormal distribution and the Kruskal-Wallis test showed no significant differences between the groups ($p = 0.296$). Interestingly, in our study, these data showed that bleeding between the various types of scoliosis was not different, in contrast to what might be expected. We can infer, for example, that in idiopathic scoliosis, the fusion may sometimes be less complicated than in cases of neuromuscular scoliosis, which has a high level of complications and more bleeding due to the greater complexity and magnitude of the treatment (16). Additionally, patients with neuromuscular and congenital scoliosis are generally much more likely to have clinical comorbidities than patients with idiopathic scoliosis (17), which may reflect a lower functional reserve and consequently, a greater need for transfusion. However, these possibilities were not clinically significant in our study.

We found a low correlation between the quantity of red blood cells transfused and the number of spinal levels submitted to fusion (R = 0.103), surgery duration in minutes (R = 0.144) and preoperative curve angle measured by the Cobb method (R = 0.004). However, in further regression analysis, the number of levels submitted to fusion (varying from 3 to 19 in our sample) was found to be significantly associated with the number of packs transfused. This finding is similar to the findings of Yu et al. (6) in China, which indicated that patients undergoing six levels of arthrodesis used more packs. In Canada and the United States, Miyanji et al. and Ialenti et al. (8), respectively, also found a significant difference for bleeding and the curve angle, magnitude of arthrodesis, sex and surgery duration.

While maintaining our previous premise of the need for blood transfusion in cases of major bleeding, it is possible that our sample may have received less aggressive surgical treatment than that offered by the other authors, which would decrease the amount of bleeding in our patients and, consequently, the need for perioperative blood transfusion. The authors from China, for example, cite the use of corrective osteotomies (6). Use of this technique would increase the likelihood of bleeding during surgery; however, this procedure was not used in our sample.

On the other hand, it is possible that our inference is incorrect and that there is no direct, measurable correlation between the amount of bleeding and the need for blood transfusion. In fact, a series of variables, such as the functional reserve and cardiac function of the patient, play

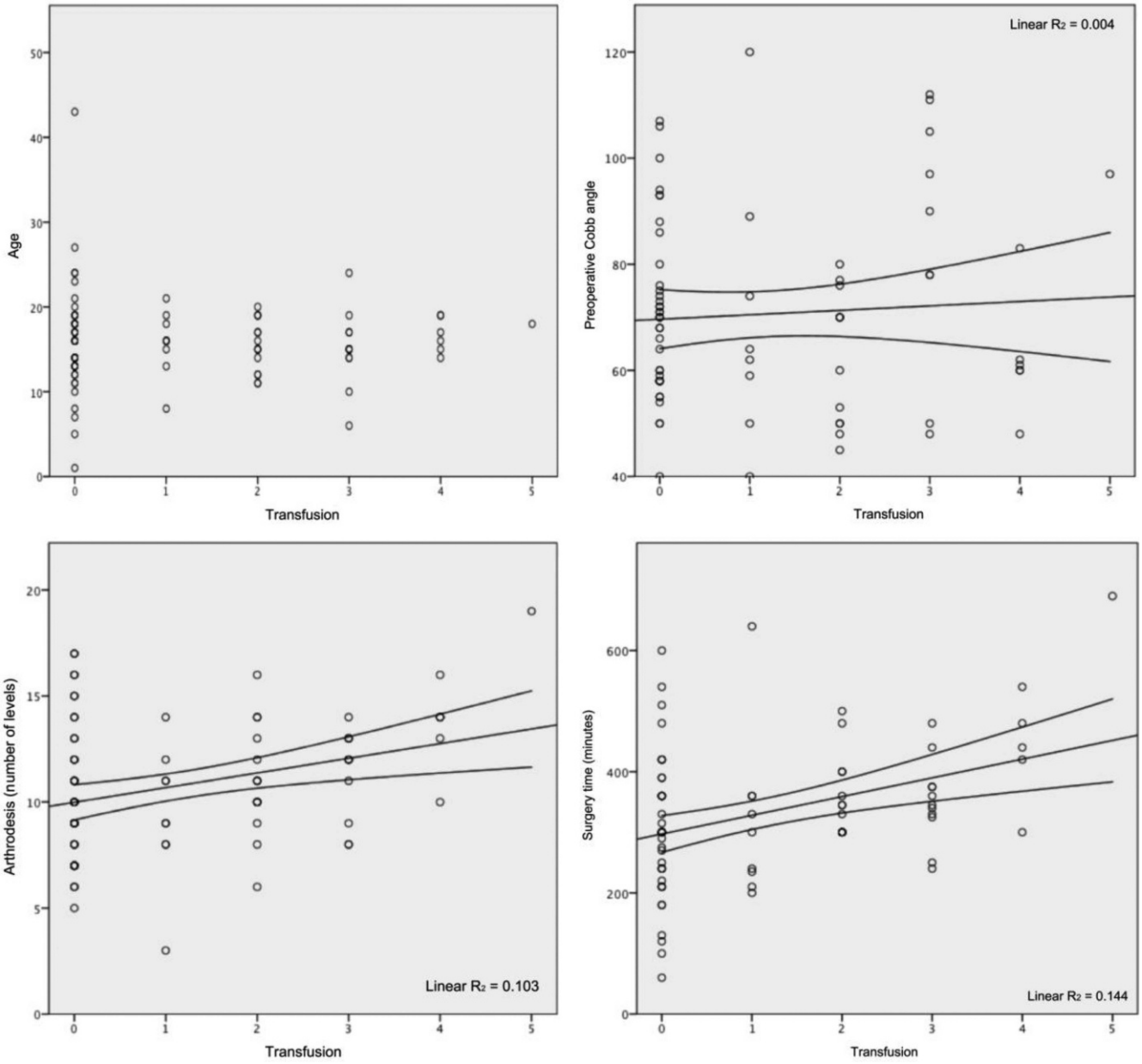

Figure 1 - Dispersion and correlation graphs, by age, levels of the spine submitted to arthrodesis, preoperative Cobb angle and duration of surgery, according to the need for blood transfusion.

Table 4 - Distribution of the number of blood packs used per patient.

	Frequency	Percentage
No transfusion	47	50.0
1 pack	9	9.6
2 packs	15	16.0
3 packs	12	12.8
4 packs	6	6.4
5 packs	1	1.1
Total	**90**	**95.7**
Missing	4	4.3
Total	**94**	**100.0**

Table 5 - Multiple linear regression analysis of the association between specific variables and the number of blood packs used per patient.

Variable	*p*-value	Beta-exp
Sex	0.122	0.185
Age	0.769	0.035
Diagnosis	0.187	0.159
Preoperative Cobb angle	0.756	-0.039
Surgery duration (minutes)	0.111	0.231
Levels of arthrodesis	0.001	0.199

a role in the indication for blood transfusion and could create a bias in this correlation.

The weak association between the need for transfusion and the curve angle, extent of the arthrodesis, sex of the patient and surgery duration is concrete based on the data in our study. In association with the conclusions of the abovementioned authors, this may lead us to infer that bleeding may not result in sufficient clinical repercussions resulting in the need for blood transfusion, although greater bleeding is associated with the factors studied. This conclusion prompts discussion as to whether this significant difference in relation to bleeding is of clinical significance, assuming that the indications for transfusion are homogenous among the anesthetists and based on international guidelines (11). It should be noted that all the patients this study were anesthetized by the same team, who followed classic indications for transfusion; this fact makes this possibility even more plausible.

This retrospective study has some limitations, including the fact that it is based on patient records, which could subject the analysis to registration errors. In our sample, we were not able to fully identify the precise indication for transfusion, which could bias the study. We conducted this study under the premise that the clinical practice is homogenous in our institution and therefore, the indications for transfusion were similar. Another problem is the small number of patients with congenital and neuromuscular scoliosis, which may have decreased our statistical power. It is possible that the small sample contributed to the negative findings of our study.

This is a pioneering study in Brazil. The findings of this study suggest that bleeding in scoliosis surgery may not have sufficient clinical repercussions to require a blood transfusion, as the mean volume of transfused blood (less than two blood packs per patient) suggests, indirectly, that there was little bleeding in these patients submitted to this major elective surgery.

An understanding of these factors is important for adequate surgical planning of this complex major surgical procedure. Therefore, our findings will help improve the treatment of these patients. Based on the findings of our study, it is possible that the need for blood transfusion is lower than expected. Alternatively, it may not be possible to predict the need for blood transfusion based on the factors studied, such as age and type of scoliosis.

This study did not reveal any statistically significant association between the need for perioperative transfusion and curve angle, sex of the patient, or surgery duration in patients with idiopathic, congenital and neuromuscular scoliosis. A higher number of spinal levels submitted to arthrodesis was associated with increased use of blood packs.

AUTHOR CONTRIBUTIONS

Cristante AF, Borges PA, Barbosa AR, Letaif OB and Marcon RM participated in the study design, data collection and interpretation, and manuscript writing. Barros-Filho TE participated in the study design and data interpretation, and revised the final version of the manuscript for publication.

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