

Predictors of blood transfusion in patients undergoing elective surgery for degenerative conditions of the spine

Raúl Torres-Claramunt, Manuel Ramírez, Mercedes López-Soques, Guillem Saló, Antoni Molina-Ros, Andreu Lladó & Enric Cáceres

Archives of Orthopaedic and Trauma Surgery

Including Arthroscopy and Sports Medicine

ISSN 0936-8051

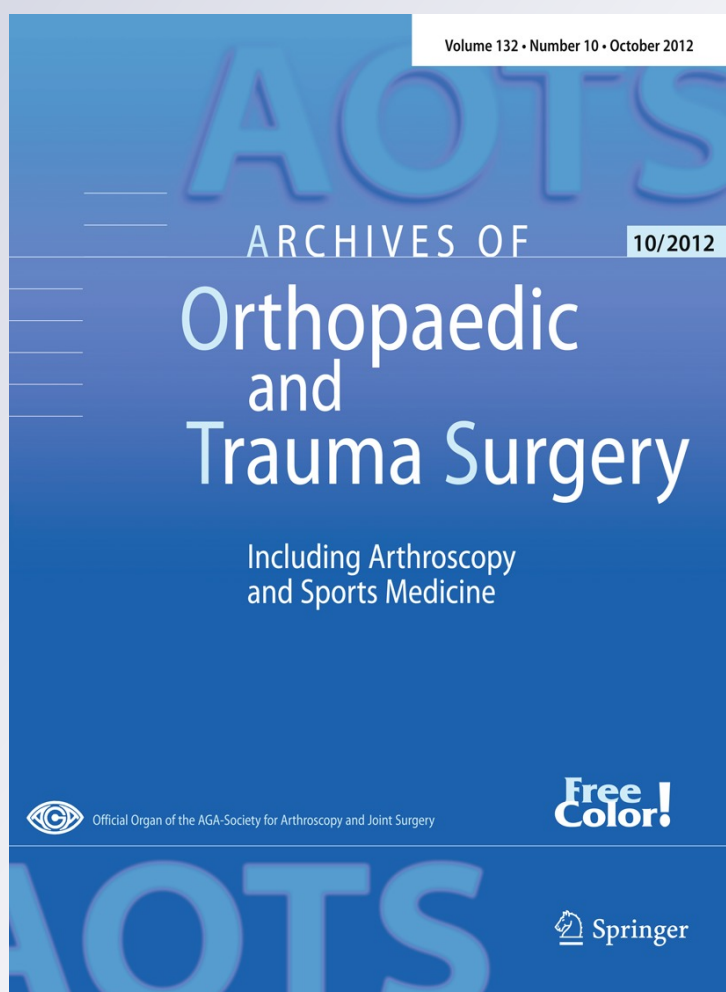
Volume 132

Number 10

Arch Orthop Trauma Surg (2012)

132:1393-1398

DOI 10.1007/s00402-012-1563-y



Your article is protected by copyright and all rights are held exclusively by Springer-Verlag. This e-offprint is for personal use only and shall not be self-archived in electronic repositories. If you wish to self-archive your work, please use the accepted author's version for posting to your own website or your institution's repository. You may further deposit the accepted author's version on a funder's repository at a funder's request, provided it is not made publicly available until 12 months after publication.

Predictors of blood transfusion in patients undergoing elective surgery for degenerative conditions of the spine

Raúl Torres-Claramunt · Manuel Ramírez · Mercedes López-Soques · Guillem Saló · Antoni Molina-Ros · Andreu Lladó · Enric Cáceres

Received: 29 November 2011 / Published online: 17 June 2012
© Springer-Verlag 2012

Abstract

Background The requirement of blood in the surgery of degenerative conditions of lumbar spine is around 10 %. Preoperative autologous blood donation is an effective method that is used in surgeries with an important blood loss. This is an expensive method because of the great number of predonated blood units not used in the postoperative period (around 70 % in our practice).

Objective To know the risk factors associated with transfusion in the postoperative period in patients who undergo surgeries of degenerative conditions of the lumbar spine.

Methods We designed a retrospective study of 142 cases of patients operated for degenerative conditions of the lumbar spine (not including simple disk hernia or adult degenerative scoliosis).

Results Female sex, age >60 years, preoperative ASA score 3 and preoperative hemoglobin ≤ 136 g/L are the risk factors related to the need of blood transfusion in the postoperative period. After application of a statistical study, female sex and preoperative ASA score 3 were the

most important variables to explain transfusional risk. A woman with ASA score 3 has a 61 % foretold probability to be transfused in the postoperative period, while a man with ASA < 3, only 1.1 %. For this reason, application of this method to patients with these risk factors is more cost-effective.

Conclusions Females, ASA 3, preoperative hemoglobin ≤ 136 g/L and age older than 60 years increase the risk to be transfused in the postoperative period for degenerative conditions of the spine.

Keywords Blood transfusion · Predictors · Spine surgery · Lumbar fusion · Autologous donation

Introduction

Lumbar surgery is associated with important blood loss, requiring the use of blood derivative products.

Blood transfusion is expensive [1], with potential disadvantages (allergic reactions, isoimmunization, hemolytic reactions or transmission of diseases, such as HIV or hepatitis C virus) [2].

Blood is a limited resource; therefore, it is important to seek alternatives in surgeries in which there is a high risk for blood transfusion in the postoperative period [3].

During the last few years, multiple techniques of blood conservation have been used, including preoperative autologous blood donation, post- or intraoperative reinfusion of shed blood, pharmacological intervention in the coagulation cascade, preoperative administration of recombinant erythropoietin (rEPO) or controlled hypotension at surgery [4–13].

Predonation has been shown to be effective in patients undergoing hip arthroplasty, knee arthroplasty or lumbar

R. Torres-Claramunt (✉) · M. Ramírez · G. Saló · A. Molina-Ros · A. Lladó
Orthopaedic Departament Parc de Salut Mar,
Universitat Autònoma Barcelona, Passeig Marítim 25-29,
08003 Barcelona, Spain
e-mail: RTorresClaramunt@parcdesalutmar.cat

M. López-Soques
Haematologic Department, Parc de Salut Mar,
Universitat Autònoma Barcelona, Passeig Marítim 25-29,
08003 Barcelona, Spain

E. Cáceres
Orthopaedic Department ICATME, Institut Universitari Dexeus,
Carrer Sabino Arana 5-19, 08017 Barcelona, Spain

spine surgeries [14]. However, because a large number of predonated units are not finally required, this procedure is not longer recommended [15, 16].

This problem was observed in our department when starting the implementation of autologous blood transfusion in patients undergoing elective lumbar surgery. More than 70 % of the predonated units obtained preoperatively was not used and had to be eliminated in the postoperative period.

To improve the effective use of blood transfusion, a retrospective study was designed, with the following objectives: (a) to audit the amount of blood transfusions required in the early postoperative period of patients undergoing spinal arthrodesis and (b) to assess risk factors for transfusion.

Methods

A retrospective study was conducted to review the medical records of 142 patients (61 men and 81 women) operated on at the spine unit of our department between January 2003 and November 2004.

All patients operated with the diagnosis of lumbar spinal degenerative conditions were included, excluding other diagnoses such as adult degenerative scoliosis and simple disc hernia. Revision cases were not included in the study. Intraoperatively, controlled hypotension was used in all patients.

The following data were recorded: age, sex and associated pathologies (by means of Charlson [17] and ASA-American Society of Anesthesiologist and comorbidity scales), blood losses estimated by the lowest hemoglobin value during the five postoperative days, the number of levels instrumented and the duration of surgery. The need of blood transfusion during the postoperative period was also assessed.

Statistical analysis

Patients who required transfusions and those who did not were compared. Qualitative variables are expressed as absolute frequency and percentage, and quantitative variables as mean and standard deviation (SD) or as median and percentiles (25th, 50th, 75th). Categorical variables were analyzed with the Chi-square test or the Fisher's exact test, and continuous variables with the Student's *t* test or the Mann–Whitney *U* test according to the distribution of variables. All statistically significant variables in the univariate analysis with a *P* value <0.10 were included in a logistic regression model to assess risk factors for blood transfusion. The discriminating value of the two final variables obtained was analyzed by the area under the

receiver operating characteristics (ROC) curve. Statistical significance was set at $P \leq 0.05$. The SPSS computer software was used for statistical analysis.

Results

There were 61 men and 81 women, with a mean (SD) age of 52.5 (14.6) years. The mean duration of operation was 153.0 (54.8) min. The mean length of hospital stay was 8.2 (5.3) days. The mean preoperative serum hemoglobin level was 138.3 (14.8) g/L. As shown in Table 1, there were statistically significant differences in age, sex, preoperative and postoperative hemoglobin levels and ASA score.

Table 2 shows differences in the percentage of patients requiring blood transfusion when the study population was divided into two groups according to age (categorized as ≤ 60 vs. >60 years), preoperative hemoglobin value (≤ 136 vs. >136 g/L) and ASA score (<3 vs. 3). Blood transfusion was required by 5.6 % of patients younger than 60 years of

Table 1 Variables in function for requiring blood transfusion

	Not transfused (<i>n</i> = 129)	Transfused (<i>n</i> = 13)	<i>P</i>
Age	51.6 ± 14.5	61.5 ± 13.0	0.02
Duration of operation	152.6 ± 52.9	156.9 ± 68.6	NS
Hb presurgery	140.22 ± 13.49	130.17 ± 17.65	0.018
Hb postsurgery	107.57 ± 17.79	89.46 ± 18.4	0.001
Sex			
Men (<i>n</i> = 61)	96.7 % (59)	3.7 % (2)	0.02
Women (<i>n</i> = 81)	86.4 % (70)	13.6 % (11)	
Levels instrumented	1 [1,2]	1 [2,3]	NS
Charlson	0 [0,0]	0 [0,0]	NS
ASA	2 [1,2]	3 [2,3]	0.001

Table 2 Transfusion frequency

		<i>P</i>
Age (years)		
≤60 (<i>n</i> = 90)	5.6 % (5)	0.063
>60 (<i>n</i> = 39)	16.3 % (8)	
Hb presurgery (g/L)		
≤136 (<i>n</i> = 58)	13.8 % (8)	0.067
>136 (<i>n</i> = 81)	4.9 % (4)	
ASA		
<3 (<i>n</i> = 115)	5.2 % (6)	0.001
=3 (<i>n</i> = 18)	38.9 % (7)	

The transfusion frequency in each group is described

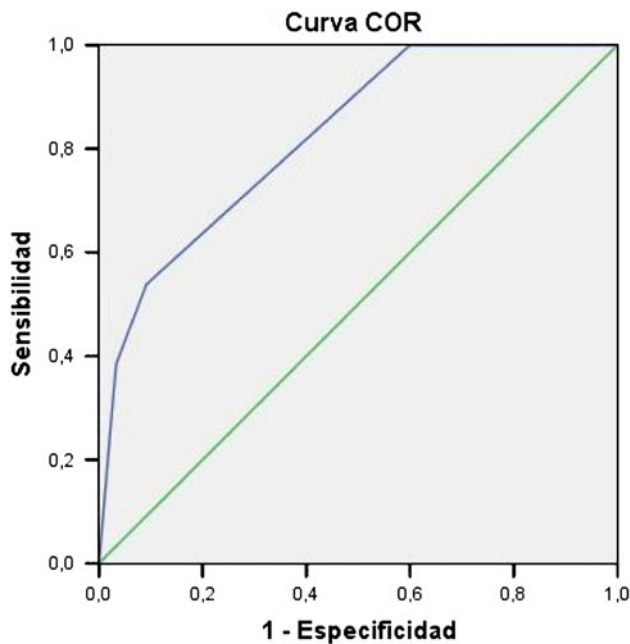


Fig. 1 ROC curve can discriminant patients who suffer the event (transfusion) and who in which not occur (discrimination power)

Table 3 Probability of being transfused with regard to sex and ASA score

	Prognosticated (%)
ASA < 3	
Man	1.1
Woman	8.2
ASA = 3	
Man	16.4
Woman	61.36

As illustrative data, the foretold probability of being transfused in women with ASA3 up to 61 % contrasts with 1.1 % in men with ASA < 3

age compared with 16.3 % of those older than 60 years ($P = 0.063$). In addition, blood transfusion was significantly more frequent among patients with preoperative hemoglobin value ≤ 136 g/L in comparison to those with a preoperative hemoglobin value > 136 g/L (13.8 vs. 4.9 %, $P = 0.067$). A significantly lower percentage of patients with ASA score <3 required transfusion in comparison with patients with an ASA score 3 (5.2 vs. 38.9 %, $P < 0.001$).

In the multivariate analysis, the only independent variables significantly associated with postoperative blood transfusion were female sex [odds ratio (OR) = 8.1, 95 % confidence interval (CI) 1.4–46.6; $P = 0.01$] and ASA score of 3 (OR = 17.8, 95 % CI 4.2–75.0; $P < 0.001$).

The ROC curve for the model showed a good discriminatory power with an area under the ROC curve of 0.82 (95 % CI 0.72–0.93), a sensitivity of 53.8 % and a specificity of 90.8 % (Fig. 1). For this, the probability of requiring transfusion was 1.1 and 8.2 % for men and women with preoperative ASA score <3, respectively. In contrast, men and women with ASA score of 3 had a probability of transfusion of 16.4 and 61.4 %, respectively (Table 3).

Discussion

Autologous blood transfusion is a well-known procedure with several drawbacks, mainly related to the availability of blood [2]. Predonation is one of the most used techniques to avoid autologous blood transfusion. However, frequently many of the units obtained are not used, representing an important additional cost [18].

Degenerative pathology of the lumbar spine is the most frequent diagnosis in patients undergoing surgical procedures of the spine. Usually, decompression and fusion of one or several levels are included. In most of the cases, decompression was done (hemilaminectomy or laminectomy). There were no differences in relation to the levels instrumented, duration of intervention and age of patient.

In our study, we excluded patients with degenerative scoliosis because of the complexity of the surgical treatment of this condition, requiring an extensive surgical approach and consequently blood transfusion in a large number of cases. On the other hand, given that blood is not usually required in patients undergoing simple discectomy due to slipped disk, this diagnosis was also considered an exclusion criterion in this study. We consider that a bias in the results could have occurred if patients with these two diagnostic categories had been included in the study.

With regard to the present results, patients in the transfusion group were significantly older and had a lower preoperative hemoglobin level than the non-transfused group. In addition, a significantly lower percentage of men compared with women required transfusion. Table 2 shows the differences between patients older and younger than 60 years, between those with a preoperative hemoglobin level lower or greater than 136 g/L, and between those with preoperative ASA score lower or equal than 3. Different authors have emphasized the importance of preoperative hemoglobin value to predict the need of postoperative blood transfusion [19, 20]. Lee et al. [19] and Kennedy et al. [21] even describe predonation as a cause of decreased preoperative hemoglobin. In the study of Nuttall et al. [22], three preoperative risk factors for transfusion were identified, including low levels of hemoglobin, number of operated levels and predonation of blood. In our

study, however, predonation of blood was not statistically significant.

The results of this study refute other studies that consider preoperative hemoglobin as an important risk factor for needing a transfusion in the postoperative period. Perhaps, as we have seen in this study, ASA and women are more important risk factors for requiring a transfusion after surgery than the others. ASA includes associated pathology of patients and age, so probably patients with low preoperative hemoglobin are those with associated pathology, and consequently they present a high ASA level. Kiliçer et al. [23] studied the assigned ASA score depending on age in patients undergoing lumbar arthrodesis. Older patients have higher scores than younger ones.

The levels instrumented did not have relevance in the final results of our study. Other studies associated this risk factor with a high incidence of complications, but they included in their study patients operated at more than three levels [22]. We consider three levels as the maximal number of operated levels, because most of the population undergoing this type of surgery require instrumentation of one or two levels.

With regard to the variable of gender, several studies [24–26] have shown differences in postoperative transfusion requirements between men and women, although statistical significance was not reached. Berenholtz et al. [24] reported a study with almost 4,000 patients in which several risk factors for postoperative blood transfusion requirements were identified. These included age, female sex and comorbidity. In this study, women had an increased risk to be transfused (OR = 1.6, 95 % CI 1.2–2.0). In the present study, women had 8.1 more probability to be transfused than men.

The need for blood transfusion has been associated with the presence of comorbid diseases [27]. In our study, two instruments were used to assess comorbidity: the Charlson index and the ASA score. In this respect, the Charlson score was not associated with blood transfusion, probably because most patients scored 0 (only less than 25 % of patients had a Charlson score of 1 or 2). In contrast, the ASA scale was useful to assess the weight of comorbidities, given that a statistically significant difference was obtained using a cutoff of 3. Only 5.2 % of patients with ASA score <3 required transfusion compared with 38.9 % for those with ASA score of 3. In fact, patients with ASA score of 3 had up to 17.8 greater probability to be transfused than patients with ASA score <3. The predictive value of both female gender and ASA score of 3 was confirmed by high specificity (91 %) shown by the ROC curve.

Wass et al. [28] studied changes in blood transfusion practice in the last two decades in major surgery, including spine surgery. In conclusion, lower acceptable hemoglobin concentrations were observed in the preoperative period in

older patients. Although there was worse comorbidity and exposure to longer major spine operations, there were no significant changes in the incidence of preoperative morbidity or mortality. Millet et al. [27] assessed risk factors for blood transfusion in patients undergoing shoulder arthroplasty. In this study, hemoglobin values lower than 11 g/L or patients older than 75 years increased the transfusion risk significantly. These authors did not recommend predonation in patients with preoperative hemoglobin level lower than 130 g/L. Hatzidakis et al. [25] studied 489 patients undergoing knee and hip replacement operations as well as re-operations. Predonation was obtained in 54 % of the patients, but postoperative transfusion was required by only 39 %. These authors conclude that patients with a preoperative hemoglobin level >150 g/L or between 130 and 150 g/L and younger than 65 years have a low risk of being transfused in the postoperative period. In a clinical series of children with scoliosis, Vitale et al. [26] established the risks for being transfused in the postoperative period in relation to four variables: the degree of curvature, type of scoliosis, use of preoperative rEPO and the need or not to perform lumbosacral fusion.

From data obtained, we recommend assessing preoperative blood autodonation in all women patients with ASA 3 undergoing lumbar arthrodesis of one, two or three levels, due to high risk of requiring a transfusion in the postoperative period. In our environment, when a surgeon indicates a surgery, the patient is visited by an anesthetist, who suggests autodonation or other kinds of blood saving. The sex of the patient and the ASA score are patient-related factors not related to the surgical procedure. So, the anesthetist suggests autotransfusion in those patients, knowing only the number of levels that are to be instrumented.

Although the relevance of preoperative hemoglobin level, female gender and underlying comorbidity have been recognized in previous studies [19–22, 24–27], the present study shows the clinical relevance of the ASA score, particularly in combination with female sex, for assessing accurately the risk for postoperative transfusion in patients undergoing elective lumbar spine surgical procedures.

The present results, however, should be interpreted taking into account some limitations, such as the retrospective design and the fact that subgroup analyses were made on data of the 13 patients (10 % of the series) who were transfused. However, the validity of the results is supported by significant differences obtained in the statistical analysis.

Conclusions

We have been able to describe four variables that predict the risk for transfusion in the postoperative period: age

older than 60 years, preoperative hemoglobin lower than 136 g/L, female sex and ASA 3.

These data are useful as they allow our institution to reorient our own blood policies regarding orthopedic spinal surgery and increase cost-effectiveness.

Our results suggest that we should obtain predonated autologous blood units from women patients with ASA 3 (or more), based on a foretold probability of up to 60 % of these women needing transfusion in the postoperative period, supported by a specificity greater than 90 %. This approach would make autologous donation more appropriate, since we would discard very few unused units. However, we are aware that these patients are often excluded from autologous blood donation due to comorbidities.

Regarding the levels of hemoglobin, we already work with the preoperative evaluation of anemia, which leads us in some cases to the use of recombinant erythropoietin EPO, a helpful treatment to address low preoperative hemoglobin levels. Additionally, we may limit or at least not promote the predonation of autologous blood in men and women younger than 60 years, as their low probability of being transfused increases the outdated rates of autologous blood.

Our data should promote prospective studies to obtain more knowledge about the risk of being transfused in the postoperative period with a greater statistical meaning and to search for more variables besides those described in this work.

Acknowledgments We thank Marta Pulido, MD, for editing the manuscript.

Conflict of interest No funds were received in support of this work. No benefits in any form have been or will be received from a commercial party related directly or indirectly to the subject of this manuscript.

References

1. 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* 332:719–724
2. Cha CW, Deible C, Muzzonigro T, Lopez-Plaza I, Vogt M, Kang JD (2002) Allogenic transfusion requirements after autologous donations in posterior lumbar surgery. *Spine* 27:99–104
3. Keating EM (2005) Preoperative evaluation and methods to reduce blood use in orthopedic surgery. *Anesthesiol Clin North Am* 23:305–313
4. Tobias JD (2004) Strategies for minimizing blood loss in orthopedic surgery. *Semin Hematol* 41:145–156
5. Hu SS (2004) Blood loss in adult spinal surgery. *Eur Spine J* 13(1):S3–S5
6. Goodnough LT, Marcus RE (1992) Effect of autologous blood donation in patients undergoing elective spine surgery. *Spine* 17:172–175
7. Copley LA, Richards BS, Safavi FZ, Newton PO (1999) Hemodilution as a method to reduce transfusion requirements in adolescent spine fusion surgery. *Spine* 24:219–222
8. Sebastian C, Romero R, Olalla E, Ferrer C, Garcia-Vallejo JJ, Muñoz M (2000) Postoperative blood salvage and reinfusion in spinal surgery: blood quality, effectiveness and impact on patient blood parameters. *Eur Spine J* 9:458–465
9. Reitman CA, Watters WC 3rd, Sassard WR (2004) The Cell Saver in adult lumbar fusion surgery: a cost-benefit outcomes study. *Spine* 29:1580–1584
10. Epstein NE, Peller A, Korsh F, DeCrosta D, Boutros A, Schmigeliski C, Greco J (2006) Impact of intraoperative normovolemic hemodilution on transfusion requirements for 68 patients undergoing lumbar laminectomies with instrumented posterolateral fusion. *Spine* 31:2227–2230
11. Martínez V, Monsaingeon- Lion A, Cherif K, Judet T, Chauvin M, Fletcher D (2007) Transfusion strategy for primary knee and hip arthroplasty to lower transfusion rates and hospital costs. *Br J Anaesth* 99:794–800
12. Colomina MJ, Bagó J, Pellisé F, Godet C, Villanueva C (2004) Preoperative erythropoietin in spine surgery. *Eur Spine J* 13:S40–S49
13. Chanda A, Smith DR, Nanda A (2002) Autotransfusion by cell saver technique in surgery of lumbar and thoracic spinal fusion with instrumentation. *J Neurosurg* 57:340–344
14. García- Erce JA, Muñoz M, Bisbe E, Sáez M, Solano VM, Beltrán S, Ruiz A, Cuenca J, Vicente-Thomas J (2004) Predeposit autologous donation in spinal surgery: a multicenter study. *Eur Spine J* 13:S34–S39
15. Billote DB, Glission SN, Green D, Wixson RL (2002) A prospective, randomized study of preoperative autologous donation for hip replacement surgery. *J Bone Joint Surg* 84:1299–1304
16. Bern MM, Bierbaum BE, Katz JN, Losina E (2006) Autologous blood donation and subsequent blood use in patients undergoing total knee arthroplasty. *Transf Med* 16:313–319
17. Charlson ME, Pompei P, Ales KL, MacKenzie CR (1987) A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic dis* 40:373–383
18. Ridgeway S, Tai C, Alton P, Barnardo P, Harrison DJ (2006) Predonated autologous blood transfusion in scoliosis surgery. *J Bone Joint Surg Br* 88:1187–1191
19. Lee GC, Cushner FD (2007) The effects of preoperative autologous donations on perioperative blood levels. *J Knee Surg* 3:205–209
20. Salido JA, Marín LA, Gómez LA, Zorrilla P, Martínez C (2002) Preoperative hemoglobin levels and the need for transfusion after prosthetic hip and knee surgery: analysis of predictive factors. *J Bone Joint Surg Am* 84:216–220
21. Kennedy C, Leonard M, Devitt A, Girardi FP, Cammisa FP Jr (2011) Efficacy of preoperative autologous blood donation for elective posterior lumbar surgery. *Spine* 15:E1736–E1743
22. Nuttall GA, Horlocker TT, Santrach PJ, Oliver WC Jr, Dekutoski MB, Bryant S (2000) Predictors of blood transfusions in spinal instrumentation and fusion surgery. *Spine* 25:596–601
23. Kilincer C, Steinmetz MP, Sohr MJ, Benzel EC, Bingaman W (2005) Effects of age on the perioperative characteristics and short-term outcome of posterior lumbar fusion surgery. *J Neurosurg Spine* 3:34–39
24. Berenholtz SM, Pronovost PJ, Mullany D, Garrett E, Ness PM, Dorman T, Klag MJ (2002) Predictors of transfusion for spinal surgery in Maryland, 1997 to 2000. *Transfusion* 42:183–189
25. Hatzidakis AM, Mendlick RM, McKillip T, Reddy RL, Garvin KL (2000) Preoperative autologous donation for total joint arthroplasty. An analysis of risk factors for allogenic transfusion. *J Bone Joint Surg* 82:89–100

26. Vitale MG, Levy DE, Park MC, Choi H, Choe JC, Roye DP Jr (2002) Quantifying risk of transfusion in children undergoing spine surgery. *Spine J* 2:166–172
27. Millet PJ, Porramatikul M, Chen N, Zurakowski D, Warner JJ (2006) Analysis of transfusion predictors in shoulder arthroplasty. *J Bone Joint Surg* 88:1223–1230
28. Wass CT, Long TR, Faust RJ, Yaszemski MJ, Joyner MJ (2007) Changes in red blood cell transfusion practice during the past two decades: a retrospective analysis, with the Mayo database, of adult patients undergoing major spine surgery. *Transfusion* 47:1022–1027