

Factors predicting blood transfusion in different surgical procedures for degenerative spine disease

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Abstract. – BACKGROUND AND OBJECTIVES:

Spine surgery frequently needs allogeneic blood transfusions to compensate for great blood loss. Autologous blood donations often are indicated to reduce homologous transfusions. In last decades interbody spinal fusion has gained popularity, being frequently performed in many spine procedures. Nevertheless, there are few studies evaluating the risk factors of additional blood transfusions in the postoperative course of degenerative spine surgery and no one concerning patients who underwent interbody fusion.

MATERIALS AND METHODS: In 15 consecutive months, in the same Department of Spine Surgery 40 different elective spine surgeries were performed, divided into four groups: laminectomy alone, laminectomy with an instrumented posterolateral fusion, laminectomy with an instrumented posterolateral and interbody fusion, extensive instrumented fusion.

All patients surgery-related data were respectively recorded: patient age, gender, diagnosis, preoperative hemoglobin rate, autologous blood availability, number of spinal level decompressed and fused, duration of surgery, type of surgical procedure, duration of hospital stay. These data were statistically analysed to determine whether variables could determine higher risk of blood transfusion.

RESULTS: In an univariate analysis of factors influencing the need of blood transfusion, significantly greater risk of blood transfusions was observed in the female, in case of low preoperative Hb rate, longer surgical times, multiple spinal level decompressed or fused and longer duration of hospital stay. Our linear multiple regression modeling showed that patients gender and increased number of levels decompressed and levels surgically fused were significant determinants of need of blood transfusion.

CONCLUSIONS: The practical value of this work can be particularly appreciated by those who are used to consider blood predonation. According to our findings blood predonation should preferably be proposed to women supposed to undergo spine instrumented fusion or a more than three levels spine decompression.

Key Words:

Complications, Blood loss, Spinal interbody fusion, Spine surgery.

Introduction

Patients undergoing spine surgery are possibly exposed to severe blood loss so that different methods have been developed to face this problem. Allogeneic transfusion can compensate the anemia but the occurrence of transfusion-related infections, the refuse secondary to cultural or religious beliefs, the limited availability, are solid reasons for evaluating possible alternatives.

Predeposit programs before surgery and plasmapheresis or intentional isovolemic hemodilution during surgery are largely adopted solutions. Particularly, predeposit programs for autologous blood transfusions have become standard in association with elective spine surgery¹ and has shown to reduce the number of allogeneic transfusions². Because the need for blood transfusion in patients undergoing spine surgery is difficult to predict due to variety of surgical procedures, various studies have been attempted to determine guidelines for its use³⁻¹¹.

In last decades interbody spinal fusion procedure with a transforaminal (TLIF) or a posterior (PLIF) approach has gained popularity, with indications including spinal stenosis, instability, degenerative disc disease, spondylolisthesis, spondylolysis, and bilateral disc herniation¹²⁻¹⁴. Even if these procedures are performed by posterior approach alone, the operation time is longer than posterior fusion and consequentially more blood loss can be expected.

Based on these preliminary remarks specific guidelines should be proposed to decide if and how many autologous units should be collected according to expected procedure.

This study was planned to evaluate the need of blood transfusion according to various risk factors and to different surgical procedures.

Materials and Methods

We retrospectively reviewed 40 patients that consecutively underwent spine surgery in our Department during 15-months period. Indications for surgery included single level or multiple level disc degenerative disease in 23 patients, adult kyphoscoliosis in 5 patients and segmental spinal stenosis in 12 patients. Procedures for neoplastic or septic conditions of the spine were excluded.

Among these patients there were 19 men and 21 women; mean age was 53.6 years (range 18 to 90 years).

Predeposit programs were adopted when and whenever the conditions of the patient allowed it; blood preservatives were eligible for surgery only within 28 days of donation. In those patients who predonated blood iron supplementation was prescribed.

Hemoglobin concentration, platelet count, bleeding time, prothrombin time, and activated partial thromboplastin time were determined before surgery. Hemoglobin value rate (Hb%) was evaluated before surgery in all patients as being at least 11 grams % (mean Hb% 13.7 g/dl, range 11.1 to 16.1 g/dl).

Different surgical procedures were performed (Table I): 23 cases laminectomy alone (group A), 3 cases laminectomy with an instrumented posterolateral fusion (group B), 9 cases PLIF (group C), extensive instrumented fusion was performed in the other 5 patients (group D). Extensive fusion was considered as an arthrodesis of more than five vertebral levels or a surgical procedure including one or more interpeduncular osteotomy.

Surgical Management

All patients had a general anesthesia. Intraoperative autotransfusion was used in all patients using a cell salvage instrument. The patient was prepared in the usual fashion and placed on a spine frame in the prone position. A standard posterior approach was used to access the vertebrae. The paraspinal muscles were subperiosteally elevated from the dorsal surface of the lamina out to the tip of the transverse process, allowing the dorsal aspect of the vertebral bodies to be exposed. Laminectomy, fixation and PLIF procedures were performed according to the standard

technique. Bony posterolateral gutters were decorticated and filled with cancellous bone graft. The contralateral interlaminar space also was decorticated and used as a fusion surface. The wound was frequently irrigated and closed, taking care to restore the normal muscular envelope.

Post-Operative Management

At the end of surgery and with the certainty of an increased demand of oxygen the Hb% was always brought above 9 g/dl with hemodilution. Indication for postoperative autologous or allogenic transfusion depended on Hb% and patient conditions.

According to the criteria of our Institution for blood products transfusion, indication for red blood cell units transfusion includes:

1. Hemoglobin value rate less than 7 g/dl in an otherwise healthy patient or Hb% less than 10 g/dl in symptomatic patients with increased risk of ischemia;
2. Acute blood loss of more than 30% of blood volume or with Hb% less than 9 g/dl.

The general transfusion criteria for coagulation blood products are as follows:

1. Transfusion of platelets, with evidence of platelet dysfunction (bleeding time more than 15 minutes) or thrombocytopenia (a platelet count less than 50.000/ml) in a bleeding patient;
2. Transfusion of fresh frozen plasma, with evidence of coagulation factor deficiencies (prothrombin time or activated partial thromboplastin time more than 1.4 times upper limits of normal).

The number of autologous and allogeneic blood product units transfused perioperatively and throughout the hospitalization were registered; as for the origin only 21.8% were autologous, constituted by predeposit, while 88.2% were by allogeneic origin.

All of the patients were discharged from hospital in good health condition after a mean postoperative period of 9.5 days (range 2 to 27 days).

Data regarding surgery, operative time, and duration of hospital stay were collected for each procedure (see Table I).

Statistical Analysis

The SPSS program (SPSS Inc., Chicago, IL, USA) was used for the statistical analyses. A *p*-value of 0.05 was considered statistically signifi-

Table I. Patients data and their significant correlation with blood transfusion. Significance of each variable is related to univariate statistical analysis.

	Transfusion	No transfusion	Overall	Significance
Age mean years (SD)	58.5 (13.2)	50.7 (19.9)	53.6 (18)	$p = 0.19$ Mann-Whitney
Gender:				
F [#]	12 (57.1%)	9 (42.9%)	21	$p = 0.001$ fisher exact chi square test
M	3 (15.8%)	16 (84.2%)	19	
Predonation of blood number of patients	15	25	40	$p = 0.22$ Mann-Whitney
Pre-op Hb% mean value (SD)	13.1 (1)	14.1 (1.4)	13.7 (1.3)	$p = 0.023$ anova
Diagnosis:				
Disc degeneration	5 (21.7%)	18 (78.3%)	23	$p = 0.004$ pearson chi square test evaluated by Monte Carlo Methods for small samples
Stenosis	5 (41.7%)	7 (58.3%)	12	
Adult scoliosis	5 (100%)	0	5	
Surgical procedure				
Decompression	4 (17.4%)	19 (82.6%)	23	$p = 0.004$ pearson chi square test evaluated by Monte Carlo Methods for small samples
Posterior arthrodesis	3 (100%)	0	3	
Posterior+Interbody fusion	4 (44.4%)	5 (55.6%)	9	
Extensive arthrodesis	4 (80%)	1 (20%)	5	
Surgical time mean minutes (SD)	392 (165)	239.8 (83.3)	296.9 (140)	$p = 0.002$ Mann-Whitney
Levels decompressed [#] mean number (SD)	3.6 (1.3)	2 (1.5)	2.6 (1.6)	$p = 0.001$ Mann-Whitney
Levels fused [#] mean number (SD)	4.7 (3.4)	1 (1.8)	2.4 (3.1)	$p < 0.0005$ Mann-Whitney
Hospital stay mean days (SD)	13.1 (4.9)	7.4 (4.8)	9.5 (5.6)	$p = 0.001$ Anova

[#]Significant determinant of blood transfusion in backward multiple regression model.

cant. The sample size was analysed taking transfusion of blood products as referring end-point. Data about blood transfusion were analysed using univariate analysis to show any statistically significant differences in this parameter as a function of identified variables. The following variables were considered as possible factors influencing blood loss and need of transfusion: patient age, gender, diagnosis, preoperative hemoglobin rate, autologous blood availability, number of spinal levels decompressed, number of levels fused, duration of surgery, type of surgical procedure (group A-D), duration of hospital stay.

Stepwise regression multivariate analysis was used to determine the best multiple regression model for need of blood transfusion for the independent variables assessed. All variables with statistical significance ($p \leq 0.05$) in the univariate analysis were included in these stepwise regressions. Duration of hospital stay had a strong statistical association with the transfusion of blood, but this information is not available before surgery, so it was excluded from the multivariable analysis.

Two-way interactions were not assessed due to low number of patients considered.

Results

The demographic data of the patients, transfusion requirements, and surgical variables are listed in Table I.

The univariate analysis achieved a statistically significant relation of blood products transfusion with patient gender, diagnosis, preoperative hemoglobin rate, type of surgical procedure, number of spinal level decompressed, number of spinal levels fused, duration of surgery, duration of hospital stay.

Particularly according to preoperative diagnosis, patients with adult scoliosis seems to have higher risk of blood transfusion (100% of the cases in our cohort underwent blood transfusion), than patients with degenerative disease or spinal stenosis (respectively 21.7% and 41.7%).

Surgical procedure: patients with posterior instrumented arthrodesis and those with extensive arthrodesis, seem to have higher risk of blood transfusion than patients who underwent spine decompression alone and those with posterior interbody fusion.

Need of blood transfusion was not dependent neither on patient age ($p=0.19$, Mann Whitney test for continuous data) nor on the availability of

autologous blood before surgery ($p = 0.22$, Mann Whitney test for continuous data).

Linear multiple regression modeling showed that patients gender, multiple spinal levels surgically decompressed and multiple levels surgically fused were significant determinants of the need of blood transfusion.

Discussion

Blood loss and need of transfusion during and after spine surgery have been always perceived as relevant. Intraoperative blood salvage (cell saver), controlled hypotensive anesthesia, acute normovolemic hemodilution¹⁵ are commonly accepted technique to approach this problem.

Cell-saver blood replacement in adults undergoing spine surgery appears to provide adequate amount of blood¹⁶, but it is not known whether this method compares favorably with autologous predonation in patients undergoing instrumented spinal fusion. Hemodilution is well-tolerated up to Hb 6-7 g per 100; below this level hemodynamic and coagulative problems may occur¹⁷.

Intraoperative and postoperative blood transfusion is always relevant but autologous blood is still moderate, mainly because the limited eligibility for use of blood preservatives.

Many studies exist to define the risk factors for blood transfusion in spine surgery. Cha et al⁴ reported that in patients who underwent fusion, preoperative autologous blood donation decreased the risk of allogeneic blood transfusion by 75% in non-instrumented fusions and 50% in instrumented fusions compared with patients who did not predonate blood. Patients in their series were all operated for degenerative conditions but no case of anterior fusion.

Zheng et al⁷ found that number of levels fused and age seem to be the most significant factors predicting hospital stay, operative time, intraoperative blood loss, and transfusion in patients undergoing posterior lumbar spine decompression, fusion, and segmental instrumentation.

In a well study conducted at Mayo Clinic⁵, it was demonstrated using linear multiple regression modeling that the significant determinants for increased amounts of both allogeneic and autologous red blood cell units transfused were low preoperative hemoglobin concentration and increased number of posterior levels surgically fused. They suggested that, according to others^{3,4}, that preoper-

ative blood donation increased the likelihood of autologous units transfusion. Opposite to this issue in our series we found no relationship between need of blood transfusion and the availability of autologous blood before surgery ($p = 0.22$, Mann Whitney test for continuous data). In our practice we routinely use programs of predonation as an alternative for allogenic blood transfusion. However, as supported also by others¹⁷, the preoperative blood donation, especially for noninstrumented or short instrumented fusion surgeries, is not cost-effective due to the number of waste units, to the morbidity of donation and to the anemia related to predonation of blood.

In our linear multiple regression model we found that patients gender, multiple spine levels surgically decompressed and multiple levels surgically fused represent best determinants for risk of blood transfusion. The female-related risk is mainly due to lower preoperative hemoglobin rate and to smaller blood mass, thus exposing to greater risk of intraoperative or postoperative anemia. According to the number of levels surgically treated, we observe in our cohort that patients with decompression in more than three levels, underwent blood products transfusion in 70% of cases (Figure 1). Considering instead the number of fused levels we found a larger patients dispersion (Figure 2), thus considering fusion of one single spinal level to expose to a greater risk of blood transfusion. However these cut-offs lacks of statistical power because of low number of patients.

To our knowledge the study of Johnson RG et al¹¹ was the only to consider both posterior lumbar fusion and anterior lumbar fusion using homograft bone. Nevertheless, our study is the first one to evaluate risk of blood transfusion in a cohort including also patients undergoing interbody fusion. Interbody fusion, both by TLIF and PLIF procedure, has gained popularity in last decades, with indications including spinal stenosis, instability, degenerative disc disease, spondylolisthesis, spondylolysis, and bilateral disc herniation^{12-14,18}. We always perform interbody fusion together with posterolateral instrumented arthrodesis and in the current study, we have always inserted a single interbody cage instead of two cages.

The limited number of patients considered in this study, makes difficult an accurate statistical analysis, like two-way interactions analysis of variables influencing risk of blood transfusion. Another limit is the low accuracy in detecting intraoperative blood loss amount. This parameter was not considered as a variable as no reliable

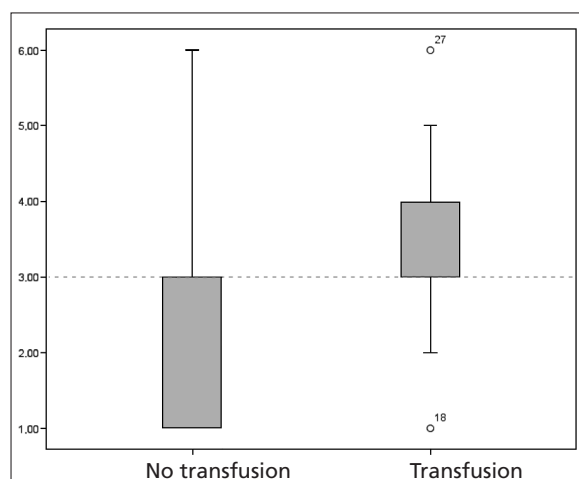


Figure 1. Distribution of patients according to number of levels decompressed.

technique rather than anesthesiologist experience³ exists to estimate accurately blood loss.

In this way our investigation is proposed to be just as first analysis that should be confirmed by a larger cohort of patients to define more accurately risk factors for blood transfusion in this kind of surgery.

A larger possibly multicenter-study should be designed to provide more accurate statistical analysis.

The practical value of this work can be particularly appreciated by those who are used to consider blood predonation. According to our results blood predonation should preferably be proposed to women supposed to undergo spine instrumented fusion or a more than three levels spine decompression.

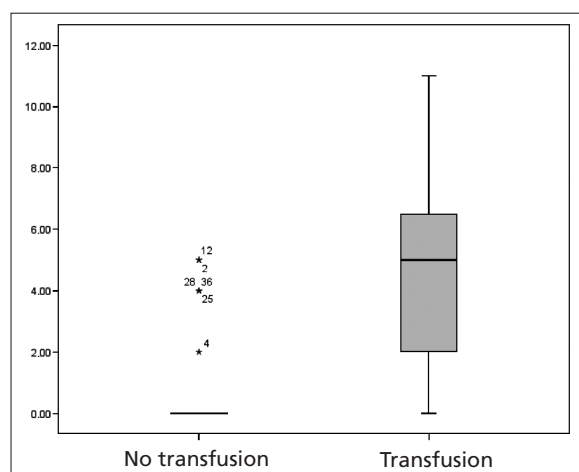


Figure 2. Distribution of patients according to number of levels fused.

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References

- 1) GOODNOUGH LT, SHAFRON D, MARCUS RE. The impact of preoperative autologous blood donation on orthopaedic surgical practice. *Vox Sang* 1990; 59: 65-69.
- 2) GOODNOUGH LT, MARCUS RE. Effect of autologous blood donation in patients undergoing elective spine surgery. *Spine* 1992; 17: 172-175.
- 3) BROOKFIELD KF, BROWN MD, HENRIQUES SM, BUTTACAVOLI FA, SEITZ AP. Allogeneic transfusion after predonation of blood for elective spine surgery. *Clin Orthop Relat Res* 2008; 466: 1949-1953.
- 4) CHA CW, DEIBLE C, MUZZONIGRO T, LOPEZ-PLAZA I, VOGT M, KANG JD. Allogeneic transfusion requirements after autologous donations in posterior lumbar surgeries. *Spine (Phila Pa 1976)*. 2002; 27: 99-104.
- 5) NUTTALL GA, HORLOCKER TT, SANTRACH PJ, OLIVER WC JR, DEKUTOSKI MB, BRYANT S. Predictors of blood transfusions in spinal instrumentation and fusion surgery. *Spine (Phila Pa 1976)* 2000; 25: 596-601.
- 6) HUMPHREYS SC, HODGES SD, PATWARDHAN AG, ECK JC, MURPHY RB, COVINGTON LA. Comparison of posterior and transforaminal approaches to lumbar interbody fusion. *Spine (Phila Pa 1976)* 2001; 26: 567-571.
- 7) ZHENG F, CAMMISA FP JR, SANDHU HS, GIRARDI FP, KHAN SN. Factors predicting hospital stay, operative time, blood loss, and transfusion in patients undergoing revision posterior lumbar spine decompression, fusion, and segmental instrumentation. *Spine (Phila Pa 1976)* 2002; 27: 818-824.
- 8) OZGUR BM, HUGHES SA, BAIRD LC, TAYLOR WR. Minimally disruptive decompression and transforaminal lumbar interbody fusion. *Spine J* 2006; 6: 27-33.
- 9) BOSTMAN O, HYRKAS J, HIRVENSALO E, KALLIO E. Blood loss, operating time, and positioning of the patient in lumbar disc surgery. *Spine* 1990; 15: 360-363.
- 10) GUAY J, HAIG M, LORTIE L, GUERTIN MC, POITRAS B. Predicting blood loss in surgery for idiopathic scoliosis. *Can J Anaesth* 1994; 41: 775-781.
- 11) JOHNSON RG, MURPHY M, MILLER M. Fusions and transfusions: An analysis of blood loss and autologous replacement during lumbar fusions. *Spine* 1989; 14: 358-362.
- 12) BRADFORD DS. Spinal instability: Orthopaedic perspective and prevention. *Clin Neurosurg* 1980; 27: 591-610.
- 13) CLOWARD RB. Spondylolisthesis: Treatment by laminectomy and posterior interbody fusion: Review of 100 cases. *Clin Orthop* 1981; 154: 74-82.
- 14) COLLIS JS. Total disc replacement: A modified posterior lumbar interbody fusion. *Clin Orthop* 1985; 193: 64-67.
- 15) DIFIORIO M, LARI S, BORIANI S, FORNARO G, PERIN S, MAFERRARI A, ZANONI A. Major vertebral surgery: intra- and postoperative anaesthesia-related problems. *Chir Organi Mov* 1998; 83: 65-72.
- 16) CHANDRA A, SMITH DR, NANDA A. Autotransfusion by cell saver technique in surgery of lumbar and thoracic spinal fusion with instrumentation. *J Neurosurg* 2002; 96(Suppl 3): 298-303.
- 17) FORGIE MA, WELLS PS, LAUPACIS A, FERGUSON D. Preoperative autologous donation decreases allogeneic transfusion but increases exposure to all red blood cell transfusion: results of a metaanalysis. International Study of Perioperative Transfusion (ISPOT) Investigators. *Arch Intern Med* 1998; 158: 610-616.
- 18) DIPAOLO CP, MOLINARI RW. Posterior lumbar interbody fusion. *J Am Acad Orthop Surg* 2008; 16: 130-139.