



## BLOOD TRANSFUSION PREDICTIVE FACTORS IN DEGENERATIVE SPINE SURGERY

### DEJENERATİF OMURGA CERRAHİSİNDE KAN TRANSFÜZYONUNU İŞARET EDEN FAKTÖRLER

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#### SUMMARY:

**Background and Objectives:** Spinal surgery frequently requires allogenic blood transfusion to compensate for major blood loss. Autologous blood donations are often used to reduce homologous transfusion. In the last few decades, interbody spinal fusion has gained in popularity and is frequently performed in many spinal procedures; however, there are few studies that evaluate the risk factors of additional blood transfusions in the postoperative course of degenerative spine surgery, and no studies concerning patients who have undergone interbody fusion.

**Materials and Methods:** In 15 consecutive months, in the same Spinal Surgery Department, 40 different elective spine surgeries were performed. These were divided into four groups: laminectomy alone, laminectomy with instrumented posterolateral fusion, laminectomy with instrumented posterolateral and interbody fusion, and extensive instrumented fusion. All patients' surgery-related data were respectively recorded, including patient age, gender, diagnosis, preoperative hemoglobin rate, autologous blood availability, number of spinal levels decompressed and fused, duration of surgery, type of surgical procedure, and duration of hospital stay. These data were statistically analyzed to determine whether any of the variables could determine a higher risk of blood transfusion.

**Results and Discussion:** In a univariate analysis of factors influencing the need for blood transfusion, no significant relationship was found with patient age or availability of autologous blood before surgery. A significantly greater risk of blood transfusion was observed for females, and in cases with a low preoperative Hb rate, longer surgical times, multiple spinal levels decompressed or fused, and longer durations of hospital stay were observed. Patients undergoing instrumented posterolateral fusion or extensive instrumented fusion are also exposed to a higher risk of blood transfusion. Our linear multiple regression model showed that the patients' gender and an increased number of levels decompressed and/or surgically fused were significant determinants for the need for blood transfusion.

**Key words:** Complications, blood loss, spinal interbody fusion, spine surgery

**Level of evidence:** Prospective clinical trial, Level II

#### ÖZET:

**Giriş ve amaçlar:** Omurga cerrahisinde yüksek oranda kan kaybını dengelemek için sıklıkla allojen kan transfüzyonu kullanılır. Bu gereksinimi azaltmak için de otolog kan toplanması kullanılabilir. Son yıllarda birçok vertebra ameliyatında "interbody" füzyon teknikleri kullanılmakla birlikte, dejeneratif omurga cerrahisinde, özellikle de interbody füzyonlarla kan kaybı ve önlenmesi konusunda herhangi bir çalışma bulunmamaktadır.

**Materyal ve metod:** On beş ayda bir omurga merkezinde gerçekleştirilmiş olan kırık birbirini izleyen cerrahi çalışmaya alındı ve dört grupta incelendi; laminektomi, laminektomi ve enstrümante posterolateral füzyon, laminektomi ve enstrümante posterolateral ve interbody füzyon, geniş enstrümante füzyon. Tüm hastaların verileri toplandı; yaş, cinsiyet, tanı, preoperatif hemoglobin düzeyi, otolog kan kullanımı, dekompresyon ve füzyon uygulanan seviye sayısı, cerrahi süresi, cerrahi tipi, hastanede kalış süresi. Bu veriler hangi parametrelerin allojen kan transfüzyonu konusunda belirleyici olabileceği açısından incelendi.

**Sonuçlar ve tartışma:** Tek değişkenli analiz ile, hasta yaşı veya otolog kan bulundurulması ile transfüzyon arasında anlamlı bir ilişki bulunamadı. Kadınlarda, düşük preoperatif Hb düzeyi olan hastalarda, uzun cerrahi girişimlerde, çok seviyede uygulanan cerrahilerde ve hastanede uzun kalan hastalarda transfüzyon olasılığının anlamlı olarak yüksek olduğu görüldü. Posterior enstrümante füzyon ve geniş enstrümante füzyon hastalarının da anlamlı olarak yüksek transfüzyon almış oldukları saptandı. Çoklu lineer regresyon modellemesi cinsiyet ve cerrahi uygulanan seviye sayısının kan transfüzyonunun belirleyici faktörleri olduğunu gösterdi.

**Anahtar Kelimeler:** Komplikasyonlar, kan kaybı, spinal cisimler arası füzyon, omurga cerrahisi

**Level of evidence:** Prospektif klinik çalışma, Düzey II

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## INTRODUCTION:

Spinal surgery exposes patients to severe blood loss. Allogenic transfusion can compensate for anemia, but the occurrence of transfusion-related infections, a patient's rejection of transfusions due to cultural or religious beliefs, and limited blood availability are reasons to evaluate possible alternatives.

Predeposit programs before surgery and plasmapheresis or intentional isovolemic hemodilution during surgery are solutions that have generally been adopted. In particular, predeposit programs for autologous blood transfusions have become standard in association with elective spine surgery<sup>11</sup> and have been shown to reduce the number of allogenic transfusions<sup>12</sup>. Because the need for blood transfusion in patients undergoing spinal surgery is difficult to predict due to the variety of surgical procedures, various studies have attempted to determine guidelines for its use<sup>1,3,4,13-18</sup>.

In the last few decades, interbody spinal fusion procedures with transforaminal (TLIF) or posterior (PLIF) approaches have gained popularity, with indications including spinal stenosis, instability, degenerative disc disease, spondylolisthesis, spondylolysis, and bilateral disc herniation<sup>2,6-8</sup>. Even if these procedures are performed using only a posterior approach, the operation time is longer than posterior fusion, and so 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 preoperatively, based on the expected procedure.

This study aims to evaluate the requirement for blood transfusion according to various risk factors and different surgical procedures.

## MATERIALS AND METHODS:

Forty patients were retrospectively reviewed who consecutively underwent spinal surgery in our department over a 15-month period. Indications for surgery included single-level or multiple-level degenerative disc disease in 23 patients, adult kyphoscoliosis in five 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; the mean age was 53.6 years (range: 18–90 years).

Predeposit programs were adopted whenever the conditions of the patient allowed it; blood preservatives were eligible for surgery only within 28 days of donation. In those patients who predated, a blood iron supplement was prescribed.

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

Different surgical procedures were performed (Table-1): 23 cases of laminectomy alone (group A), three cases of laminectomy with instrumented posterolateral fusion (group B), nine cases of PLIF (group C), and extensive instrumented fusion was performed on the other five patients (group D).

Extensive fusion was considered to be an arthrodesis of more than five vertebral levels, or a surgical procedure including one or more interpedicular osteotomies.

### SURGICAL MANAGEMENT:

All patients received general anesthesia. Intraoperative autotransfusion was used for all patients using a cell salvage instrument.

The patient was prepared in the usual fashion and placed on a spine frame in a prone position. A standard posterior approach was used to access the vertebrae. The paraspinous 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 techniques.

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

**Table-1.** Patients' data and 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	
Pre-donation 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 linear multiple regression model.

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## **POSTOPERATIVE MANAGEMENT:**

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

According to the criteria of our institution for the transfusion of blood products, indications for the transfusion of red blood cell units include:

1. Hemoglobin less than 7 g/dl in an otherwise healthy patient or Hb% less than 10 g/dl in symptomatic patients with an 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 allogenic blood product units transfused perioperatively and throughout the hospitalization period were registered. Only 21.8% of these were from an autologous origin, constituted by predeposit, while 88.2% were of allogenic origin.

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

Data regarding blood loss, operation time, and duration of hospital stay were collected for each procedure (see Table 1).

## **STATISTICAL ANALYSIS:**

The SPSS program was used for statistical analyses. A p-value of 0.05 was considered statistically significant. The sample size was analyzed, taking the transfusion of blood products as a reference end-point. Data regarding blood transfusion were analyzed using univariate analysis to show any statistically significant differences in this parameter as a function of the 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), and duration of hospital stay.

Stepwise regression was used to determine the best multiple regression models for the 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. The duration of the hospital stay had a strong statistical association with blood transfusion, but this information is not available before surgery, so it was excluded from the multivariable analysis.

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

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## RESULTS:

The demographic data of the patients, transfusion requirements, and surgical variables are listed in Table-1.

The univariate analysis showed a statistically significant relationship between blood transfusion and patient gender, diagnosis, preoperative hemoglobin rate, type of surgical procedure, number of spinal levels decompressed, number of spinal levels fused, duration of surgery, and duration of hospital stay.

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

In terms of the surgical procedure, patients receiving posterior instrumented arthrodesis and those with extensive arthrodesis seemed to have a higher risk of blood transfusion than patients who underwent spinal decompression alone and those with posterior interbody fusion.

The need of blood transfusion was not dependent on either patient age ( $p=0.19$ , Mann-Whitney test for continuous data) or on the availability of autologous blood before surgery ( $p=0.22$ , Mann-Whitney test for continuous data).

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

## DISCUSSION:

Blood loss and the need for transfusion during and after spinal surgery have always been considered relevant. Intraoperative blood salvage (cell saver), controlled hypotensive anesthesia, and acute normovolemic hemodilution<sup>8</sup> are commonly accepted approaches to this problem.

Cell-saver blood replacement in adults undergoing spinal surgery appears to provide an adequate amount of blood<sup>5</sup>, 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 6–7 grams Hb per 100; below this level, hemodynamic and coagulation problems may occur<sup>10</sup>.

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

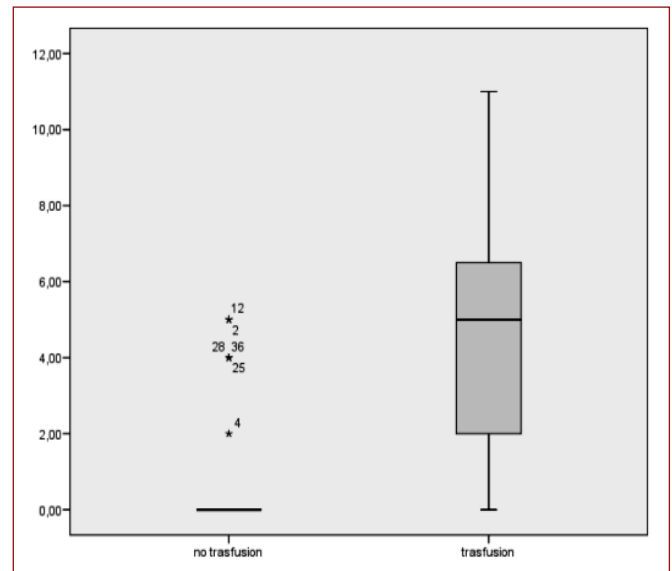
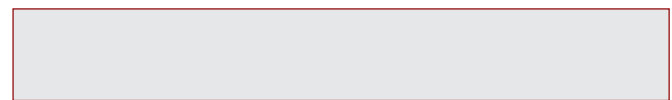
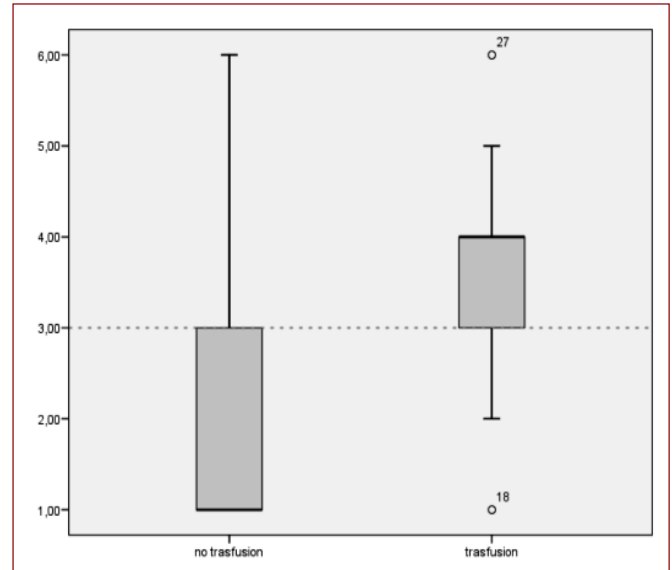
Many studies have attempted to define risk factors for blood transfusion in spinal surgery. Cha et al.<sup>4</sup> reported that, in patients who underwent fusion, preoperative autologous blood donation decreased the risk of allogenic blood transfusion by 75% in non-instrumented fusions and 50% in instrumented fusions, compared with patients who did not predonate blood. Patients in their study all received surgery for degenerative conditions, but there were no cases of anterior fusion.

Zheng<sup>18</sup> found that the number of levels fused and age seemed 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 study conducted at the Mayo Clinic<sup>16</sup>, it was demonstrated using linear multiple regression that the significant determinants for increased amounts of both allogenic and autologous red blood cell units transfused were low preoperative hemoglobin concentration and an increased number of posterior levels surgically fused. They suggested that, according to others<sup>3,4</sup>, preoperative blood donation increased the likelihood of autologous transfusion. Conversely to this, in our study we found no relationship between the need for 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, in agreement with others<sup>10</sup>, we consider preoperative blood donation not to be cost-effective, particularly for surgeries with no or short instrumented fusion, due to the number of waste units, the morbidity of donation and anemia related to the predonation of blood.

In our linear multiple regression models we found that the patients' gender, multiple spine levels surgically decompressed and multiple levels surgically fused represent the best determinants for the risk of blood transfusion. We think that the high female risk is mainly due to a lower preoperative hemoglobin rate and lower blood mass, therefore exposing them to greater risks of intraoperative or postoperative anemia. With respect to the number of levels surgically treated, we observed in our cohort that patients with decompression at more than three levels received blood transfusion in 70% of cases (Figure-1).



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

Considering the number of fused levels, we found a larger patient dispersion (Figure-2), and therefore consider the fusion of a single spinal level to expose to a greater risk of blood transfusion. However these cut-offs lack statistical power due to the low number of patients.

To our knowledge, a study by Johnson et al.<sup>15</sup> is the only one to consider both posterior lumbar

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fusion and anterior lumbar fusion using a homograft bone. Nevertheless, our study is the first to evaluate the risk of blood transfusion in a cohort that includes patients who have also undergone interbody fusion. Interbody fusion, both by the TLIF and PLIF procedures, has gained popularity in the last few decades, with indications including spinal stenosis, instability, degenerative disc disease, spondylolisthesis, spondylolysis, and bilateral disc herniation<sup>2,6,7,9</sup>. We always perform interbody fusion together with posterolateral instrumented arthrodesis, and in the current study, we always inserted a single interbody cage instead of two cages.

The limited number of patients considered in this study makes an accurate statistical analysis difficult, and no two-way interaction analysis of the variables influencing the risk of blood transfusion was possible. Another limitation is the low accuracy of detecting the intraoperative blood loss amount. This parameter was not considered as a variable, as no reliable technique other than the experience of the anesthesiologist<sup>3</sup> exists to accurately estimate blood loss.

In this way, our study is proposed to be a preliminary analysis, which should be confirmed by a larger cohort of patients in order to more accurately define the risk factors for blood transfusion with these kinds 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 consider blood predonation. According to our results, blood predonation should preferably be proposed to women who will undergo spine instrumented

fusion or a spinal decompression at more than three levels.

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