

THE IMPACT OF BLOOD TRANSFUSION ON OUTCOMES IN POSTERIOR LUMBAR FUSION SURGERY

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ABSTRACT

Objective: Posterior lumbar fusion (PLF) is becoming increasingly common. One of the most critical aspects of these operations is the management of bleeding and blood products, which is of great importance for anesthetists and surgeons. The objective of this study was to examine the relationship between blood transfusion and complications after PLF surgery. The secondary objective was to identify risk factors associated with transfusion.

Materials and Methods: The data from the PLF surgeries that were performed over a four-year period at a training and research hospital were subjected to a comprehensive retrospective analysis. A comprehensive examination of the following variables was conducted: age, comorbidities, laboratory values, anti-coagulant use, surgical and anesthetic notes, blood and blood product use, post-operative complications, and length of stay.

Results: The study included 497 patients. The mean age of the patients was 60.78 years, the mean body mass index was 28.89, and the mean operation time was 3.63 hours. A total of 30.6% of patients received blood transfusions. Complications occurred in 10.1% of patients, and a higher prevalence was noted among those who received blood transfusions. The most common complication was sepsis. The likelihood of receiving blood transfusions was higher in patients who were older and female, had lower pre-operative hemoglobin (Hb) levels, underwent more fusions, experienced longer operative times, and had surgeries involving the sacral region. Logistic regression analysis identified pre-operative low Hb levels, a greater number of fusions, and an extended operation duration as significant risk factors for blood transfusion.

Conclusion: A higher incidence of complications was observed among patients undergoing PLF surgery who received blood transfusions. The implementation of improved pre-operative management of haemoglobin levels, along with more effective intraoperative transfusion practices, and reducing post-operative complications will lead to more favorable outcomes.

Keywords: Blood transfusion, complication, spine, neurosurgery

INTRODUCTION

With the aging population, the frequency of spinal deformities is increasing, and this has made spinal surgery one of the most commonly performed surgical procedures. Posterior lumbar fusion (PLF) surgery is widely used for the treatment of various conditions such as stenosis, spondylolisthesis, deformity, tumor, trauma and infection⁽¹⁾. This type of surgery provides spinal stability by relieving nerve compression, which can significantly alleviate nerve root symptoms and pain⁽²⁾. As more PLF surgeries are performed each year, it becomes increasingly important to identify features that predispose surgical candidates to a

higher complication risks^(3,4). Studies have shown that blood transfusions increase post-operative mortality and morbidity in many surgical procedures⁽⁵⁾.

As evidence grows that blood transfusions increase the risk of post-operative infections, lead to cancer recurrence, shorten survival in cancer patients, and carry other direct risks such as infections transmitted through transfusion, blood transfusion policies have become stricter in recent years^(6,7). However, PLF surgery may be associated with significant intraoperative blood loss, which can lead to cardiac, pulmonary, and renal dysfunction, hemodynamic instability, and coagulopathy⁽⁸⁾. In some patients, blood transfusion may be necessary to avoid perioperative morbidity and mortality of this blood loss⁽⁹⁾.

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Received: 03.12.2024 **Accepted:** 06.01.2025 **Epub:** 14.01.2025 **Publication Date:** 22.01.2025

Cite this article as: Erten E, ŐimŐek F, Pehlivan MT, Kurtulgu FN, Erođlu B, Bayazit Z. The impact of blood transfusion on outcomes in posterior lumbar fusion surgery. J Turk Spinal Surg. 2025;36(1):40-46.



When considering the impact on perioperative outcomes, a balance should be struck between the risks of anemia and the benefits of blood transfusion⁽¹⁰⁾. With the recent development of the concept of enhanced recovery after surgery, better blood management to prevent perioperative anemia has become increasingly important.

The primary aim of this study was to examine the effects of blood transfusion during the intraoperative period on post-operative complications in the 30-day period following PLF surgery. Our secondary aim was to identify risk factors for blood transfusion.

MATERIALS AND METHODS

After the study protocol was determined, Ethical Approval was obtained from the University of Health Sciences Türkiye, Gülhane Scientific Research Ethics Committee (approval number: 2024/508, date: 05.11.2024). The files of the patients who underwent PLF surgery in neurosurgery clinic of a tertiary education and research hospital between January 2021 and August 2024 were retrospectively reviewed. The patients' perioperative data were accessed through the hospital data system, neurosurgery and anesthesia clinic archive records. The study was conducted in accordance with the principles of the Declaration of Helsinki.

The demographic data and medical history, pre-operative and post-operative laboratory values, surgery and anesthesia notes, blood and blood product transfusion data, length of hospital stay, consultations received, and their reasons are recorded using the information management system employed by our hospital.

Patients over the age of 18 and under the age of 85 who underwent PLF surgery were included in the study. All patients underwent interpedicular screw placement for stabilisation, followed by osteotomy of the posterior elements for decompression. It should be noted that no patients underwent only interpedicular screw placement or only osteotomy for decompression. Patients with coagulation disorders, thrombocytopenia, liver disease, as well as those undergoing revision surgery, those undergoing surgery due to spinal tumors or infections, emergency surgeries, and patients for whom the necessary medical information could not be obtained due to deficiencies in their medical records were excluded from the study.

Data

Patients' age, accompanying chronic diseases (diabetes mellitus, hypertension, coronary artery disease, chronic obstructive pulmonary disease, asthma, renal diseases and other diseases), pre-operative and post-operative hemoglobin (Hb) levels, number of spine levels treated in the surgical procedure, duration of the surgical procedure, whether they used blood thinners, whether they were given intraoperative allogeneic blood and blood product, presence of any complications in the post-operative 30-day period, what kind of complication

[infection, pneumonia, deep vein thrombosis (DVT), sepsis, urinary complications, pulmonary complications, etc.] and whether complications developed due to transfusion (acute hemolytic reactions, late hemolytic reaction, graft-versus-host disease, febrile non-hemolytic transfusion reaction, transfusion-related acute lung injury, allergic transfusion reaction, post-transfusion purpura length of hospital stay were examined.

In our clinic, blood transfusion in the perioperative period is performed in case of blood loss, anaemia or haemodynamic instability. The decision for blood transfusion is usually made by the anaesthesiologist, taking into account the clinical condition, Hb levels, type of surgery and general health status of our patient. In our clinic, the perioperative blood transfusion protocol is determined as follows: In case of mild anaemia (Hb \geq 10 g/dL), transfusion is usually not performed, but it is assessed whether our patient is symptomatic. In case of moderate to severe anaemia (Hb $<$ 10 g/dL or symptomatic) transfusion may be recommended. When there is large blood loss during the surgical procedure, transfusion can be performed without the need for a low Hb level. In case of significant blood loss after major surgical procedures and traumatic injuries, early blood transfusion may be administered to ensure haemodynamic stability of the patient.

Table 1. Demographic data, medical history and operation information of the patients

n=497

Age (year) median (IQR)	63 (53-70)
BMI (kg/m²) median (IQR)	28.73 (27.53-30.04)
Number of fusion levels	3 (2-4)
Operation time (hour)	3.5 (3-4)
Gender, n (%)	
Female	289 (58.1)
Male	208 (41.9)
ASA	
1	140 (28.2)
2	207 (61.8)
3	50 (10.0)
Anti-coagulant use, n (%)	103 (20.7)
Additional disease, n (%)	357 (71.8)
Vertebral region, n (%)	
Thoracic and lumbar	38 (7.6)
Sacral and lumbar	52 (10.5)
Only lumbar	407 (81.9)
Number of fusion levels, n (%)	
1-2 segments	133 (26.8)
3 segments	230 (46.3)
\geq 4 segments	134 (27.0)
Patient receiving blood transfusion, n (%)	152 (30.6)

BMI: Body mass index, ASA: American Society of Anesthesiologists, n: Number, IQR: Inter quantile range

Statistical Analysis

Mean standard deviation, median, minimum, maximum values were given in descriptive statistics for continuous data, and percentages were given for discrete data. Shapiro-Wilk test was used to examine the conformity of continuous data to normal distribution. In the comparison of continuous data between patients who received blood transfusions and patients who did not, t-test (independent samples t-test) was used for data with normal distribution and Mann-Whitney U test was used for data without normal distribution.

Chi-square and Fisher's exact tests were used for group comparisons of nominal variables (cross tables). Paired samples t-test was used to examine the difference between pre-operative and post-operative Hb levels in dependent groups. Risk factors affecting blood transfusion were examined by multivariate logistic regression analysis (MLRA).

IBM SPSS version 20 (Chicago, IL, USA) program was used in the evaluations, and $p < 0.05$ was accepted as statistical significance limit.

RESULTS

A total of 497 patients, 289 (58.1%) female and 208 (41.9%) male, were included in the study. Demographic data of the patients and the data related to the operation information are given in Table 1.

Blood transfusion was performed in 152 (30.6%) of the patients. A comparison of the demographic characteristics of patients who received a blood transfusion and those who did not revealed some significant differences. The proportion of females

was higher ($p < 0.01$) and the mean age was higher ($p < 0.05$) in patients who received a transfusion. The rate of comorbidities was similar between patients who received and those who did not receive blood transfusions ($p > 0.05$). Additionally, there was no significant difference in the body mass index values ($p > 0.05$), American Society of Anesthesiologists (ASA) scores ($p > 0.05$), and anti-coagulant use ($p > 0.05$) between the two groups (Table 2).

It was determined that 10.1% of the patients developed complications and wound infection (4.2%) was the most common. Complications were more common in the post-operative period in patients who underwent blood transfusion ($p < 0.005$) and sepsis was the most common ($p = 0.002$) (Table 3). However, it was determined that blood transfusion did not cause any difference in terms of complications such as pneumonia, pulmonary embolism, wound infection, DVT, and urinary infection in the post-operative period. The mean length of hospital stay was 8.52 ± 5.82 days and the median was 7 days. The length of hospital stay of the patients who underwent blood transfusion was also significantly longer ($p = 0.002$) (Table 4).

57.2% of patients who underwent blood transfusion were given erythrocyte suspension (ES), 37.5% fresh frozen plasma (FFP), and 36.8% of patients were given only ES, and 63.2% were given ES+FFP. There was no difference between the post-operative complications of patients who received only ES and those who received ES+FFP ($p > 0.05$).

The fusion level of 46.3% of the patients was "3 segments". It was founded that the duration of surgery was longer and the

Table 2. Comparison of the characteristics of patients with and without blood transfusion

	BT+ (n=152)	BT- (n=345)	p-value
Age median (IQR)	65 (57-71)	63 (52-70)	0.042 ^b
BMI median (IQR)	28.89 (27.77-30.38)	28.73 (27.44-29.99)	0.106 ^b
Gender, n (%)			
Female	104 (68.4)	185 (53.6)	<0.001 ^c
Male	48 (31.6)	160 (46.4)	
ASA			
1	35 (23.0)	105 (30.4)	0.164 ^c
2	98 (64.5)	209 (60.6)	
3	19 (12.5)	31 (9.0)	
Anti-coagulant use	31 (20.4)	72 (20.9)	0.904 ^c
DM, n (%)	46 (30.3)	102 (29.6)	0.875 ^c
HT, n (%)	81 (53.3)	154 (44.6)	0.075 ^c
CAD, n (%)	23 (15.1)	48 (13.9)	0.721 ^c
COPD, n (%)	1 (0.7)	8 (2.3)	0.287 ^c
Asthma, n (%)	12 (7.9)	21 (6.1)	0.456 ^c
Renal, n (%)	1 (0.7)	1 (0.3)	0.519 ^c

^b: Mann-Whitney U test, ^c: Chi-square test/Fisher's exact test.

BT+: Patients receiving blood transfusion, BT- : Patients not receiving blood transfusion, IQR: Inter quantile range, BMI: Body mass index, n: number, ASA: American Society of Anesthesiologists, DM: Diabetes mellitus, HT: Hipertension, CAD: Coronary artery disease, COPD: Chronic obstructive pulmonary disease

rate of having a fusion level of 4 or more was higher in patients who received blood transfusion (Table 5).

While the operated vertebral region was only in the “lumbar” region in 81.9% of the patients, a difference was found between the operated vertebral regions of the patients who underwent blood transfusion and the patients who did not ($p<0.05$). In patients who received blood transfusion, the rate of occurrence in the sacral vertebrae in addition to the lumbar region was found to be higher (Table 5).

In the study, post-operative Hb levels of all patients were significantly lower than pre-operative Hb levels ($p<0.001$). A difference was also found between the pre-operative Hb levels of the patients who underwent blood transfusion and those who did not ($p<0.001$). Pre-operative Hb values of the

patients who underwent blood transfusion were found to be lower (Table 5).

In the examination of the risk factors affecting blood transfusion, independent variables (age, gender, pre-operative Hb levels, number of fusion levels, vertebral region, operation time) considered to be related to blood transfusion and found to be significant in the univariate analysis were included in the MLRA. As a result of the analysis, pre-operative Hb level, fusion level number, and operation time were determined as risk factors for blood transfusion.

According to the analysis results, a 1 g/dL decrease in pre-operative Hb levels increased the likelihood of blood transfusion by 2,150 times ($p<0.001$). Having 3 fusion levels increased the likelihood of blood transfusion by 2,769 times compared to 1-2 levels ($p<0.01$), and having 4 or more fusion levels increased it by 5,584 times compared to 1-2 levels. Additionally, a 1-hour increase in operation time increased the likelihood of blood transfusion by 1,337 times ($p<0.001$). Logistic regression analysis showed that age, gender, and the vertebral region operated on were not found to be significant for blood transfusion (Table 6).

Table 3. The distribution of length of hospitalization, intraoperative transfusion, and post-operative complications

Length of hospital stay (day) median (IQR)	7 (5-10)
RBC, n (%)	87 (57.2)
FP, n (%)	57 (37.5)
RBC/FP, n (%)	
RBC	32 (36.8)
RBC+FP	55 (63.2)
Post-operative complication, n (%)	50 (10.1)
Pneumonia, n (%)	8 (1.6)
Pulmonary embolism, n (%)	5 (1.0)
Wound site infection, n (%)	21 (4.2)
DVT, n (%)	5 (1.0)
Sepsis, n (%)	14 (2.8)
Urinary infection, n (%)	10 (2.0)

IQR: Inter quantile range, RBC: Red blood cell, FP: Frozen plasma, n: Number, DVT: Deep vein thrombosis

DISCUSSION

This study reveals that pre-operative Hb levels, the number of fusion levels, and the duration of the operation are significantly associated with intraoperative blood transfusion during PLF surgery. Additionally, the most common complication associated with PLF surgery was wound infection, and intraoperative blood product transfusion was found to be significantly associated with an increased rate of post-operative sepsis.

Many studies have demonstrated that intraoperative blood transfusion leads to various post-operative complications after surgery^(11,12). These complications not only increase mortality and morbidity but also lead to higher costs⁽¹¹⁻¹³⁾. Studies on

Table 4. Comparison of post-operative complications in patients with and without blood transfusion

	BT+ (n=152)		BT- (n=345)		p-value
	Mean±SD	median (min.-max.)	Mean±SD	median (min.-max.)	
	(IQR)		(IQR)		
Hospitalization duration (day)	10.09±8.52	8 (3-66);(6-11)	7.73±3.92	7 (2-35);(5-9)	0.002^b
Post-operative complication	n	%	n	%	
Pneumonia	24	15.8	26	7.5	<0.005^c
Pulmonary embolism	4	2.6	4	1.2	0.256 ^c
Wound site infection	1	0.7	4	1.2	1,000 ^c
DVT	10	6.6	11	3.2	0.083 ^c
Sepsis	3	2.0	2	0.6	0.170 ^c
Urinary infection	10	6.6	4	1.2	0.002 ^c
	1	2.6	6	1.7	0.503 ^c

^b: Mann-Whitney U test, ^c: Chi-square test/Fisher's exact test. BT+: Patients receiving blood transfusion, BT-: Patients not receiving blood transfusion, n: Number, DVT: Deep vein thrombosis, IQR: Inter quantile range, SD: Standard deviation, min.-max.: Minimum-maximum

spinal surgeries have reported that the most common post-operative complication in patients receiving blood transfusions is wound infection⁽¹⁴⁾. Wound infections are most observed after combined anterior/posterior spinal fusion surgeries, whereas cervical spinal surgeries have been shown to be associated with a lower risk⁽¹⁵⁾. For this reason, we limited our study to spinal fusion surgeries performed with a posterior approach involving the lumbar spine. In our study, as in the literature, the most common complication after PLF surgery was wound infection, while the most common complication associated with blood transfusion was sepsis.

Although the exact mechanism is unclear, studies have shown that blood transfusions increase infection risk by suppressing the immune system through immunomodulatory effects⁽¹⁶⁻¹⁸⁾. In a study by Park et al.⁽¹⁹⁾, which examined 188,581 patients who underwent lumbar spinal fusion surgery, blood transfusion was found to be associated with post-operative infections, although the types of infections were not compared. Kato et al.⁽²⁰⁾ compared 80,000 patients who underwent elective

lumbar surgery for post-operative infections and found that the most common infections in those receiving blood transfusions were wound infections, followed by urinary tract infections. Basques et al.⁽¹⁴⁾, in their study involving more than 400 patients, demonstrated that blood transfusion was associated with an increase in wound infections and thromboembolic events. Unlike these studies, we did not find any differences in thromboembolic complications, urinary tract infections, or wound infections between those who received and those who did not receive blood transfusions. We observed that sepsis occurred more frequently in patients who received allogeneic blood transfusion during the intraoperative period. No allergic reactions related to allogeneic blood transfusion were observed in any of the patients in our study. A review of the literature indicates that there is no dose-response relationship between the number of blood units transfused and post-operative infections⁽²¹⁾. In our study, although the number of blood units administered was not specifically assessed, the effect of FFP transfusion on post-operative complications was examined,

Table 5. Comparison of pre-operative Hb values and operative characteristics of patients with and without blood transfusion

	BT+ (n=152)	BT- (n=345)	p-value
Pre-operative Hb, mean±SD	12.35±1.52	13.84±1.42	<0.001^a
Number of fusion levels median (IQR)	3 (3-4)	2.93±0.89 3 (1-6); (2-3)	<0.001^b
Operation time (hour) median (IQR)	4 (3-4.5)	3.5 (3-4)	0.002^b
Number of fusion levels, n (%)			
1-2 segments ^a	24 (15.8)	109 (31.6)	a-b 0.029
3 segments ^b	65 (42.8)	165 (47.8)	a-c<0.001
≥4 segments ^c	63 (41.4)	71 (20.6)	b-c<0.001
Vertebral region, n (%)			
Thoracic and lumbar ^a	16 (10.5)	22 (6.4)	a-b 0.985
Sacral and lumbar ^b	22 (14.5)	30 (8.7)	a-c 0.068
Only lumbar ^c	114 (75.0)	293 (84.9)	b-c 0.033

^a: Independent samples t-test, ^b: Mann-Whitney U test, ^c: Chi-square test/Fisher's exact test. BT+: Patients receiving blood transfusion, BT-: Patients not receiving blood transfusion, n: Number, IQR: Inter quantile range, SD: Standard deviation, Hb: Hemoglobin

Table 6. Results of multivariate logistic regression analysis of factors affecting blood transfusion

Variable	Regression coefficient (SE)	Adjusted OR	95% CI	p-value	
Age	-0.008 (0.010)	1,008	0.988	1,028	0.992
Gender (female)	0.106 (0.247)	1,112	0.685	1,804	0.668
Pre-operative Hb	-0.767 (0.091)	2,150	1,801	2,570	<0.001
Number of fusion levels					
3 segments	1.08 (0.321)	2,769	1,477	5,191	0.001
≥4 segments	1,720 (0.362)	5,584	2,746	11,357	<0.001
Vertebral region					
Sacral and lumbar	0.536 (0.520)	1,709	0.617	4,736	0.302
Only lumbar	-0.193 (0.427)	1,207	0.525	2,801	0.625
Operation duration	0.290 (0.107)	1,337	1,084	1,647	0.007

SE: Standart error, OR: Odds ratio, CI: Confidence interval, Hb: Hemoglobin

and no significant difference was found when compared to ES transfusion. We found that this topic had not been previously studied in the literature.

In patients undergoing spinal surgery, various factors such as female gender, pre-operative low Hb levels, pre-operative ASA score, comorbidities, longer surgery time, fusion surgery, and a greater number of decompression or fusion levels have been associated with blood transfusion^(19,22,23). In our study, the identified risk factors for blood transfusion were pre-operative low Hb levels, an increased number of fusion levels, and longer operation times. Studies have shown that the posterior approach in spinal fusion surgery is a risk factor for blood transfusion by itself⁽¹⁸⁾. Therefore, we only included patients who underwent surgery with a posterior approach in our study. Furthermore, when comparing spinal surgeries that involve the lumbar region with additional thoracic or sacral vertebrae, we found, similar to the study by Morcos et al.⁽²⁴⁾, that the surgical levels involving the sacral region increased the risk of blood transfusion.

With a better understanding of the risks associated with blood transfusion, including the risk of infection transmission and immunomodulation, a more cautious and limited approach to blood transfusion has been adopted⁽²⁵⁾. Various studies have shown that aprotinin, tranexamic acid, and aminocaproic acid reduce perioperative blood loss in spinal surgeries, although discussions continue regarding their safety profile, potential side effects, and appropriate dosing regimens. A review of the literature indicates that there is no dose-response relationship between the number of blood units transfused and post-operative infections⁽²⁶⁻²⁸⁾. In appropriate patients, the use of intraoperatively salvaged blood and the use of pre-operative hemodilution are also methods to reduce the risk of blood transfusion⁽²⁵⁾. It has also been stated that pre-operative epoetin alfa administration in eligible patients may reduce the need for perioperative transfusion⁽²⁹⁾. New blood products used may also reduce the risk of complications. Studies have demonstrated that minimizing blood use older than 15 days can reduce the risk of post-operative complications, including infection⁽³⁰⁾.

Study Limitations

Our study has some limitations. Since our study was retrospective, some data such as the amount of intraoperative bleeding are missing. Our study is single-centered, and the sample size is not large enough. It would be possible to confirm the results with a prospective, multicenter study with a larger sample size. We think that studies examining the role of blood transfusion in immunomodulation in more detail may also be useful in preventing possible complications.

CONCLUSION

We think that reducing intraoperative blood transfusion would be beneficial in reducing post-operative complications in PLF patients. For this purpose, patients at risk of blood transfusion

should be identified in advance and necessary precautions should be taken. Thus, better surgical results can be achieved, and treatment costs can be reduced.

Ethics

Ethics Committee Approval: Ethical approval for this study was obtained from Gülhane Scientific Research Ethics Committee, University of Health Sciences Türkiye (approval number: 2024/508, date: 05.11.2024).

Informed Consent: Retrospective study.

Footnotes

Authorship Contributions

Design: E.E., F.Ş., Data Collection or Processing: M.T.P., Z.B., Analysis or Interpretation: F.N.K., Literature Search: E.E., F.Ş., Writing: E.E., F.Ş., B.E.

Conflict of Interest: The authors have no conflicts of interest to declare.

Financial Disclosure: The authors declared that this study received no financial support.

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