



Early Postoperative Effects of Allogenic Red Blood Cell Transfusion in Scoliosis Surgery

Skolyoz Cerrahisinde Allojenik Eritrosit Süspansiyonu Transfüzyonunun Erken Dönem Postoperatif Etkileri

Selen ÇAKICI ARSLAN, Nesil COŞKUNFIRAT, İlker Öngüç AYCAN, Zekiye BİGAT, Atilla RAMAZANOĞLU

Akdeniz University Faculty of Medicine, Department of Anesthesiology and Reanimation, Antalya, Turkey

Correspondence Address
Yazışma Adresi

Nesil COŞKUNFIRAT
Akdeniz University Faculty
of Medicine, Department of
Anesthesiology and Reanimation,
Antalya, Turkey
E-mail: nesildgr@yahoo.com

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Selen ÇAKICI ARSLAN
ORCID ID: 0000-0002-9045-991X
Nesil COŞKUNFIRAT
ORCID ID: 0000-0003-0179-0043
İlker Öngüç AYCAN
ORCID ID: 0000-0001-8159-5680
Zekiye BİGAT
ORCID ID: 0000-0002-2191-4595
Atilla RAMAZANOĞLU
ORCID ID: 0000-0002-7215-6237

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ABSTRACT

Objective: Intraoperative blood loss during scoliosis surgery often leads to blood transfusion. Allogenic blood transfusion affects outcomes negatively in several patient populations. Our primary aim was to determine the influence of intraoperative blood transfusion on the postoperative blood transfusion rate and early postoperative outcomes in scoliosis surgery.

Material and Methods: A total of 202 patients who had undergone scoliosis surgery between 2009 and 2014 were included in this retrospective study. Postoperative red-blood cell usage, postoperative mechanical ventilation, Intensive Care and Post Anesthesia Care Unit stay, and postoperative hospital discharge times were compared between intraoperatively-transfused and intraoperatively-non-transfused patients. Only intraoperatively-transfused, both intraoperatively and postoperatively transfused, only postoperatively transfused and patients with no transfusion were also compared.

Results: Postoperative blood transfusion rates and hospital discharge times were significantly higher in intraoperatively transfused patients than intraoperatively-non-transfused patients ($p<0,001$). Postoperative mechanical ventilation times were significantly lower in patients with no transfusion compared to only intraoperatively ($p=0.006$) and intra-and-postoperatively transfused patients ($p<0.001$). Hospital discharge times were significantly different between no transfusion [median:5 (min: 2-max: 12) days] and intra-and-postoperatively transfused patients [median:8 (min: 4 - max: 22) days] ($p<0.001$).

Conclusion: Our results reveal that intraoperative blood transfusions have negative effects on early postoperative results. We can say that perioperative strategies to decrease blood loss and transfusion of allogenic blood products in scoliosis surgery will be beneficial for patients.

Key Words: Scoliosis surgery, Red blood cell transfusion, Early postoperative outcome

ÖZ

Amaç: Skolyoz cerrahisi sırasında intraoperatif kan kaybı sıklıkla kan transfüzyonuyla sonuçlanmaktadır. Allojenik kan transfüzyonunun bazı hasta popülasyonunda sonuçları olumsuz etkilediği gösterilmiştir. Çalışmamızdaki primer amacımız skolyoz cerrahisinde intraoperatif kan transfüzyonunun postoperatif kan transfüzyon oranına ve erken dönem postoperatif sonuçlara etkisini belirlemektir.

Gereç ve Yöntemler: 2009-2014 yılları arasında skolyoz cerrahisi geçiren 202 hasta retrospektif olarak incelendi. İntraoperatif transfüzyon yapılan ve intraoperatif transfüzyon yapılmayan hastalarda postoperatif eritrosit süspansiyonu kullanımı, postoperatif mekanik ventilasyon süreleri, Yoğun Bakımda ve Anestezi Sonrası Bakım Ünitesinde kalış ve hastaneden taburculuk süreleri karşılaştırıldı. Sonra sadece intraoperatif transfüzyon yapılan, hem intraoperatif hem de postoperatif transfüzyon yapılan, sadece postoperatif transfüzyon yapılan ve transfüzyon yapılmayan hastalar karşılaştırıldı.

Bulgular: Postoperatif kan transfüzyon oranları ve hastaneden taburculuk süreleri intraoperatif transfüzyon yapılan hastalarda intraoperatif transfüzyon yapılmayan hastalara göre anlamlı derecede yüksekti ($p<0,001$). Postoperatif mekanik ventilasyon süreleri transfüzyon yapılmayan hastalarda sadece intraoperatif transfüzyon yapılan ($p=0.006$) ve intraoperatif ve postoperatif transfüzyon

yapılan hastalara göre ($p<0,001$) anlamlı derecede düşüktü. Transfüzyon yapılmayan [median:5 (min: 2-max: 12) gün] ve intraoperatif ve postoperatif transfüzyon yapılan [median:8 (min: 4 - max: 22) gün] ($p<0,001$) hastalar arasında hastaneden taburculuk süreleri açısından anlamlı farklılık vardı.

Sonuç: Çalışmamız intraoperatif kan transfüzyonlarının erken dönem postoperatif sonuçlar üzerine negatif etkileri olabileceğini göstermiştir. Skolyoz cerrahisinde kan kaybını ve allojenik kan ürünlerinin kullanımını azaltmak için perioperatif stratejilerin geliştirilmesinin hastalar için faydalı olacağı kanaatindeyiz.

Anahtar Sözcükler: Skolyoz cerrahisi, Eritrosit süspansiyonu transfüzyonu, Erken dönem postoperatif sonuçlar

INTRODUCTION

Scoliosis is a complex 3-dimensional vertebral deformity associated with lateral flexion and rotation of the spine (1). Scoliosis surgery is a difficult and lengthy surgery that may cause excessive blood loss (2-7). Allogenic blood transfusion used in the treatment of operative blood loss is reported to affect outcomes in a negative manner in several different patient populations (8-12). Although there are various methods to reduce intraoperative bleeding, these techniques cannot be considered completely reliable and have been shown to be insufficient to avoid transfusion in major spinal surgical procedures (13-15).

The primary purpose of the present study was to determine the effects of intraoperative red blood cell transfusions (RBCT) on the postoperative RBCT rate and early postoperative outcomes. We also aimed to compare the early postoperative outcome between patients who were only intraoperatively transfused, only postoperatively transfused and patients both intra and postoperatively transfused and patients who received no transfusion during and after surgery. We believe that the results of our study will guide other similar prospective studies on scoliosis surgery.

MATERIALS and METHODS

In this retrospective study, surgery records of all patients operated between 01.01.2009 and 31.12.2014 were retrospectively screened with the approval of the Ethics Committee of Akdeniz University and the Archive Unit of Akdeniz University Faculty of Medicine Hospital, and 207 patients with a diagnosis of scoliosis were identified. Five patients were excluded as their medical records were not available. None of the remaining 202 patients were excluded throughout the study.

The data used in the study were obtained from patient registries, hospital computer database system, preoperative evaluation forms and intraoperative anesthesia, Post-Anesthesia Care Unit (PACU) and Intensive Care Unit (ICU) follow-up forms.

We first identified the patients who were given allogenic red blood cell during their operation and determined the

hemoglobin (Hb) values of the patients just before RBCT and the amount of RBCT administered intraoperatively. We recorded and compared the factors that might influence intraoperative RBCT such as age, gender, American Society of Anesthesia (ASA) score, preoperative hemoglobin level and operation durations, and vertebral fusion levels in the patients who received RBCT during the operation and the patients without RBCT. We then compared the postoperative hemoglobin values, pre-postoperative hemoglobin difference and postoperative (1) mechanical ventilation duration, (2) length of stay in the ICU/PACU, (3) RBCT requirement, and (4) discharge times between patients with or without intraoperative red blood cell transfusions.

We also determined the number of patients with postoperative RBCT and the amount of units given and compared the mechanical ventilation duration and ICU/PACU length of stay, postoperative hospital stay, between patients with only intraoperative RBCT, only postoperative RBCT, both intraoperative and postoperative RBCT, and without intra-postoperative RBCT.

Statistical Analysis

Statistical analysis was performed using the PASW Statistics (Predictive Software Analytics) 23.0 software with the help of University Medical Faculty Biostatistics Department. Descriptive statistics were presented as means and standard deviation, median, min-max, frequency and percent values. Quantitative data were compared using Pearson Chi-square test or Fisher's Exact tests. Normality of data was tested by the Shapiro Wilks Test. The difference between age, operation times, preoperative hemoglobin levels and postoperative hemoglobin levels, preoperative-postoperative hemoglobin differences (Δ Hb), intensive care stay times, mechanical ventilation times, and home discharge times of the patients with and without RBCT were evaluated with the Mann Whitney U test when data was not normally distributed and the independent Samples t-test when data were normally distributed. The relationship between the level of fusion and intraoperative RBCT usage and RBCT usage during the postoperative period for patients with and without intraoperative RBCT

was evaluated with the Pearson Chi-square test. ICU/PACU stay times, mechanical ventilation times, discharge times were compared using the Kruskal-Wallis test between patients without RBCT, only intraoperative RBCT, only postoperative RBCT, and both intraoperative and postoperative RBCT. The intraoperative transfusion and postoperative transfusion amount of patients transfused intraoperatively were compared with Spearman's rho test. The study power was 0.99, with two-sided analysis and significance of 0.05, for comparing the rates of postoperative transfusions between patients with (67% postoperatively transfused) and without (20% postoperatively transfused) intraoperative transfusion. The results were evaluated using a confidence interval of 95% and a p value <0.05 was considered statistically significant.

RESULTS

We evaluated the data of 202 patients with a diagnosis of scoliosis between 01.01.2009 and 31.12.2014. The female/male ratio was 138 (68%) / 64 (32%) (p<0.001).

Patients with intraoperative RBCT: Of the 202 patients, 116 (57%) needed intraoperative RBCT, and the average erythrocyte suspension units needed was 2.13 U (SD±1.33) (min. 0.5 U, max. 8 U).

Differences between patients with intraoperative RBCT and without intraoperative RBCT: Table I shows the differences when the study population was allocated into groups as with and without intraoperative RBCT. We could access the hemoglobin levels prior to RBCT in 96 of 116 patients, and the mean hemoglobin value before transfusion was 9.56 (SD±1.42) g / dL.

Effect of intraoperative RBCT on rate of postoperative RBCT: In our study, the number of patients with postoperative RBCT requirement was significantly higher in patients with intraoperative RBCT compared to patients without RBCT (p<0.001).

Differences between the amount of postoperative RBCT: The mean amount of postoperative RBC given

Table I: Comparison of demographics, intraoperative and postoperative data between intraoperative transfused and nontransfused patients.

	Patients with intraoperative RBCT (n=116)	Patients without intraoperative RBCT (n=86)	P-value
Women / Men	90/26	48/38	p=0.001
Age	Med: 15 min: 2.5 max: 69	Med: 13 min: 1 max: 52	p=0.001
Weight	Med: 50 min: 10 max: 80	Med: 42.5 min: 11 max: 76	p=0.057
ASA I	75	64	
ASA II	34	20	p=0.236
ASA III	7	2	
Fusion level	Med: 8 (min: 1 max: 16)	Med: 7 (min: 1 max: 14)	p=0.631
Anesthesia duration (minutes)	378 (SD±100)	220 (SD±112)	p<0.001
Operation duration (minutes)	339 (SD±98)	193 (SD±106)	p<0.001
Preoperative Hb (g/dL)	Med: 12.9 min: 8.6 max: 16.4	Med: 12.8 min: 7.8 max: 16.3	p=0.849
Postoperative RBCT, n (%)			
Yes	72 (62.1%)	17 (19.8%)	
No	44 (37.9%)	69 (80.2%)	p<0.001
Postoperative RBCT (unit)	Med: 2 min: 1 max: 7	Med: 1 min: 1 max: 3	p=0.232
ICU/PACU length of stay (hours)			
ICU	30.73±47.86	17.82±3.46	p=0.381
PACU	6.73±3.21	6.16±2.95	p=0.532
Postoperative mechanic ventilation duration (hours)	5.70±26.75	6.45±30.90	p=0.708
Postoperative Hgb (g/dL)	Med: 10.4 min: 6.2 max: 14.1	Med: 10.75 min: 8.2 max: 13.3	p=0.241
Postoperative hospital length of stay (days)	Med: 7 min: 3 max: 22	Med: 5 min: 2 max: 16	p<0.001

RBCT: Red blood cell transfusion, **Hb:** Hemoglobin, **Med:** Median, **Min:** Minimum, **Max:** Maximum

was 1.76 ± 1.13 U. In the intraoperative RBCT group, there was no statistically significant difference between the amount of intraoperative RBCT and the amount of postoperative RBCT ($p=0.193$). The median values of the postoperative RBCT volume of the patients with and without intraoperative RBCT were 2 (min: 1 max: 7) (1.83 ± 1.21) U and 1 (min: 1 max: 3) (1.47 ± 0.71) U, respectively. There was no significant difference in the amount of RBCT between groups in the postoperative period ($p=0.232$).

Differences between amount of postoperative Hemoglobin: The mean first postoperative hemoglobin value was 10.43 (SD ± 1.51) g/dL. Patients with and without RBCT had postoperative hemoglobin levels of 10.32 ± 1.67 g/dL and 10.61 ± 1.21 g/dL, respectively and there was no significant difference between groups ($p=0.241$).

There was no significant difference between preoperative-postoperative hemoglobin differences (Δ Hb) of patients with and without intraoperative RBCT ($p=0.763$).

Differences between early postoperative outcome measures

The mean postoperative length of stay in the ICU and PACU: In our study, 55 (27%) of 202 patients were extubated at the end of the operation. Of the 147 intubated patients, 93 were followed up in the ICU and 54 were in PACU. ICU and PACU total length of stay was 19.3 ± 33.35 (min. 3 h and max. 288 h). When evaluated separately, the length of stay at PACU and ICU was 8.62 ± 16.41 h and 26.7 ± 40.1 h, respectively. When the patients with and without intraoperative transfusion were compared in terms of the length of stay in the ICU; the ICU length of stay of patients with intraoperative RBCT was 30.73 ± 47.86 h, ICU length of stay of patients without intraoperative RBCT was 17.82 ± 3.46 h. Although ICU length of stay seemed to be longer in patients with intraoperative RBCT, there was no statistical significance (Table I) ($p=0.381$). When the patients with and without intraoperative transfusion were compared in terms of the length of stay in the PACU; patients with intraoperative RBCT had a PACU length of stay of 6.73 ± 3.21 h and, patients without intraoperative RBCT had a PACU length of stay of 6.16 ± 2.95 h. There was no significant difference between two groups ($p=0.532$).

When PACU/ICU length of stay was compared among 4 different patient groups (without RBCT, intraoperative RBCT, postoperative RBCT, both intraoperative and postoperative RBCT) in a pairwise combination, no statistically significant difference was found ($p=0.118$).

The mean postoperative mechanical ventilation duration: The mean postoperative mechanical ventilation duration was 6.11 ± 28.48 hours. There was no significant difference between patients with intraoperative RBCT

and in patients without intraoperative RBCT ($p=0.708$). Nevertheless, when patients without RBCT, only intraoperative RBCT, only postoperative RBCT, both intraoperative and postoperative RBCT were compared mechanical ventilation duration was 1.68 ± 2.41 h, 9.75 ± 43.03 h, 3.0 ± 2.87 h and 8.58 ± 33.59 h, respectively. Regarding the mechanical ventilation times; there was a statistically significant difference between the patients without RBCT and intraoperative RBCT ($p=0.006$) and between the duration of mechanical ventilation of patients without RBCT and patients with both intraoperative and postoperative RBCT ($p<0.001$).

The mean postoperative hospital length of stay: The mean postoperative hospital length of stay was 6.73 (SD ± 3.17) days (min. 2- max. 22) in the study population. A significant difference was found between patients without RBCT [median: 5 (min: 2 - max: 12) days] and patients with both intraoperative and postoperative RBCT ($p<0.001$).

DISCUSSION

Effect of intraoperative RBCT on postoperative RBCT rates and amount: Of the 202 patients included in the present study, 116 (57%) underwent intraoperative RBCT. The primary purpose of our study was to evaluate the effects of intraoperative RBCT on postoperative RBCT rates and early postoperative outcomes. In our study, the number of patients with postoperative RBCT requirement was significantly higher in patients with intraoperative RBCT compared to patients without intraoperative RBCT. Postoperative RBCT was used in 72 (62.1%) of the 116 patients with intraoperative RBCT and 17 (19.8%) of 86 patients without intraoperative RBCT ($p<0.001$). This result may be interpreted as the effect of intraoperative RBCT on postoperative RBCT requirement. Nevertheless, there was no significant difference in the amount of RBCT given in the postoperative period between patients with and without intraoperative RBCT ($p=0.232$). Patients with and without intraoperative RBCT had postoperative hemoglobin levels of 10.32 ± 1.67 g/dL and 10.61 ± 1.21 g/dL, respectively ($p=0.241$). The postoperative Hb values revealed that the patients who have not received RBCT during surgery were not discharged from the operating room with lower hemoglobin levels and the patients that bled more (who received RBCT) during surgery did not have a lower postoperative first Hb value (they were replaced). In addition, preoperative-postoperative hemoglobin differences (Δ Hb) of patients with and without intraoperative RBCT were not significantly different ($p=0.763$). We can therefore say that patients who underwent RBCT were not discharged from the operating room with lower hemoglobin levels.

Amount of intraoperative RBCT: In our study, the amount of intraoperative RBCT varied between 0.5 U

and 8.0 U (mean 2.13 ± 1.33). Mean RBCT volume used in scoliosis surgery was shown to be in a range of 1-8 U by previous studies in the literature (7, 16-18). Replacement for massive intraoperative bleeding with crystalloid and packed erythrocytes during the scoliosis correction can dilute the coagulation factors and further increase surgical bleeding. There are reports stating that blood loss is variable and at least 1/3 of total blood loss is encountered in postoperative period (7).

In our study, hemoglobin levels prior to RBCT could be obtained in 96 of 116 patients who underwent intraoperative RBCT and the mean hemoglobin value was $9.56 (SD \pm 1.42)$ g/dL. Although that hemoglobin level was obtained prior to RBCT, it may be inappropriate to take this value as a threshold for RBCT for the scoliosis surgery in our clinic because there remains the possibility of starting RBCT without measuring hemoglobin level in immediate circumstances.

Correlation between intra and postoperative blood loss: In order to eradicate the idea that factors causing excessive intraoperative bleeding would also affect postoperative bleeding, various analyses were conducted. To investigate the possibility of excessive blood loss in the postoperative period due to massive blood loss in the intraoperative period, we compared 1) The amount of intraoperative RBCT and the amount of postoperative RBCT in patients with intraoperative RBCT, and 2) The amount of postoperative RBCT in patients with and without intraoperative RBCT. There was no statistically significant difference in the amount of intraoperative RBCT and the amount of postoperative RBCT in patients with intraoperative RBCT ($p=0.193$). The median and mean volumes of postoperative RBCT for patients with and without intraoperative RBCT were 2 (min: 1 max: 7) (1.83 ± 1.21) and 1 (min: 1 max: 3) (1.47 ± 0.71) U, respectively. There was no significant difference in RBCT volumes between the groups ($p=0.232$).

The amount of RBCT given postoperatively was similar in patients who received RBCT intraoperatively and in patients who did not receive RBCT intraoperatively. This is important to show that people who received blood intraoperatively are not given blood because they are patients who bleed more.

The comparison of known predictive factors for intraoperative bleeding between intraoperative RBCT positive and negative patients

Operation duration: Patients with intraoperative RBCT had significantly longer anesthesia and operation durations (19-21). In our study, the mean duration of anesthesia was $311.56 (SD \pm 131.52)$ minutes and the mean

duration of operation was $277.26 (SD \pm 124.76)$ minutes. In a study about the predictors of RBCTs in scoliosis surgery, patients were allocated into 2 groups as patients with more than 4 U of RBCT and less than 4 U of RBCT (19). Patients who received more than 4 U were found to have significantly longer operation duration than patients who received RBCT with than 4 U. P. Sundarathiti et al. found anesthesia and operation durations as 228.67 and 266 minutes, respectively, in a study about the efficacy of thoracic epidural analgesia in patients with thoracolumbar scoliosis (20). Carling et al. found a mean operation duration of 194 ($SD \pm 50$) minutes in their study evaluating preoperative fibrinogen levels, and they reported that there was a significant difference in the amount of blood loss according to the operation duration (21). Bowen et al. reported that the transfusion requirement was doubled when the operation duration was longer than 6 hours in patients with pediatric idiopathic scoliosis (22).

Gender: In our study, intraoperative RBCT was significantly higher in women. The gender distribution was found to be significantly different between groups with RBCT ($n=116$) and without RBCT ($n=86$) ($p=0.001$). Karlsson et al. reported higher risk of RBCT in female patients with on-pump CABG (23). Carling et al. demonstrated that female gender was associated with increased transfusion in a study about the relationship between preoperative fibrinogen level and transfusion requirement in adolescent idiopathic scoliosis patients (21). The authors stated that hemodilution might have a more powerful effect on women due to lower preoperative hemoglobin values and blood volume.

Comparison of early postoperative outcome

Mechanical ventilation duration

In our study, no statistical significance was found between the mean duration of mechanical ventilation between patients with intraoperative RBCT and without intraoperative RBCT. However, when the patients were divided into 4 groups as without RBCT, intraoperative RBCT, postoperative RBCT, and both intraoperative and postoperative RBCT, the postoperative mechanical ventilation duration was prominently shorter in patients without perioperative RBCT. The mean duration of mechanical ventilation was significantly different between patient groups without intraoperative RBCT and with only intraoperative RBCT, and with both the intraoperative and postoperative RBCT groups. These results suggest that the postoperative period should be taken into consideration while evaluating the relationship between RBCT and mechanical ventilator duration.

Mean length of PACU and ICU stay times: The mean length of stay was $26.7 (SD \pm 40.1)$ hours and 8.62

(SD±16.41) hours in ICU and PACU, respectively, for patients not extubated. Patients with intraoperative RBCT were found not to have longer length of stay in the ICU and PACU compared to patients without intraoperative RBCT. In the study of Ridgeway et al., autologous blood transfusion was compared with allogeneic blood transfusion in scoliosis surgery and although the ICU length of stay of allogeneic blood transfusions group was longer than in the predonation group, no significant difference was found ($p<0.3$) ($p<0.11$) (24).

Mean length of hospital stay times: The mean postoperative hospital length of stay was 6.73 (SD±3.17) days (min.2- max.22) in the study population and was significantly longer in the intraoperative transfused patients (Table I). When postoperative transfusions were assessed, there was a significant difference between patients without

RBCT [median: 5 (min: 2 - max: 12) days] and patients with both intraoperative and postoperative RBCT [median: 8 (min: 4 - max: 22) days] ($p<0.001$).

Limitations of the study: The indications for RBCT initiation were not clearly identified as they were not found in the registry. In most of the retrospective studies about the effects of RBCT on the outcomes, it is similarly stated that it was not possible to identify the trigger point hemoglobin level or the reasons for RBCT.

CONCLUSION

This study showed that intraoperative blood transfusions have negative effects on early postoperative outcomes in scoliosis surgery. Therefore, patients undergoing scoliosis surgery would benefit from measures to prevent blood loss and blood transfusion in the perioperative period.

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