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Factors Affecting the Perioperative Blood Transfusion Need in Geriatric Hip Fractures

Geriatrik Kalça Kırıklarında Perioperatif Kan Transfüzyon İhtiyacına Etki Eden Faktörler

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Abstract

Hip fractures are an important cause of hospitalization and long hospital stays in the elderly. Allogeneic blood transfusion(ABT) affects patient health and also has economic effects.Therefore, more data on blood management are needed to improve patient outcomes, and optimize resource use. In this study,our primary aim was to determine the predictive factors affecting the need for ABT after geriatric hip fractures. A total of 596 hip fractures patients who were treated surgically in our clinic between 2011 and 2021 were analyzed. Age, gender, fracture type ,ASA score, surgical delay time, anesthesia type, surgery type, use of antiaggregants or anticoagulants, complications and hemoglobin (Hg), hematocrit (Hct), creatinine and INR levels at the time of admission were obtained. Binary logistic regression was employed to determine the risk factors. The receiver operating characteristic(ROC) curve was used to determine the appropriate cut-off point . While the mean Hg value of the patients who underwent ABT was 10.6±1.2 g/dl at the time of admission (p<0.001), the mean Hct value was 31.6±3.7%(p<0.001) and the mean creatinine was 1.25±0.88mg/dl (p=0.007). The outcomes of the regression analysis showed that the preoperative Hg level (p<0.001, OR:0.113, CI:0.068-0.190) and the preoperative Hct level (p=0.016,OR: 0.841, CI:0.730-0.968) were predictive factors for ABT. The ROC analysis showed that, a cut-off value of ≤11.9 g/dl was found for preoperative Hg and ≤35.5% for preoperative Hct. The main factors determining the need for blood transfusion are the Hg and Hct values at the time of admission. A Hg level of ≤11.9 g/dl and a Hct level of ≤35.5% can be safely used as a cut-off value.
Keywords: geriatric hip fractures, blood transfusion, cut-off value, predictors

Özet

Kalça kırıkları geriatrik hastalarda hastaneye yatışların önemli bir nedenidir. Allojenik kan transfüzyonu (AKT) hasta sağlığını etkiler ve ayrıca ekonomik etkileri vardır. Bu nedenle, hasta sonuçlarını iyileştirmek ve kaynak kullanımını optimize etmek için kan yönetimi hakkında daha fazla veriye ihtiyaç vardır. Bu çalışmada birincil amacımız geriatrik kalça kırıkları sonrası AKT ihtiyacını etkileyen prediktif faktörleri belirlemekti. Yöntemler: Kliniğimizde 2011-2021 yılları arasında cerrahi olarak tedavi edilen toplam 596 kalça kırığı hastası analiz edildi. Yaş, cinsiyet, kırık tipi, ASA skoru, cerrahi gecikme süresi, anestezi tipi, ameliyat tipi, antiagregan veya antikoagülan kullanımı, komplikasyonlar ve başvuru anındaki hemoglobin (Hg), hematokrit (Hct), kreatinin ve INR değerleri belirlendi. Risk faktörlerini belirlemek için ikili lojistik regresyon kullanıldı. Uygun kesme noktasını belirlemek için ROC eğrisi kullanıldı. AKT uygulanan hastaların başvuru anında ortalama Hg değeri 10,6±1,2 g/dl iken (p<0,001), ortalama Hct değeri %31,6±3,7 (p<0,001) ve ortalama kreatinin değeri; 1,25±0,88mg/dl (p=0,007). Regresyon analizi sonuçları, preoperatif Hg seviyesinin (p<0,001, OR:0.113, CI:0.068-0.190) ve preoperatif Hct seviyesinin (p=0.016,OR:0.841, CI:0.730-0.968) AKT için prediktif faktörler olduğunu gösterdi. ROC analizi, preoperatif Hg için ≤11,9 g/dl ve preoperatif Hct için ≤35.5'lik bir cut-off değerinin bulunduğunu gösterdi. Kan transfüzyonu ihtiyacını belirleyen ana faktörler başvuru anındaki Hg ve Hct değerleridir. ≤11,9 g/dl'lik bir Hg seviyesi ve ≤35.5'lik bir Hct seviyesi, cut-off değeri olarak güvenle kullanılabilir.
Anahtar Kelimeler: geriatrik kalça kırıkları, kan transfüzyonu, cut-off değer, prediktörler

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1. Introduction

The prevalence of geriatric hip fractures is increasing worldwide, rendering it a major public health problem. Of the 9 million osteoporotic fractures that occurred worldwide in 2000, 1.6 million were hip fractures [1]. Even if the incidence of hip fractures remains unchanged, this number is expected to rise to 6.26 million by 2050 [2]. Hip fractures are an important cause of hospitalization and long hospital stays in the elderly [3]. In addition, it is known that the rates of early and late mortality and major complications are high after geriatric hip fractures [4].

The relationship between low postoperative hemoglobin levels after geriatric hip fractures and poor functional outcomes in the early term, long hospital stays, and high readmission and mortality rates has been demonstrated [5, 6]. Allogeneic blood transfusion (ABT) is a known risk factor for immunosuppression that increases the risk of infection; excessive transfusion affects patient health and also has economic effects [7-9]. For these reasons, a "restrictive transfusion policy" has been recommended [10-12]. However, the indications for ABT in patients operated for geriatric hip fractures are not standardized and are controversial. Therefore, more data on blood management are needed to improve patient outcomes, reduce the need for perioperative ABT, and optimize resource use.

In this study, our primary aim was to determine the predictive factors affecting the need for ABT after geriatric hip fractures. In addition, we aimed to obtain evidence to help predict the perioperative blood requirement at admission. By managing the process better this way, we believe that patients can receive optimal medical care and avoid unnecessary costs.

2. Patients and Methods

A total of 743 hip fracture patients who were treated surgically in our clinic between January 2011 and June 2021 were retrospectively reviewed. After excluding those who were younger than 60, who had hip fractures following a high-energy trauma, had pathological fractures, had applied to the hospital after the first 12 hours, who had to undergo a second surgery for any reason within the first 30 days, and those who had insufficient or inconsistent perioperative data, 596 patients (205 males, 391 females) were included in the study. The flowchart for patient selection is shown in Figure 1. The hospital database, patient files, and radiological images of the patients were reviewed. Patients' age, gender, fracture type (intracapsular-extracapsular), American Society of Anesthesiologists (ASA) score, surgical delay time, anesthesia type (regional-general), surgery type (internal fixation-arthroplasty), use of antiaggregants or anticoagulants, need for ABT, postoperative complications, need for postoperative intensive care, and hemoglobin (Hg), hematocrit (Hct), creatinine and INR levels at the time of admission were obtained. Based on our standard approach for ABT transfusion in our clinic, transfusion was indicated for all patients included in the study. Allogeneic blood transfusion was performed in patients whose Hg levels fell below 8 mg/dl, and in those whose Hg levels were between 8-9 mg/dl and were symptomatic (chest pain, extreme weakness, palpitations) or had abnormal vital signs (tachycardia, hypotension).

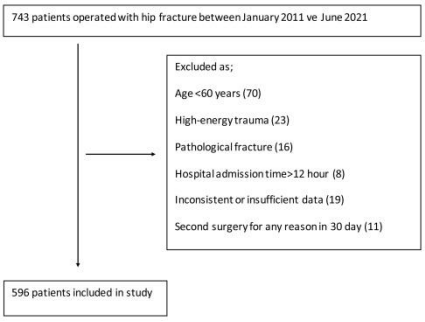


Figure 1. *Flowchart demonstrating the exclusion criteria.*

Age, Hg, Hct, creatinine, and INR values were analyzed as continuous data. In this way, we aimed to investigate the existence of a cut-off value that could predict the need for ABT. Preoperative radiological images of the patients were examined, and femoral neck fractures were grouped as intracapsular and trochanteric fractures as extracapsular fractures. Detailed preoperative data regarding comorbidities and ASA scores were obtained through the evaluation of anesthesiology notes, consultation information, and patients' files. The ASA scores were grouped as 1-2 or 3-4 based on previous literature [13]. The date of presentation and the date of surgery were checked to determine the surgical delay in days and it was analyzed as continuous data. The type of surgery was determined by examining the patients' postoperative radiological images. The preferred methods for internal fixation were classified as proximal femoral nail (PFN), dynamic hip screw (DHS), and cannulated screw. Data on the use of antiaggregants and anticoagulants such as warfarin, low-molecular-weight heparin (LMWH), clopidogrel, acetyl salicylic acid, rivaroxaban, and dabigatran were analyzed. Postoperative complications were classified as life-threatening major complications (mortality, pulmonary embolism, cardiac arrest, myocardial infarction, sepsis, acute renal failure, cerebrovascular accident) and minor complications (urinary tract infection, deep vein thrombosis, pneumonia, peripheral nerve damage, superficial wound infection). The 30-day mortality rate was determined by the collected data from the national data system and telephone questionnaires. Permission was obtained from the local ethics commission prior to the study (15.06.2021/25).

Statistical analysis

The continuous data were expressed as mean±standard deviation, while the categorical data were given as a percentage (%). The Shapiro-Wilk test was used to assess the normality of the data. In the comparison of the two groups that exhibited a normal distribution the independent samples t-test was used, whereas groups without a normal distribution were compared using the Mann-Whitney U test. Pearson's and Yate's chi-squared, and Pearson's exact chi-square tests were used in the analysis of the created cross tables. Binary logistic regression was employed to determine the risk factors. The receiver operating characteristic (ROC) curve was used to determine the appropriate cut-off point for the independent markers and calculate the sensitivity and specificity values. IBM SPSS Statistics for Windows v.21.0 (IBM Corp., Armonk, NY, USA) and MedCalc v.20.0 software were used in all analyses. The level of statistical significance was set at $p<0.05$.

3. Results

The mean age of the patients was 78.3 years (range: 60 to 102 years). In terms of fracture type, 359 patients (60.2%) were operated on for extracapsular and 237 (39.8%) for intracapsular fractures. Arthroplasty was performed in 256 (43%) patients, PFN in 251 (42.1%), DHS in 68 (11.4%), and cannulated screw in 21 (3.5%) patients. While 523 (87.8%) of the patients had an ASA score of 1 or 2, 73 (12.2%) had an ASA score of 3 or 4. The majority (64.8%) of the patients were given regional anesthesia and the rest (34.2%) general anesthesia. Allogeneic blood transfusion was performed in 238 patients (39.9%). Forty-two patients (7%) developed major complications, while 143 (24%) suffered from minor complications. Forty-eight patients (8.1%) needed postoperative intensive care. The mean surgical delay was 3.2 days (range: 1 to 9 days). The average 30-day mortality rate was 6.5%.

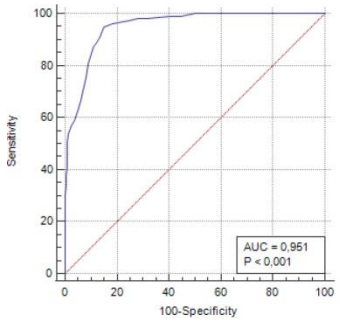
Allogeneic blood transfusion

Of the patients who underwent ABT, 77 (32.4%) were males and 161 (67.6%) were females, albeit the difference was insignificant ($p=0.442$). While the mean age of the 238 patients who underwent ABT was 78.9±8.0 years, the mean age of the 358 patients that did not require ABT was 78.0±8.4 years ($p=0.158$). Of the 238 patients who underwent ABT, 106 (44.5%) were performed arthroplasty, 103 (43.3%) PFN, 26 (10.9%) DHS, and three (1.3%) fixation with cannulated screws. There was no significant

relationship between the type of surgery and ABT (p=0.140). Of the patients who underwent ABT, 153 (64.3%) had extracapsular fractures and 85 (35.7%) intracapsular fractures. Again, no significant relationship was detected between fracture type and ABT (p=0.118). The ASA score was 1 or 2 in 87.8% of the patients who underwent ABT and in 87.7% of those who did not undergo ABT (p=1.000). Of the patients who underwent ABT, 66.8% did not use any antiaggregant or anticoagulant, while 15.5% used acetylsalicylic acid, 10.9% clopidogrel, 4.2% warfarin, 1.3% rivaroxaban, 0.8% dabigatran, and 0.4% LMWH. There was no significant relationship between antiaggregant or anticoagulant use and ABT (p=0.707). General anesthesia was performed on 31.9% of the patients who underwent ABT and regional anesthesia on 68.1% (p=0.198). The mean surgical delay was 3.4±1.7 days in patients who underwent ABT and 3.1±1.7 days in those who did not (p=0.058). No significant relationship was observed between the 30-day mortality rate and ABT (p=0.090). Minor complications were seen in 22.3% of the patients who underwent ABT, while major complications developed in 7.6%, again demonstrating an insignificant relationship with ABT (p=0.480 and p=0.819, respectively). Intensive care was needed for 10.1% of the patients who underwent ABT and for 6.7% of the patients who did not (p=0.183).

While the mean Hg values of the patients who underwent ABT were 10.6±1.2 g/dl at the time of admission, the values were 12.9±1.1 g/dl in those who did not receive ABT (p<0.001). The mean Hct value in the patients who underwent ABT was 31.6±3.7% at the time of admission and 38.3±3.7% in the patients who did not undergo ABT (p<0.001). The mean creatinine values in patients who underwent ABT was 1.25±0.88 mg/dl at the time of admission. The values were measured as 1.15±0.94 mg/dl in patients who did not undergo ABT (p=0.007). In patients who underwent ABT the mean INR value at the time of admission was 1.11±0.36, whereas the mean INR was 1.09±0.28 in patients who did not undergo ABT (p=0.438). Patients who underwent ABT were hospitalized for a mean period of 10.4±3.5 days. On the other hand, the length of hospitalization in those who did not undergo ABT was 8.8±3.5 days (p<0.001). The univariate analysis for predictive factors affecting ABT is given in Table 1.

The Hg, Hct, and creatinine levels, which were found to be significant as a result of the univariate analysis, were evaluated with multivariate logistic regression. The outcomes of the regression analysis showed that the preoperative Hg level (p<0.001, OR: 0.113, CI: 0.068-0.190) and the preoperative Hct level (p=0.016, OR: 0.841, CI: 0.730-0.968) were predictive factors for ABT. The results of the multivariate analysis are summarized in Table 2. ROC analysis was performed to determine the cut-off value for the Hg and Hct values found to be significant as a result of the multivariate analysis and to calculate the sensitivity and specificity values. As a result, a cut-off value of ≤11.9 g/dl was found for preoperative Hg (p<0.0001, sensitivity: 94.96, specificity: 84.92) and ≤35.5% for preoperative Hct (p<0.0001, sensitivity: 89.92, specificity: 77.09) (Figs. 2 and 3).



Area under the ROC curve (AUC)

Area under the ROC curve (AUC)	0,951
Standard Error [a]	0,00785
95% Confidence interval [b]	0,931 to 0,967
z statistic	57,469
Significance level P (Area=0.5)	<0,0001

[a] DeLong et al., 1988
[b] Binomial exact

Youden index

Youden index J	0,7987
Associated criterion	≤11,9
Sensitivity	94,96
Specificity	84,92

Figure 2. *ROC analysis to determine the cut-off value for preoperative hemoglobin*

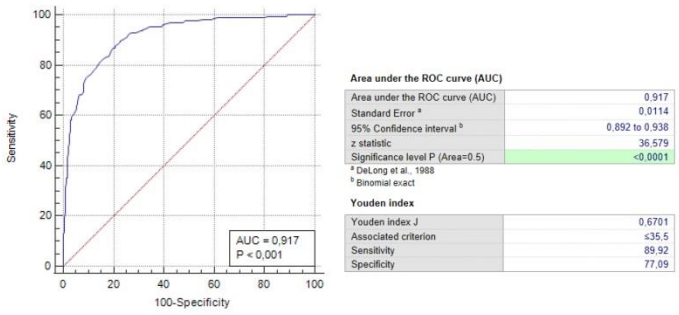


Figure 3. *ROC analysis to determine the cut-off value for preoperative hematocrit.*

Table 1. Results of the univariate analysis for predictive factors affecting allogeneic blood transfusion (ABT).

	Non-ABT (n=358)	ABT (n=238)	p
Gender			
Male	128 (35.8%)	77 (32.4%)	0.442
Female	230 (64.2%)	161 (67.6%)	
Age (years)	78.0±8.4	78.9±8.0	0.158
Surgical delay time (days)	3.1±1.7	3.4±1.7	0.058
Surgery type			
Arthroplasty	150 (41.9%)	106 (44.5%)	
DHS	42 (11.7%)	26 (10.9%)	0.140
PFN	148 (41.3%)	103 (43.3%)	
Cannulated screw	18 (5.0%)	3 (1.3%)	
Fracture type			
Extracapsular	206 (57.5%)	153 (64.3%)	0.118
Intracapsular	152 (42.5%)	85 (35.7%)	
ASA score			
1-2	314 (87.7%)	209 (87.8%)	1.000
3-4	44 (12.3%)	29 (12.2%)	
Antiaggregant–anticoagulant use			
ASA	70 (19.6%)	37 (15.5%)	
Dabigatran	2 (0.6%)	2 (0.8%)	
Clopidogrel	26 (7.3%)	26 (10.9%)	
LMWH	1 (0.3%)	1 (0.4%)	0.707
Rivaroxaban	4 (1.1%)	3 (1.3%)	
Warfarin	16 (4.5%)	10 (4.2%)	
None	239 (66.8%)	159 (66.8%)	
Anesthesia type			
General	134 (37.4%)	76 (31.9%)	0.198
Regional	224 (62.6%)	162 (68.1%)	
Major complication			
Yes	24 (6.7%)	18 (7.6%)	0.819
No	334 (93.3%)	220 (92.4%)	
Minor complication			0.480
Yes	90 (25.1%)	53 (22.3%)	
No	268 (74.9%)	185 (77.7%)	
Hospitalization in ICU			
Yes	24 (6.7%)	24 (10.1%)	0.183
No	334 (93.3%)	214 (89.9%)	
Length of hospital stay (days)	8.8±3.5	10.4±3.5	**<0.001**
Preoperative Hg (g/dl)	12.9±1.1	10.6±1.2	**<0.001**
Preoperative Hct (%)	38.3±3.7	31.6±3.7	**<0.001**
Creatinine (mg/dl)	1.15±0.94	1.25±0.88	**0.007**
INR	1.09±0.28	1.11±0.36	0.438

ASA: acetylsalicylic acid, DHS: dynamic hip screw, Hg: hemoglobin, Hct: hematocrit, ICU: intensive care unit, INR: international normalized ratio, LMWH: low-molecular-weight heparin, PFN: proximal femoral nail. Significant p values are written in bold.*

Table 2. Results of the multivariate analysis.

Multivariate predictor	Regression coefficient	Odds ratio	95% Confidence interval		p
			Lower	Upper	
Hemoglobin at admission	-2.177	0.113	0.068	0.190	**<0.001**
Hematocrit at admission	-0.173	0.841	0.730	0.968	**0.016**

**Significant p values are written in bold.*

4. Discussion

We retrospectively analyzed 596 individuals to determine the ABT rate in geriatric hip fracture patients and the predictive factors affecting it. Our sample size was relatively small, however, we had a great range of relevant confounders in our study. In addition, we aimed to form a homogeneous study group by excluding the patients aged less than 60 years and those who had fractures as a result of a high-energy trauma. To produce a more reliable regression model, the confounders were analyzed as continuous variables where possible. In particular, we investigated for a cut-off value by not grouping the preoperative Hg and Hct values and analyzing them as continuous variables. In this way, we wanted to create evidence to predict the need for ABT in geriatric patients presenting with hip fractures, since the first step in the management of ABT is to predict the possible need. Good management of transfusion can prevent complications caused by anemia, while also preventing the risks of transfusion and effectively reducing the economic burden [14-17].

In our study, the rate of ABT application was 39.9%. In a study by Hou et al., where 220 geriatric patients with trochanteric fractures were examined, the rate of ABT was reported as 40.5% [18]. In another study, Shokoohi et al. reported an ABT rate of 32.6% among 919 patients [19]. The blood transfusion rate in our study is in line with the literature.

Contrary to some studies from the literature [18-21], age was not found as a predictive factor for perioperative ABT in our study. The mean age of the patients that underwent ABT was 78.9 years, while the mean age of the patients who did not receive ABT was 78.0 years. In the ABT group, 72.7% of the patients were 75 years of age or older whereas this rate was 65.6% among those that did not undergo ABT, exhibiting an insignificant difference. We believe that the lower preoperative Hg and Hct values in older patients may have caused the difference in other studies.

Several studies in the literature have suggested that preoperative anemia is a predictive factor for perioperative need for ABT [3, 18-25]. Hou et al. stated that values of 12.4 g/dl and below pose a risk for ABT [18], while Shokoohi et al. reported that the ABT rate was six times higher in patients who were anemic at first admission [19]. In Robbins and Steingold's study, only one of nine patients with a Hg level above 11g/dl needed ABT [24]. Kurdy and Hokan recommended blood preparation for patients with a Hg value below 12 g/dl [25], whereas Adunsky et al. suggested that patients with a Hg value above 12g/dl can be operated without blood preparation [3]. In our study, a preoperative Hg value of ≤11.9 g/dl was found to be a strong predictive factor for ABT, a finding in parallel with previous studies.

Contrary to some studies in the literature [3, 18, 19], we found no relationship between the type of surgical technique and ABT. Although PFN application is considered to be minimally invasive and is thought to cause less bleeding due to small incisions, it may cause a high amount of hidden bleeding as reported by Foss and Kehlet [26]. The reason for this is the opening of the medullary cavity and proximal reaming [18]. We believe that the relatively low number of patients who were performed DHS or cannulated screws compared to the other groups may be the reason for not finding a difference in terms of

ABT in these surgery types, where lower bleeding is anticipated.

Some researchers suggested a relationship between the fracture type and ABT [19], whereas some reported otherwise [27] as we did. In our study, complications were grouped as major and minor, and no relationship was observed between ABT and complications. Shokoohi et al. reported a relationship between transfusion rate and chest infection, urinary tract infection, and superficial and deep wound infection [19]. In patients who were operated on for hip fracture, Koval et al. reported a relationship of transfusion with urinary tract infection [9], Carson et al. with chest infection [10], and Levi and Sandberg with wound infection [8]. On the other hand, Johnson et al. found no relationship between infection and transfusion again in patients who were operated on for hip fractures [28]. Although the immunomodulatory effects of ABT are known, its mechanism is still not clear. Similarly, the relationship between ABT and infection is still controversial.

In our study, we did not observe a relationship between ABT and 30-day mortality. Similarly, Shokoohi et al. did not report a relationship between transfusion and 28-day and 180-day mortality rates [19]. Carson et al. also failed to demonstrate a relationship between transfusion and 60-day mortality [10]. In Foss and Kehlet's study conducted on patients with hip fractures, the mortality rate was lower in the restricted transfusion group than in the liberal transfusion group [26]. In our study, a restrictive transfusion policy was followed as explained in the Patients and Methods section.

The main limitations of this study are its retrospective design and limited number of patients. In addition, intraoperative blood loss and surgical time were not analyzed separately. The fact that our study may not reflect the general trend since it was performed at a single center may be considered another limitation. However, we strengthened our study by analyzing almost all potential predictors examined in the literature. In addition, by analyzing the Hg and Hct values as continuous variables, we were able to determine a cut-off value for ABT, which was one of the main objectives of our study.

In conclusion, the main factors determining the need for blood transfusion in geriatric patients operated on for hip fractures are the Hg and Hct values at the time of admission. A Hg level of ≤11.9 g/dl and a Hct level of ≤35.5% can be safely used as a cut-off value in predicting the need for transfusion.

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