

Changes in the hemoglobin level after one unit of packed red blood cell transfusion in Intensive Care Unit patients

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Background: Blood transfusion is essential in severely ill patients whose hemoglobin (Hb) levels are low, but there are some factors that inhibit optimal increase in Hb. The aim of this study was to evaluate the amount of increase in Hb levels after packed red blood cell (PRBC) transfusions in the Intensive Care Unit (ICU) patients and its related factors. **Materials and Methods:** This cross-sectional study included 124 patients admitted to the ICU, and needed PRBC transfusion. Demographic information, Hb on the 1st day of admission, blood volume transfusions during the 7 days, and the 7th day of admission Hb level were extracted from patients' records. **Results:** The average initial Hb level of patients was reported as 6.17 ± 1.43 g/dl, and after administrating PRBC (4.23 ± 1.87 units during 7 days), the Hb level was 8.09 ± 1.66 g/dl after 7 days (mean difference was 1.91 ± 1.93 , $t = 11.06$, $P < 0.001$). No significant differences were found between change in Hb level in the terms of age, gender, underlying illness, body mass index, hospitalization history, fever, and duration of hospitalization ($P > 0.05$). However, the mean increased Hb level in hospitalized patients with internal disorders was the lowest (0.25 g/dl, $P = 0.002$). **Conclusion:** The results of our study showed that the increased Hb level based on one unit of received PRBC was low, especially in patients with internal. Therefore, based on high frequency of anemia in ICU patients and relative complications, physicians should pay attention to factors affecting Hb levels after PRBC transfusion such as medical history.

Key words: Hemoglobin, Intensive Care Unit, packed red blood cells

How to cite this article: Kashefi P, Rahmani A, Khalifesoltani M. Changes in the hemoglobin level after one unit of packed red blood cell transfusion in Intensive Care Unit patients. J Res Med Sci 2018;23:85.

INTRODUCTION

Anemia is a common problem in critically ill patients admitted to Intensive Care Units (ICUs).^[1] Although all the ill patients admitted to the ICU do not need infusion of packed red blood cell (PRBC), blood loss following trauma, gastrointestinal bleeding, and surgery are the most important indications of transfusion of PRBC in these patients.^[2,3] Indeed, previous studies demonstrated that 95% of critically ill patients who were hospitalized in the ICU for more than 72 h are diagnosed with anemia, and roughly one-third of them receive PRBC transfusions.^[4,5] Therefore, PRBC transfusion in ill patients could increase hemoglobin (Hb) levels which should improve patient's oxygen carrying capacity and

help deliver oxygen to hypoxic tissues.^[6] However, in some cases, anemia is persistent throughout their ICU and hospital stay, with or without PRBC transfusion. However, they do not systematically increase oxygen consumption, and effects on oxygen delivery are not always very impressive.^[4,5,7-10]

Groeger *et al.* showed that 16% of patients in medical ICUs and 27% of those in surgical ICUs are transfused on any given day.^[11] In the United States, 85% of patients with an ICU length of stay >1 week received at least 1 unit of PRBC transfusion, and the mean number of units of blood transfused per patient was 9.5.^[12] An observational study of 4892 patients admitted to ICUs in the USA throughout 2000 and 2001^[4] found that almost 50% of patients were still transfused. The results also

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10.4103/jrms.JRMS_64_17

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Received: 04-02-2017; **Revised:** 09-04-2017; **Accepted:** 04-07-2017

showed that initial PRBC transfusion tends to occur early in the ICU stay, with ongoing PRBC transfusions throughout the ICU stay.

Blood transfusion in severely ill patients, whose Hb levels are low, is critical and also finding the risk factors preventing optimal increase the Hb is essential. Hence, this study aimed to evaluate the amount of Hb after PRBC transfusions in patients who were admitted to the ICU and some related factors.

MATERIALS AND METHODS

This cross-sectional study was conducted in the ICU Department of Isfahan Alzahra Hospital, Center of Iran, from March 2016 to February 2017. In this study, all patients hospitalized in the ICU of Alzahra Hospital (18–65 years old) who had to receive PRBC under doctor's supervision were enrolled in the study by convenience sampling method. The inclusion criteria were consist of patients admitted to the ICU, and needed PRBC transfusion (based on laboratory results of anemia (basal Hb <8) and ICU physician opinion) and our study exclusion criteria consist of active bleeding during the time of blood transfusion, wound drainage during the time of blood transfusion, incomplete data, hematuria, gastrointestinal bleeding, and positive stool examination in terms of occluded blood and hemoptysis.

Procedures and variables assessment

The data collection tool was a two-part questionnaire, in which demographic information was recorded in the first part, and admission Hb level, mean blood volume transfusion during 7 days, Hb level at the 7th day of admission were recorded in the second part of the questionnaire. Furthermore, in the patients who had received PRBC based on doctor's prescription, the Hb level was measured at the time of infusion cell and 6 h later. Our primary outcome was changing Hb level after PRBC administrating and our secondary outcome was evaluating changing Hb level after PRBC administrating based on demographic and medical history. We calculated the mean increase in Hb level using the following method: (Hb level after 7 days – initial Hb level)/number of administered red blood cells (RBCs) units.

Statistical analysis

Analysis of data was performed using (SPSS, Version 10.0, Chicago, Illinois, USA) statistical software. Descriptive statistics were reported as the mean and standard deviation (mean \pm SD) for quantitative and frequency (percentage) for qualitative. Chi-square test was used for comparing categorical data between groups. We used the paired *t*-test for within-group analysis. Independent and ANOVA and Bonferroni *post hoc* test were

used for between-group analyses. Paired *t*-test was used to compare data for the same patients over time. Moreover, Pearson correlation coefficient and multiple linear regression analysis were used for evaluating the association predictors with amount of increase in Hb after PRBC transfusions. All tests were analyzed at an error level of 5%.

RESULTS

Of 124 hospitalized patients in the ICU of Alzahra Hospital who entered the study, 97 patients (78.2%) were males and 27 (21.8%) of them were females; the mean \pm SD age of the patients was 41.87 ± 11.99 years. The average initial Hb level of patients was reported as 6.17 ± 1.43 g/dl and after administrating PRBC the Hb level was 8.09 ± 1.66 g/dl after 7 days (mean difference was 1.91 ± 1.93 , $t = 11.06$, $P < 0.001$). It was also found that mean received PRBC of the patients was 4.23 ± 1.87 units during the 7-day period.

No significant differences were found between change in Hb level based in terms of age, gender, underlying illness, body mass index (BMI), hospitalization history, fever, and duration of hospitalization ($P > 0.05$). However, there were significant differences between hospitalized patients in different wards ($P = 0.002$), in which the mean increased Hb level in hospitalized patients with internal disorders was the lowest (0.25 g/dl) and the highest amount was in the patients hospitalized due to infectious problems (0.7 g/dl) and the observed difference was related to patients in internal and infection wards ($P = 0.003$, Bonferroni test). Furthermore, the mean increased Hb level based on one unit of received PRBC in patients with initial Hb level <4 g/dl was the highest (0.7 g/dl), and the lowest (0.29 g/dl) was in patients with initial Hb level over 6 g/dl ($P = 0.003$) [Table 1].

Correlation coefficients between different variables and change in Hb are depicted in Table 2.

There is a positive significant correlation between change in Hb level and number of received PRBC ($r = 0.40$, $P < 0.001$). Furthermore, multivariable linear regression analysis showed that positive association between Hb changes in terms of one unit of received PRBC remains statistically significant ($B = 0.35$, $P < 0.001$) [Table 3].

DISCUSSION

Anemia is a serious problem in the patients hospitalized in the ICU which increased morbidity and mortality.^[13] Thus, blood transfusion is necessary in severely ill patients with low Hb levels, and it is necessary to find risk factors that prevent the increase to the desired Hb level. The results of our study showed that the mean initial Hb level of patients was 6.17 ± 1.43 g/dl and this amount after receiving PRBC

Table 1: Hemoglobin level changes after one unit of packed red blood cell transfusion based on demographic and medical history

Variables	Number of patients	Increase of Hb after one unit pack cell transfusion (g/dl)	P
Age groups (years)			
<30	25	0.6±0.49	0.286
30-39	22	0.36±0.59	
40-49	27	0.367±0.56	
≥50	50	0.44±0.39	
Sex			
Male	97	0.47±0.49	0.166
Female	27	0.33±0.47	
BMI (kg/m ²)			
<18	2	0.72±0.31	0.668
18-25	100	0.43±0.49	
>25	22	0.48±0.53	
Medical history			
Diabetes	39	0.41±0.5	0.751
Cardiovascular disease	18	0.48±0.41	
Hypertension	28	0.55±0.62	
Hyperlipidemia	25	0.4±0.54	
Causes of admission			
Internal diseases	55	0.25±0.55	0.002
Neurologic	23	0.54±0.32	
Infectious	21	0.7±0.51	
Cardiac diseases	17	0.53±0.3	
Poisoning	8	0.59±0.31	
History of hospitalization			
No	85	0.44±0.46	0.986
Yes	39	0.44±0.55	
Fever			
No	45	0.47±0.51	0.655
Yes	79	0.43±0.48	
Hospitalization duration (day)			
<10	57	0.42±0.46	0.782
10-15	25	0.5±0.52	
>15	42	0.44±0.52	
Level of primary Hb (g/dl)			
<4	7	0.7±0.34	0.003
4-4.99	24	0.56±0.33	
5-5.99	27	0.64±0.38	
≥6	66	0.29±0.55	

Hb = Hemoglobin; BMI = Body mass index

and after 7 days of initial Hb level test was 8.09 ± 1.66 g/dl. These changes were statistically significant (an increase of 1.91 ± 1.93 g/dl). It was also revealed that the mean received PRBC that patients obtained as 4.23 ± 1.87 units. The mean increased Hb level based on one unit of received PRBC and after 6 h after transfusion was equal to 0.44 ± 0.49 units.

In a study by Valizadeh *et al.* it was clarified that the mean Hb level before admission in ICU was 11.1 g/dl, but some of the patients during admission in ICU required blood transfusion, which the mean Hb level before prescribing was 8.41 g/dl and blood transfusion volume was 7.82 units.^[14] A study of Crowin *et al.* showed that the Hb level

before prescribing PRBC was 8.6 g/dl. This study also indicated that the highest blood transfusion volume was done in the 1st week and the minimum Hb level <9 g/dl was the predictor of increased mortality and duration of hospitalization.^[15]

The results of one Zilberberg *et al.*^[16] study showed that 67% of patients experienced at least one blood transfusion and the average 12.9 units of blood was administered per patient during hospitalization. The number of transfused blood units in Zilberberg *et al.*'s study was more than the current study. While this amount in Volar *et al.* study on average was less than the number of transfused units in

Table 2: Pearson correlation coefficient between studied variables

Variable	Age	Primary Hb	Hb after transfusion	Hospitalization duration	BMI	Receive pack cell	Change Hb	Increase of Hb after on unit pack
Age	1							
Primary Hb	0.023	1						
Hb after transfusion	-0.121	0.0229*	1					
Time of hospitalization	-0.096	0.044	0.031	1				
BMI	-0.068	0.033	0.021	0.033	1			
Receive pack cell	-0.127	-0.630**	-0.072	-0.015	-0.042	1		
Change Hb	-0.122	-0.544**	0.692**	-0.006	-0.006	0.404**	1	
Increase of Hb after on unit pack	-0.93	-0.282**	0.728**	0.032	0.042	0.027	0.837**	1

* $P < 0.05$, ** $P < 0.001$. BMI = Body mass index; Hb = Hemoglobin

Table 3: Multivariate regression analysis of studied variables

Model	Unstandardized coefficients		Standardized coefficients	t	Sig.	95.0% ci* for B	
	B	Std. error	Beta			Lower bound	Upper bound
(Constant)	6.166	0.898	-	6.866	<0.001	4.388	7.944
Pack cell (number)	0.350	0.082	0.33	4.26		0.187	0.512
Age	-0.013	0.012	-0.079	-1.098	0.274	-0.036	0.01
Sex (female)	-0.558	0.337	-0.12	-1.657	0.100	-1.224	0.109
BMI**	0.008	0.051	0.012	0.154	0.878	-0.093	0.109
Causes of admission							
Internal diseases	-1.278	0.441	-0.330	-2.899	0.004	-2.150	-0.405
Neurologic	0.501	0.533	0.098	0.939	0.350	-0.556	1.557
Infectious	0.193	0.567	0.035	0.341	0.734	-0.929	1.315
Cardiac diseases	0.889	0.739	0.114	1.202	0.232	-0.575	2.353
Poisoning	-1.278	0.441	-0.330	-2.899	0.004	-2.150	-0.405
Basal Hb***	-0.734	0.103	-0.544	-7.133	<0.001	-0.938	-0.530

*ci= Confidence Interval;**BMI=body mass index;***Hb=hemoglobin

our patients,^[17] Gould *et al.*^[18] indicated that the receiver of the PRBC had worse outcomes than in those who had not received blood transfusions. Zilberberg *et al.*^[16] revealed that blood transfusion was accompanied with increased mortality, duration of hospitalization, and hospital cost.

In our study, no significant relationship was found among the mean increased Hb levels and age, gender, underlying illness, hospitalization history, fever, BMI, and duration of hospitalization. However, it was determined that the increased Hb level in hospitalized patients due to internal problems based on one unit of received PRBC had the least amount (0.25 g/dl). In addition, the lower initial Hb level was equal to the higher rate of an increase in Hb level and the amount of received PRBC. Therefore, it can be seen that patients with a very low level of initial Hb received more PRBC, and thus, the increase in the amount Hb level was greater.

In a study conducted by Thurer *et al.*^[19] in 2010, it was shown that the mean increased Hb was 1 g/dl. However, in our study, it was found that the mean increased Hb level based on one unit of received PRBC was 0.44 ± 0.49 g/dl. Furthermore, in the mentioned study, it was revealed that the rate of increased Hb among females was more than in males. However, we could not find a relationship between

Hb level and gender. The reason for the difference in the increased Hb level in the two studies and an increased less than half of Hb in our study compared with favorable conditions revealed that some conditions occur in severely ill patients (hospitalized in ICU), in which blood transfusions could not increase the amount of desirable Hb.

Naidech *et al.*'s study in 2008 showed that if the initial Hb levels were low, the Hb level increase in the blood transfusions would be higher.^[20] Our study was similar to the mentioned study obtained identical results. Although our study indicated that the low levels of Hb before injection required more blood transfusions, finally, more increase Hb level after the injection was observed.

Based on available information, there is no study indicating the factors affecting the level of increase in the patients hospitalized in ICU after the injection. However, a study by Macciò *et al.*^[21] in 2005 showed that inflammatory factors including interleukin-1 beta, interleukin-6, tumor necrosis factor alpha, and C-reactive protein levels had a significant inverse relationship with Hb level. In a study by Tamer Abdullah Helmy *et al.*^[22] in 2014, it was indicated that inflammatory factors were increased in patients hospitalized in ICU, especially due to internal diseases (especially respiratory), and there is a direct relationship with

admission to the ICU, duration of hospitalization in ICU, duration of hospitalization in general ward, and duration of ventilator device connection. Therefore, it can be seen that the lack of a favorable increase in Hb level in patients hospitalized in ICU due to internal disease is caused by the relationship between increased inflammatory factors and initial Hb level.

Limitations

We calculated the mean increase in Hb level using the following method: (Hb level after 7 days – initial Hb level)/number of administered RBCs units, which did not evaluate the patients' conditions or other factors affected the increase of Hb levels. Since this study was the first research regarding the evaluating process of different factors affecting the increased Hb level and because of the limitations of the survey such as being a cross-sectional study with ICU patients, who could not have appropriate contribution, therefore, we were unable to measure all possible factors that influenced the increased Hb level such as different medical history such as inflammatory factors and the course of patients illness during the hospitalization. Therefore, it is recommended to conduct a prospective study for assessing the effects of all possible factors in the absence of favorable increased Hb level in the patients hospitalized in the ICU.

CONCLUSIONS

The results of our study showed that the increased Hb level based on one unit of received PRBC was low especially in patients with internal. Therefore, based on high frequency of anemia in ICU patients and relative complications, physicians should pay attention to factors affecting Hb levels after PRBC transfusion such as medical history. Therefore, for high-risk patients, we should administrate more PRBC to have better increase in Hb levels.

Acknowledgments

This study has been supported by Research Deputy of Isfahan University of Medical Sciences, Iran (Research project number: 394651).

Financial support and sponsorship

This study was funded by a grant from Isfahan University Of Medical Sciences School Of Medicine.

Conflicts of interest

There are no conflicts of interest.

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