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Impact of Erythrocyte Suspension Transfusion and Viscosity on Perfusion Index in the Emergency Department

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Abstract

Objective: Erythrocyte suspension (ES) transfusion is a frequently needed and performed procedure in emergency departments. In this study, the effect of transfusion on the perfusion index (PI), shock index (SI), vital parameters, hemoglobin (Hb), and hematocrit (Hct) values in adult patients who applied to the emergency department and required ES transfusion was investigated.

Materials and Methods: Fifty-five adult patients who applied to the emergency medicine clinic within three months and underwent ES replacement were included in the study. The changes in PI, SI, vital parameters, Hb, and Hct values of patients with ES transfusion compared with those pre-transfusion were analyzed.

Results: The mean age of 55 patients included in the study was 62.5±16.5 years, of which 28 (50.9%) were female. Pre-transfusion values of the patients were Hb 6.4±1.2 g/dL, mean arterial pressure (MAP) 83.2±11.6 mmHg, SI 0.73±0. 19, and PI was 3.07±2.21. After the transfusion procedure, Hb was 9.0±1.2 g/dL ($p<0.001$), MAP 90.0±13.0 mmHg ($p<0.001$), SI 0.67±0.14 ($p=0.003$), PI 4.25±3.18 ($p=0.004$).

Conclusion: The ES transfusion procedure causes a statistically significant increase in post-transfusion PI, MAP, Hb, Hct, and body temperature values compared with pre-transfusion, and a statistically significant decrease in mean pulse and SI. PI can be used as a parameter to evaluate treatment response as well as transfusion decisions in patients.

Keywords: Perfusion index, emergency department, erythrocyte suspension, transfusion, shock index

Introduction

Using non-invasive methods such as the perfusion index (PI) in the emergency department can provide clinicians with a preliminary estimate of patients' hemodynamic status. In emergency medicine, pulse oximetry may be more useful than interventional perfusion measurement techniques. This is a result of its ability to provide continuous monitoring, cost-effectiveness, suitability for bedside applications, and swift and simultaneous measurement capabilities. Regarding PI, there are few published works, and studies involving large patient populations, such as emergency room patients, are required. Tissue perfusion is essential for cellular resistance to infectious organisms, metabolic continuity, and tissue repair [1]. Numerous clinical studies have demonstrated that in critically ill patients, early resolution of tissue-level hypoxia and systemic oxygen supply can reduce the incidence of mortality and morbidity [2].

Non-invasive imaging methods are recommended as an alternative approach to identifying and correcting hemodynamic deficits as early as possible because time is the most important determinant in first aid, resuscitation, and treatment in emergency clinic patients [3]. In terms of the early identification of hemodynamic instability, it is more appropriate to use non-invasive imaging methods in patients with short-term emergencies [3].

The main aim of continuous circulation monitoring is to accurately evaluate peripheral tissue perfusion in a clinical

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environment and detect probable circulatory diseases in their early stages. The rationale underlying this method posits that peripheral tissues serve as primary markers of hypoperfusion in cases of shock and as ultimate indicators of reperfusion following resuscitation [4]. Impaired peripheral circulation can be detected with a comprehensive clinical assessment, the use of optical monitoring systems, and the quantification of body temperature [5-7]. In contemporary times, there has been a proposal suggesting that pulse oximetry can be used as an indicator of changes in peripheral perfusion [8].

The objective of this study was to precisely assess the impact of transfusion on PI, shock index (SI), and other essential parameters in patients requiring erythrocyte suspension (ES) transfusion in the emergency department. Additionally, this study attempted to identify the appropriate candidates for transfusion.

Materials and Methods

Study Design and Population

The study was conducted as a prospective, single-center, cross-sectional, descriptive study. A total of 55 individuals who were above the age of 18 years and needed medical attention at the Emergency Medicine Clinic of University of Health Sciences Turkey, İstanbul Training and Research Hospital between the dates of 15.04.2015 and 15.06.2015 were selected for this study. These individuals underwent ES transfusion following a comprehensive evaluation.

The physician in charge of the study was informed of the patients who needed ES transfusion because of the physical examination, examination, and clinical condition performed by the physician in charge after their admission to the emergency service. The physician who was supervising the research provided the participants with information about the study. Individuals who volunteered for the study were provided with information and provided written and verbal consent. To ensure ethical participation in the study, informed consent was obtained directly from each patient. In instances where the patient could not provide assent, arrangements were made to obtain consent from a first-degree relative. In the absence of a first-degree relative, consent was obtained from the individual accompanying the patient to the hospital. Exclusion criteria for this study included patients who were admitted to the intensive care unit in a state of cardiopulmonary arrest and subsequently underwent resuscitation, individuals who required immediate surgical intervention and subsequent treatment as indicated by a referral, participants who could not be reached for follow-up, individuals under the age of 18, patients whose vital signs could not be measured accurately, and those who experienced complications during the study. The research was designed as a prospective, single-center, descriptive cross-sectional study. A total of 55 adults over the age of 18 who presented to the Emergency Medicine Clinic of University of Health Sciences Turkey, İstanbul Training and Research Hospital between April 15, 2015, and June 15, 2015, and received ES transfusions because of the evaluation were included.

Vital signs, including blood pressure, arterial pressure, pulse, respiratory rate, body temperature, and saturation, were measured with the General Electric farmscape V100 Dinamap SH612260165SA device before and after the transfusion of the patients included in the study, and they were recorded in the patient file. Simultaneously with the vital signs of the patients, PIs were measured noninvasively by waiting for 30 seconds with the Massimo-SET Root 7362A RDS7 pulse oximetry device saturation probe from the fourth distal phalanx of the non-dominant hand, with the hand at the heart level. Hemoglobin (Hb) and hematocrit (Hct) values from the hemogram parameters sent before and after the transfusion of the patients were taken from the automation system and recorded. The next measurement was taken immediately after completion of the ES transfusion, simultaneously with the control blood values. The formula "Shock index: heart rate/systolic blood pressure" was used to calculate the SI [9].

The procedures adhered to the ethical standards set forth by the institutional and national committees overseeing human experimentation and the principles outlined in the Declaration of Helsinki. The study participants who volunteered were provided with information and subsequently acquired written and verbal consent. The author responsible for correspondence hereby affirms, representing all authors, that there are no conflicts of interest present. The University of Health Sciences Turkey, İstanbul Training and Research Hospital Clinical Research Ethics Committee granted approval for the study, as evidenced by document date and number 09.01.2015/569.

Statistical Analysis

The patient data used in the study were documented inside the Statistical Package for the Social Sciences 15.0 for Windows software and then subjected to analysis. The provided information included descriptive statistics, which encompassed numerical measures such as numbers and percentages for categorical variables, as well as the mean, standard deviation, minimum, and maximum values for numerical variables. The Mann-Whitney U test was employed to compare two independent groups because of the non-normal distribution of the numerical variables. Spearman correlation analysis was employed to examine the correlations between numerical variables because the parametric test assumption was not satisfied. The numerical variable was analyzed using the linear regression analysis backward technique. The statistical significance level, denoted as alpha, was deemed acceptable when it was 0.05.

Results

The mean age of 55 patients included in the study was 62.5±16.5 (range: 22-89 years), and 28 (50.9%) were female. The mean age of women was 61.2±18.0 years, and that of men was 63.8±15.1 years. While active bleeding was in 8 (14.5%) of the cases, 50 (90.9%) patients had symptomatic anemia. The mean number of ES transfusions administered was 2.1±0.5 units.

Considering the additional diseases of the cases included in the study, malignancy ranked first with 17 (30.9%). Anemia of chronic disease was observed in 15 (27.2%) cases and hypertension was observed in 13 (23.6%) cases. No statistically significant correlation was found between the presence of the disease and the mean PI values before the transfusion according to the additional disease types of the patients included in the study (Table 1).

Hb values of the cases were 6.4±1.2 before transfusion and 9.0±1.2 after transfusion ($p<0.001$). PI was 3.07±2.21 before transfusion and 4.25±3.18 after transfusion ($p=0.004$). The SI was 0.73±0.19 before and 0.67±0.14 after ($p=0.003$). While there was a statistically significant increase in the mean values of Hb, hematocrit (Hct), mean arterial pressure (MAP), body temperature, and PI with blood transfusion in the patients included in the study, a statistically significant decrease was found in the mean pulse and SI values. There was no statistically significant change in the mean saturation levels of the patients after transfusion (Table 2, Figure 1).

Discussion

Using PI as an alternative metric for cardiac output was used in various fluid responsiveness evaluation maneuvers. A passive limb-raising test increased PI by 9%, whereas an end-expiratory obstruction test increased PI by 2.5%. These findings suggest that these tests can predict fluid responsiveness with reasonable accuracy. According to a study, the administration of a 200-mL fluid infusion results in a 5% increase in the PI, which can serve as a predictor of fluid responsiveness in patients with septic shock [10-13]. According to a study [14], the lung recruitment method significantly reduces the PI by 26%. This decrease in PI can be used as a predictor of fluid responsiveness during surgery. In the absence of a cardiac output monitor, this application represents a significant achievement in guiding fluid therapy [14]. There was a significant association between the average PI within the initial 30 min following an out-of-hospital arrest in individuals with post-return spontaneous circulation and their subsequent clinical outcomes [15]. The mortality rate of patients with PI levels in the lowest tertile was found to be twice that of patients with PI levels in the highest tertile [15]. Higher PI is associated with improved patient outcomes because it indicates enhanced tissue perfusion. Alakaya and Arslanköylü [16] also reported in their study that the PI permits non-invasive evaluation of unstable patients, either alone or in conjunction with the pediatric trauma score.

Table 1. Comparison of pre-transfusion perfusion index averages according to the types of comorbidities

Co-morbidity	Yes/no	n (%)	Perfusion index Mean ± SD	*p value
Malignancy	Yes	17 (30.9)	2.61±1.76	0.500
	No	38 (69.1)	3.27±2.37	
Anemia of chronic disease	Yes	15 (27.2)	2.79±1.55	0.992
	No	40 (72.8)	3.17±2.42	
Hypertension	Yes	13 (23.6)	3.11±2.06	0.774
	No	42 (76.4)	3.06±2.28	
Coronary artery disease	Yes	7 (12.7)	3.90±2.32	0.261
	No	48 (87.3)	2.95±2.19	
Diabetes mellitus	Yes	6 (10.9)	3.72±3.21	0.617
	No	49 (89.1)	2.99±2.09	
Chronic renal disease	Yes	5 (9)	2.08±1.13	0.372
	No	50 (91)	3.17±2.27	
Congestive heart failure	Yes	2 (3.6)	1.45±1.20	0.270
	No	53 (96.4)	3.13±2.22	
Chronic obstructive pulmonary disease	Yes	2 (3.6)	6.65±4.74	0.138
	No	53 (96.4)	2.93±2.03	
Cerebrovascular disease	Yes	1 (1.8)	1.80±1.03	-
	No	54 (98.2)	3.09±2.22	

*Mann-Whitney U test, SD: Standard deviation

In the study, the mean PI of 55 patients before transfusion was 3.07. Although there are not enough studies in the literature reporting the value of PI in the normal population, the mean PI value was found to be 1.4 in a study by Lima et al. [7] in 108 healthy adults with a mean age of 30, but the pulse oximetry used in this study is a different device than ours, but the value it can measure. It has been reported to be between 0.3 and 10.0 [7]. While this value stated in this study was analyzed with data from healthy individuals included in the study, it was taken from patients who applied to the emergency department and needed erythrocyte transfusion in our study. It can be considered that this difference in PI is due to the difference in the device used and the patient groups [7]. Arslan et al. [17] in the study on PI, which included 2.300 patients, the mean PI value was found to be 3.71. In addition, Akben and Topaçoğlu [18] in a study that included 288 patients, the mean PI was found to be 2.9. The fact that the patient selection in all three studies covers different groups and the number of patients; it can be thought that this difference in mean values is caused by this difference. In the literature, precise expressions for the mean PI value could not be found.

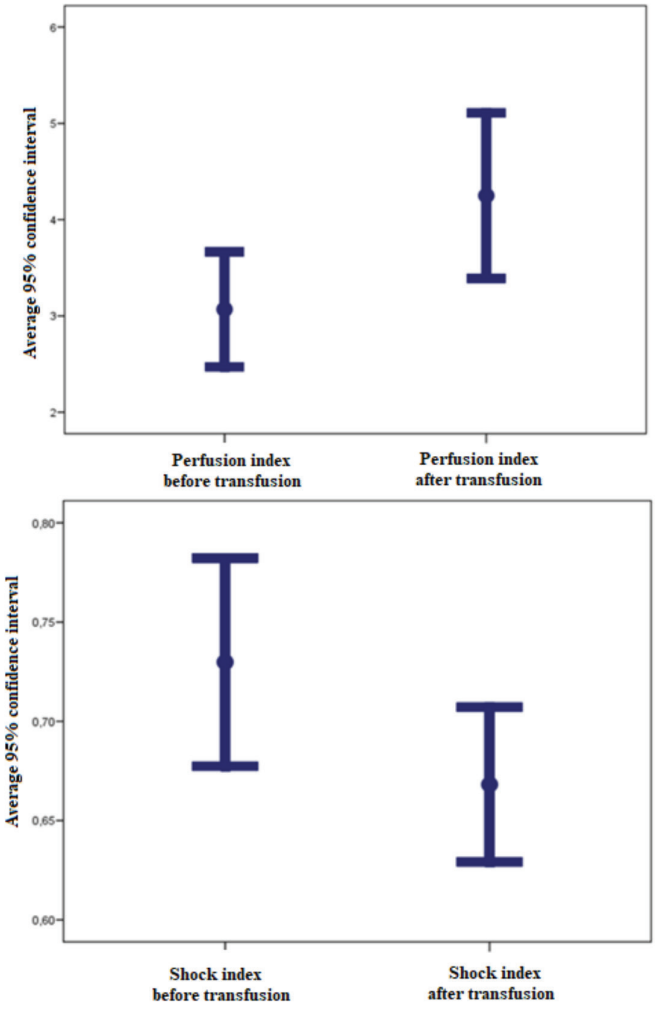

Figure 1. Perfusion index and shock index distribution before and after transfusion

In the study, the mean PI before transfusion was 2.64 in female patients and 3.52 in male patients. There was no statistical relationship between gender and pre-transfusion PI. Although the number and mean age of the female and male patients included in our study were similar, the mean PI of male patients was higher than that of female patients. Akben and Topaçoğlu [18] also found that the mean PI of male patients was higher than the mean PI of female patients, but there was no statistically significant difference. In the study conducted by Arslan et al. [17], which included 2.300 patients, the mean PI of male patients was found to be higher than that of female patients, and a statistically significant difference was found between gender and PI. The fact that there were not as many cases in our study as in the mentioned study may be the reason for this. It would be appropriate to conduct more comprehensive studies to determine whether there is a statistical difference.

In the study by Lima et al. [7], it was shown that PI was not associated with additional diseases such as diabetes and hypertension. In our study, there was no significant relationship between PI measured before transfusion and additional diseases of the patients, which supports this finding.

Table 2. Comparison of changes in patient's parameters with blood transfusion

Parameters	Pre-transfusion Mean ± SD	Post-transfusion Mean ± SD	Difference Mean ± SD	*p value
Hemoglobin (g/dL)	6.4±1.2	9.0±1.2	2.5±1.2	**<0.001**
Hematocrit (%)	21.5±3.6	28.7±3.8	7.3±3.7	**<0.001**
Mean arterial pressure (mmHg)	83.2±11.6	90.0±13.0	6.7±13.3	**<0.001**
Pulse (/min)	87.1±15.1	83.5±10.3	-3.5±11.2	**0.023**
Body temperature (°C)	36.4±1.3	36.8±0.4	0.4±0.5	**0.004**
Saturation (%)	97.7±1.3	97.3±1.7	0.4±1.5	**0.082**
Perfusion index	3.07±2.21	4.25±3.18	1.18±3.14	**0.004**
Shock index	0.73±0.19	0.67±0.14	-0.06±0.15	**0.003**

*t-test independent groups, SD: Standard deviation

Randomized controlled studies are needed to determine whether PI values change in any disease. In addition, it was not determined how long the patients included in the study had these diseases or their stages.

PI is determined by calculating the ratios of pulsatile and non-pulsatile blood flow based on infrared light absorption [10]. The Hct is determined by the ratio of the cellular portion of the blood to the blood volume, and as the number of shaped blood cells increases, so does the Hct value [19]. In our study, a statistically significant positive correlation was discovered between the mean values of Hb and Hct before transfusion and the mean PI values before transfusion. In a similar study, a positive, significant, and strong relationship was observed between blood Hct values and PI [18]. Blood Hb levels are also one of the most significant determinants of Hct. In our study, the positive correlation between pre-transfusion Hb and Hct levels and the pre-transfusion PI may indicate this. In the literature, there was a correlation between the Hb and Hct values of patients and PI, but in our study, there was no correlation between the post-transfusion Hb and Hct values and the post-transfusion mean PI values. The effect of blood transfusions administered to patients on Hb or Hct levels can be interpreted as a small percentage of the overall effects. Patients who participated in the study received a maximum of three ES transfusion units.

While a statistically significant increase was found in the mean MAPs measured before and after blood transfusion in the patients included in the study, a statistically significant decrease was found in the mean pulse and SI. Considering that 50 of the 55 patients included in our study did not have active bleeding, the intravascular volume of these patients may have increased with the transfusion procedure. We believe that this is the reason for the increase in MAP in these patients. As expected, the minute pulse rates of patients whose volumes increased and tissue perfusion improved were also found to be decreasing. Because the SI was calculated as the ratio of heart rate to systolic blood pressure, the SI tended to decrease in patients with increased MAP and decreased heart rate in our study.

Statistically significant increases were found in the mean Hb, Hct, and PI values of the patients included in the study with ES transfusion compared with pre-transfusion. In a study conducted by Tanrıverdi et al. [20] on the effects of erythrocyte transfusion on PI in 132 newborns, it was shown that the PI of newborns whose anemia was corrected with erythrocyte transfusion also increased significantly. In a study by Kanmaz et al. [21] in which they measured PI by administering ES to anemic infants born below 35 weeks of age, PI values increased significantly after transfusion compared with pre-transfusion [21]. However, there was no correlation between PI and Hct values before and after transfusion. The lack of correlation at the same level may be the relatively low increase in blood Hb and Hct levels, as defined above. In addition, it seems possible that this result may be because other studies were not conducted in adults. The definitive conclusion that can be deduced from both studies is the significant increase in the PI with the transfusion procedure.

Study Limitations

The most important limitation was the duration of the study and the relatively small number of cases we included. The uncertainty of the relationship between erythrocyte volume and PI and SI was another limitation of our study.

Conclusion

The rise in the PI during the transfusion process is anticipated to be primarily influenced by the elevation of Hb and Hct levels. This finding is supported by the identification of a statistically significant positive correlation between the initial PI value and the corresponding Hct and Hb values before transfusion. The procedure of transfusing ES leads to a notable rise in the average values of MAP, Hb, Hct, and body temperature post-transfusion, in comparison with the pre-transfusion levels. Additionally, there was a significant decrease in the average values of pulse and SI following the transfusion. A statistically significant positive association exists between the mean values of Hb and Hct and the mean PI values before transfusion. Because of the study, significant changes in PI and SI values during the pre-and post-transfusion process showed that they are parameters that can be used in transfusion, especially in the evaluation of treatment response.

Ethics

Ethics Committee Approval: The study was conducted with the permission of the University of Health Sciences Turkey, İstanbul Training and Research Hospital Clinical Research Ethics Committee (date: 09.01.2015, decision no: 569).

Informed Consent: The study participants who volunteered were provided with information and subsequently acquired written and verbal consent.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Concept: M.O.A., H.T., B.D., N.A., B.A., A.C., Design: M.O.A., H.T., B.D., N.A., B.A., A.C., Data Collection or Processing: M.O.A., H.T., B.D., N.A., B.A., A.C., Analysis or Interpretation: M.O.A., H.T., B.D., N.A., B.A., A.C., Literature Search: M.O.A., H.T., B.D., N.A., B.A., A.C., Writing: M.O.A., H.T., B.D., N.A., B.A., A.C.

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