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ORIGINAL RESEARCH

Acute Serum Calcium Level Changes Following Non-Massive Blood and Blood Product Transfusion in Emergency Department; a Cross-sectional Study

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Abstract: **Introduction:** The specific impact on calcium dynamics after non-massive blood transfusions remains relatively unexplored. This study aimed to compare pre- and post-transfusion calcium levels in patients receiving blood and blood product in the emergency department. **Methods:** This is a single-center, prospective, cross-sectional study conducted at the Emergency Department of Gazi University Health Research and Application Center Hospital in Ankara, Turkey, from January 1, 2020, to August 31, 2020. The study included adult patients who underwent blood and blood product transfusions, and serum calcium levels were measured and compared from samples taken before and after transfusion. **Results:** A total of 292 participants were enrolled in the study, with 242 participants included in the final analysis. The mean total calcium level was 8.41 ± 0.76 mg/dL before transfusion and 8.34 ± 0.71 mg/dL after transfusion (p=0.012). When examining the corrected calcium values after receiving blood products based on the type of blood products, participants who received apheresis platelets had a post-transfusion corrected calcium value of 8.26 ±0.41 mg/dL, with a pre-transfusion value of 9.09 ±0.49 mg/dL (p<0.01). The post-transfusion ionized calcium value for participants receiving apheresis was 1.04 ±0.08 mg/dL, compared to 1.15 ±0.09 mg/dL for those who did not receive apheresis (p=0.049). There was a significant relationship between receiving fresh frozen plasma and post-transfusion ionized calcium values (p=0.024). **Conclusion:** This study demonstrated that transfusion-associated hypocalcemia can occur even at mild levels in patients receiving blood and blood product transfusions in the emergency department. However, it is suggested that the clinical effects of hypocalcemia, even when occurring based on the type and quantity of blood products, are minimal and negligible.

Keywords: Blood component transfusion; Blood transfusion; Hypocalcemia; Emergency service, Hospital

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1. Introduction

For more than 50 years, blood and blood product transfusion has played a crucial role in modern medicine, becoming an increasingly prevalent treatment, especially for trauma patients and the elderly (1). The growing elderly demographic, coupled with the success of treatments in areas like organ transplantation and cancer therapies, has heightened the demand for blood and its components (1, 2). Calcium is an ion frequently subject to irregularities in critical patients. Blood transfusion procedures can also lead to a reduction in blood calcium levels (3). Components such as citrate, phosphate, dextrose, and adenine are used in many blood components to chelate calcium. Ionized calcium levels can significantly decrease even after receiving small amounts of blood products (4). Calcium plays a vital role in coagulation, but hypocalcemia is commonly observed after massive transfusion, often associated with citrate and calcium chelation (5). Despite the knowledge of all these factors, there is limited literature on whether transfusion-associated hypocalcemia occurs and, if so, whether it has clinically significant effects in patients receiving blood and blood product transfusions in the emergency department. The existing studies are often retrospective and/or involve a limited number of patients. The investigation into the alterations in calcium levels following non-massive transfusions has encountered a notable dearth of evidence. Despite the significant attention given to transfusion-related research, the specific impact on calcium dynamics after non-massive transfusions remains relatively unexplored (6, 7). The scarcity of

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available data poses a challenge in comprehensively understanding the intricate interplay between blood transfusions and calcium homeostasis. Addressing this gap in knowledge is crucial for advancing our understanding of the physiological consequences associated with non-massive transfusions and for informing clinical practices. Furthermore; the uncertainties surrounding calcium level fluctuations following non-massive transfusions underscore potential risks for patients (8). Calcium plays a pivotal role in various physiological processes, including blood clotting, muscle function, and nerve transmission. Any alterations in its levels may have cascading effects on these vital functions. Insufficient research on the consequences of calcium changes after non-massive transfusion raises concerns about the potential impact on patient health (7). The lack of a comprehensive understanding of these risks poses challenges for clinicians in optimizing transfusion practices to mitigate adverse outcomes. Ascertaining the precise implications of calcium fluctuations in the context of non-massive transfusions is paramount for tailoring transfusion strategies to individual patient needs and ensuring the overall safety and well-being of those undergoing such medical interventions. Our primary aim with this study was to compare pre- and post-transfusion calcium levels in patients receiving blood and blood products in the emergency department. By addressing the issue of transfusion-associated hypocalcemia in the specific context of emergency department patients receiving blood and blood product transfusions, we intended to determine the occurrence of transfusion-associated hypocalcemia and also its clinical significance in acute care setting. By conducting a prospective, cross-sectional analysis, we captured real-time data on ionized calcium levels before and after transfusions, allowing for a nuanced understanding of the changes associated with different blood products.

2. Methods

2.1. Study design and setting

This study is a single-center prospective cross-sectional research designed to investigate calcium levels changes in patients who presented to an emergency department of University Hospital in Ankara, Turkey, and received blood and blood product transfusions during 1st January 2020 – 31st August 2020. Sample size calculations based on previous studies revealed that 252 patients were required for 95% confidence interval. Through a preliminary pilot research, it was found that 54 units of blood and blood products were transfused to 45 patients in the department in October 2019. After the COVID-19 pandemic cases were seen in our country in March, there was a significant change in the number of emergency room applications. While there was an average of 5500-6500 patient applications per month to our emergency department before the pandemic, this number decreased to 2500-3000 per month during the pandemic. Based on this information, 300 patients were expected to be included during the 8-month study period. The study was approved by Gazi University Clinical Research Ethics Committee (264/09.12.2019). Informed consent form was obtained from all patients. The case report form was filled out by investigators not responsible for the patient's treatment. All methods were carried out in accordance with relevant guidelines and regulations, such as The Declaration of Helsinki, The Belmont Report, Council for International Organizations of Medical Sciences (CIOMS) Guidelines, and the International Conference on Harmonization in Good Clinical Practice (ICH-GCP). The right to not participate in the study was communicated to the patients, and the responses on the case report form were kept confidential and not shared with anyone other than the researchers.

2.2. Participants

All adult patients (18 years and older) who underwent blood and blood product transfusions in the emergency department of Gazi University Hospital, Turkey, for any reason during the study period and agreed to participate by signing the informed consent form were included in the study. Patients with known hypocalcemia, chronic kidney failure, chronic pancreatitis, vitamin D deficiency, magnesium deficiency, hypoparathyroidism, malignancies, alcoholism, massive blood transfusion, malabsorption, and/or those undergoing related treatments, patients under 18 years of age, and those unwilling to participate in the study were excluded.

2.3. Study protocol

In the Gazi University Hospital Emergency Department, all patients are primarily visited and assessed by emergency resident doctors under supervision of consultant emergency specialist. After completion of medical history taking and physical examinations, the differential diagnoses are defined and the blood tests and necessary initial treatments and/or consultations are ordered/done by emergency resident doctors together with consultant physicians. Within these steps, if differential/primary diagnosis include gastrointestinal or external bleeding, related blood tests (including venous blood gas analysis and blood cross match) are routinely ordered from the first veno-puncture blood taken from the patient. The need and the time for blood and blood products transfusions are decided primarily by consultant physician. According to our study protocol, when there was suspected bleeding in the ED patient based on the opinion of the primary physician, the patient was taken as a candidate case for our study and the researchers were informed. If the primary physician decided to transfuse blood and blood products to the patient, the researcher previously informed contacted the patient and/or primary care givers, informed them about the study and requested permissions and asked them to sign of informed consent. To ensure standardization in our study, researchers who had been working in the emergency department for at least 2 years, were informed about the study protocol, and a practical training session lasting 3

hours was provided for taking medical histories, conducting physical examinations, and identifying signs/symptoms related to the study. The study did not involve randomization. Patients underwent blood gas analysis for ionized calcium levels (determined using ABL800 Basic Analyzer®) from approximately 1 cc of blood obtained from venous catheter introduced or veno-puncture done (generally from upper extremity peripheral veins) for routine blood tests taken before and after transfusion within the emergency department. The control calcium levels were determined (using Siemens ADVIA Chemistry XPT System Analyzer®) for patients both before and after the transfusion process was completed. Ionized calcium values were calculated.

2.4. Data gathering

The patients' symptoms and complaints were determined by interviewing the patients and/or their relatives before and after transfusion. The findings were recorded in the study form by emergency research assistant doctors who had received the specified training. The physical examination before transfusion was performed when the patient was taken to the examination room at the time of admission, and after transfusion, it was conducted within 15 minutes of completing the transfusion process. To avoid inconsistencies and increase the reliability of subjective data, the symptoms, complaints, and findings recorded by the physician responsible for the patient's diagnosis and follow-up in the official emergency department file were compared with the study form data before the patient was discharged from the emergency department. In case of discrepancies, the treating physician was consulted, examinations were repeated if necessary, and the study form data were revised through consulting with the faculty physician involved in the study. Patients included in our study underwent physical examinations in the same manner and on time, regardless of their outcomes. Since our study was conducted under emergency room conditions, data collection continued 24 hours a day, 7 days a week throughout the study period.

2.5. Outcomes

The outcome was to determine whether hypocalcemia develops in patients who present to the emergency department and receive blood and blood products.

2.6. Statistical analysis

A statistical package program, SPSS 20.0, was utilized for the statistical analysis of research data. Descriptive findings in the statistical analysis section were presented as numbers and percentages for categorical variables, and as mean ± standard deviation and median (min, max) for continuous variables. The normal distribution of continuous variables was assessed visually (histograms and probability plots) and analytically (Kolmogorov-Smirnov/Shapiro-Wilk tests). The presence of frequency differences among groups for categorical variables was evaluated using chi-square test. McNemar's test was employed for the comparison of categorical variables within dependent groups. For dependent groups, paired t-test was used to compare known normally distributed variables, while the Wilcoxon test was used for non-normally distributed variables. Descriptive analyses were conducted, comparing groups using Student's t-test and analysis of variance (ANOVA) for parameters with known normal distribution. For parameters with a non-normal distribution, the Mann-Whitney U test was used for group comparisons. In cases where there was a significant difference between groups, pairwise comparisons were done using Tukey and Tamhane tests for normally distributed measurement-indicated variables. The level of statistical significance in this study was accepted as $p<0.05$.

3. Results

3.1. Baseline characteristics of studied cases

A total of 292 participants were initially enrolled. However, after excluding those who did not provide informed consent, those with missing laboratory results, those lacking information, and etc., a total of 242 cases with the mean age of 67.26 ± 16.93 (range 18-99) years (57.4% male) were included in the study (figure 1). Baseline characteristics as well as outcome of included cases are presented in table 1. The most frequent indications of transfusion were anemia (76.8%) and shock due to bleeding (24.8%). Table 2 shows the indication of transfusion based on different blood products. Red blood cell suspension was most commonly administered for anemia (80.6%), fresh frozen plasma (FFP) was most frequently given for factor deficiency (60.9%), apheresis was predominantly used for thrombocytopenia (83.3%), and pooled platelet concentrates were most commonly utilized for thrombocytopenia (75.0%).

Comparing the signs and symptoms as well as laboratory parameters before and after transfusion are presented in Table 3. Analysis of signs and symptoms revealed improvements after blood product transfusion. Among 44 participants with hypotension before receiving blood products, hypotension was resolved in 26 (59.1%) after receiving blood products ($p<0.001$). Similarly, among 41 participants who reported dizziness before receiving blood products, dizziness was completely resolved in 19 (46.3%) after receiving blood products ($p<0.001$). Among 123 participants who had reported weakness before receiving blood products, weakness was alleviated in 49 (39.8%) after receiving blood products ($p<0.001$). 9 (3.7%) cases died (6 hemorrhagic shock, and 3 sepsis) in the ED during their course of treatment.

3.2. Analysis of calcium levels before and after transfusion

Table 4 compares the total and ionized calcium levels before and after transfusion based on demographic and transfusion characteristics of participants. Pre-transfusion, mean total calcium level was 8.41 ±0.76 mg/dL, showing a slight

decrease to 8.34 ±0.71 mg/dL in the post-transfusion phase (p=0.012). Participants who underwent apheresis had significantly lower post-transfusion corrected calcium values compared to those who did not undergo apheresis (8.26 ± 0.41 mg/dL vs. 9.09 ± 0.49 mg/dL; p<0.01). The ionized calcium values after receiving blood products were also significantly lower in participants who underwent apheresis compared to those who did not (1.04 ± 0.08 mmol/L vs. 1.15 ± 0.09 mmol/L; p=0.049). Additionally, a significant relationship was observed between receiving fresh frozen plasma and post-transfusion ionized calcium values (p=0.024). The mean ionized calcium level for participants not receiving FFP was 1.16 ±0.11 mmol/L in the whole study group, while those receiving 1 unit, 2 units, 3 units, and 4 units or more had mean ionized calcium values of 1.16 ±0.25 mmol/L, 1.13 ±0.09 mmol/L, 1.02 ±0.05 mmol/L, and 1.01 ±0.05 mmol/L, respectively (p = 0.024). The extent of hypocalcemia was notably influenced by both the type and quantity of administered blood products as significant hypocalcemia was seen for FFP (when transfused 3 units) and platelet apheresis, but not pooled platelet and/or erythrocyte suspension. The mean corrected calcium value for male participants in the post-transfusion measurement was 9.01 ±0.53 mg/dL, while for female participants, it was 9.16 ±0.48 mg/dL (p=0.030). The mean corrected calcium value for participants with comorbid diseases in the post-transfusion measurement was 9.10 ±0.52 mg/dL, whereas for those without comorbidities, it was 8.76 ±0.39 mg/dL (p=0.004).

4. Discussion

The primary findings of our study include a significant decrease in mean total calcium levels in the post-transfusion phase compared to pre-transfusion. Notably, participants undergoing apheresis exhibited significantly lower post-transfusion corrected calcium values compared to those without apheresis. Moreover, ionized calcium values post blood product transfusion were significantly reduced in participants undergoing apheresis compared to those who did not and a noteworthy association was identified between the administration of fresh frozen plasma and post-transfusion ionized calcium values. Additionally, participants with comorbid diseases exhibited a higher mean corrected calcium value in the post-transfusion measurement compared to those without comorbidities. While red blood cell suspension was the most commonly infused blood product in our department, it is noteworthy that, although males required more transfusions than females, sex did not exert a significant impact on ionized calcium values after transfusion. In the literature, there are numerous studies demonstrating that citrate used in the preservation and storage of blood products can lead to transfusion-related hypocalcemia. In a study conducted in 1971 on patients undergoing rapid blood transfusion under anesthesia, a decrease in ionized calcium levels was observed. Although factors such as body temperature, serum pH, and protein concentration are known to affect ionized calcium levels, it has been reported that the observed changes in calcium levels during rapid blood transfusion are primarily a result of citrate in blood products binding to ionized calcium (9). Looking at more recent studies, an article on complications of blood transfusions mentioned that while citrate levels are low in red cell suspensions, there is a higher concentration of citrate in fresh frozen plasma and platelet suspensions, and this citrate binds to calcium, reducing ionized calcium levels in plasma (10). In a study involving major trauma patients receiving blood in the emergency department, the average pre-transfusion ionized calcium level was 1.11 mmol/l, and post-transfusion ionized calcium levels were observed to be 0.98 mmol/l (4). Citrate-associated hypocalcemia has been the subject of many studies for years. These studies have shown that citrate, especially in patients undergoing massive blood transfusion, binds to ionized calcium, leading to a decrease in serum ionized calcium values. While whole blood products were more commonly used in older studies, current studies have replaced them with specific blood products. Moreover, these studies were predominantly conducted on trauma-related blood transfusions. In our study, participants received blood and blood products mainly for non-trauma-related reasons. Therefore, although there was a decrease in transfusion-related calcium values in our study, this decrease did not reach a significant level in ionized and corrected calcium values. The decrease in uncorrected calcium values is statistically significant, but the average corrected calcium values with albumin are within normal range before and after transfusion. Our participants were generally elderly and vulnerable due to comorbidities, and their albumin levels were low. This may explain why corrected calcium values remain within the normal range despite low total calcium values. In our study, although there were no significant changes in calcium values in patients who received pooled platelet transfusions, there was a significant decrease in ionized calcium values in patients who received 4 units or more of fresh frozen plasma (FFP) transfusion, especially when compared to those who did not receive FFP transfusion. We believe that this is due to high-volume citrate exposure and hemodilution. The study comparing the calcium content of whole blood and FFP in terms of their impact on ionized calcium levels revealed that FFP was more effective in decreasing ionized calcium levels compared to platelet suspensions (11). The results indicated that an increase in the amount of FFP units administered in the study led to a greater decrease in ionized calcium levels. Among the reasons cited were the larger volume of FFP units (300 ml) compared to platelet suspensions (50 ml) and the higher citrate content, which resulted in a greater binding of calcium (12). It is important to note that in the emergency department, particularly in patients receiving 4 units or more of rapid FFP transfusion, caution should be exercised regarding ionized calcium values, and frequent monitoring of ionized calcium is recommended for early intervention. In our study, participants who received aphere-

sis platelets showed a post-transfusion decrease in corrected calcium and ionized calcium levels. Apheresis platelets have a larger volume compared to pooled platelets. While the volume of apheresis platelets ranges from 200 to 500 ml, pooled platelets have a volume ranging from 40 to 60 ml, and approximately 5 units of pooled platelets are equivalent to 1 unit of apheresis platelets. Consequently, patients receiving apheresis platelet transfusions are exposed to a higher volume load and a greater amount of citrate. This situation can lead to hemodilution and a decrease in calcium values related to citrate. In a retrospective study in the United States focusing on post-massive blood transfusion hypocalcemia in trauma patients, a significant decrease in ionized calcium levels was observed, particularly in patients receiving platelet suspensions. This phenomenon was associated with hemodilution and citrate administration following massive blood transfusion (5, 13). In our study, we observed a decrease in calcium levels in participants receiving apheresis platelets. In the emergency department, especially in elderly patients, even those with low-volume blood transfusions, there should be consideration for the potential development of hemodilutional and citrate-related hypocalcemia.

When comparing the corrected calcium values after blood product transfusion based on comorbidities, participants with comorbidities had a higher average corrected calcium value after transfusion compared to those without comorbidities. The difference in calcium levels can be attributed to various factors such as medication use related to comorbid conditions, senility, and dietary factors. A study conducted in a university emergency department in Switzerland involving 8270 patients revealed that calcium disorders in the emergency department can vary according to many factors, especially in the geriatric population, where calcium metabolism disorders are more commonly observed. Both hypocalcemia and hypercalcemia in the emergency department have been shown to be associated with increased mortality. The most common cause of hypocalcemia in the emergency department was reported to be post-thyroidectomy, while hypercalcemia was associated with malignancy (14). In our study, the predominance of the geriatric population and the presence of numerous comorbidities align with the existing literature and provide guidance on the differences in patients' calcium levels.

In our study, 92% of patients received red blood cell suspension as a blood product. In a study conducted on patients receiving blood and blood product transfusions in the emergency department in our country, it was reported that 72% of patients receiving blood product transfusion received red blood cell suspension, 60% received fresh frozen plasma, and 1% received platelet transfusion (15). When examining studies conducted in Europe, a study in a university emergency department in the UK, focusing on the frequency of blood product transfusions, indicated that the most frequently used blood products in the emergency department were red blood cell suspension, fresh frozen plasma, and platelet suspensions, respectively (16). Similarly, a retrospective study conducted at a university hospital transfusion service in Germany revealed that over a 2-year period, 88% of transfused blood products were red blood cell suspension, 78% were fresh frozen plasma, and platelets were also transfused (17). Despite variations in transfusion indications, our study's results align with similar literature, reinforcing the commonality of red blood cell suspension, fresh frozen plasma, and platelet suspension use in emergency departments.

Our findings indicated that males required more transfusions than females, aligning with a consistent prevalence of males in emergency department transfusion studies (18-21). On the other hand, sex did not significantly impact ionized calcium values after transfusion in our study, and no age group differences were observed in post-transfusion calcium values. Similar results were found in a Malaysian study on ionized calcium limitations in critically ill patients (22). Factors such as underlying diseases, medication use, and transfusion specifics may contribute to lower calcium levels in males.

4.1. Limitations

First and foremost, due to the single-center nature of our study, it is not possible to generalize our study results. The exclusion of pediatric and pregnant patients is one of the limitations of our study. Including these patients could have increased both the sample size and potentially altered the results. The participants' history of chronic illnesses related to blood transfusions and previous blood transfusion experiences were not thoroughly investigated in our study. Not including patients with known hypocalcemia disorders, chronic kidney failure, chronic pancreatitis, vitamin D deficiency, magnesium deficiency, hypoparathyroidism, malignancies, alcoholism, massive blood transfusion, malabsorption, or those undergoing treatment for these conditions has limited the study's scope. Another limitation of our study is the absence of patients who underwent massive blood transfusion or had indications for massive blood transfusion. The outcomes of our participants were only assessed for the emergency department, and patients were not followed up afterward. Therefore, there are no short-term and long-term outcomes for the patients in our study. Conducting multicenter studies with a larger portion of the population could increase the number of these patients and provide more comprehensive results.

5. Conclusions

The participants, predominantly geriatric with comorbidities and multiple medications, showed mild variations in calcium levels influenced by age, sex, comorbidities, and medication use. Despite observable changes in symptoms before and after transfusion, post-transfusion hypocalcemia did not significantly affect the clinical conditions of the patients, resulting in a low rate of complications. Notably, the type and quantity of blood products administered influenced the de-

gree of hypocalcemia, with greater reductions seen in patients receiving fresh frozen plasma and platelet apheresis compared to other blood products. The study underscores that while transfusion-associated hypocalcemia may occur, its clinical implications are minimal, emphasizing the overall safety of blood transfusions in the emergency setting.

6. Declarations

6.1. Acknowledgments

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6.2. Competing interests

The authors declare that they have no competing interests.

6.3. Funding

None.No funding was received for this study.

6.4. Authors' contribution

HEK, BY, SK and MAK designed the study and developed the protocol. HEK, and BY were responsible for data collection. HEK, BY, SK and MAK were responsible for data analysis. HEK, BY and SK wrote the manuscript. HEK, BY, SK and MAK provided final approval of this version to be published. HEK and MAK agree to be accountable for all aspects of the work. All authors read and approved the final manuscript.

6.5. Data availability

The data are not available for public access because of patient privacy concerns, but they are available from the corresponding author upon reasonable request.

6.6. Ethics approval and informed consent

This study was approved by the ethics committee of the Faculty of Medicine, Gazi Hospital, Gazi University (264/09.12.2019). All methods were carried out in accordance with relevant guidelines and regulations, such as The Declaration of Helsinki, The Belmont Report, CIOMS Guidelines, and the International Conference on Harmonization in Good Clinical Practice (ICH-GCP). Informed consent was obtained from all participants/patients.

6.7. Using artificial intelligence chatbots

None.

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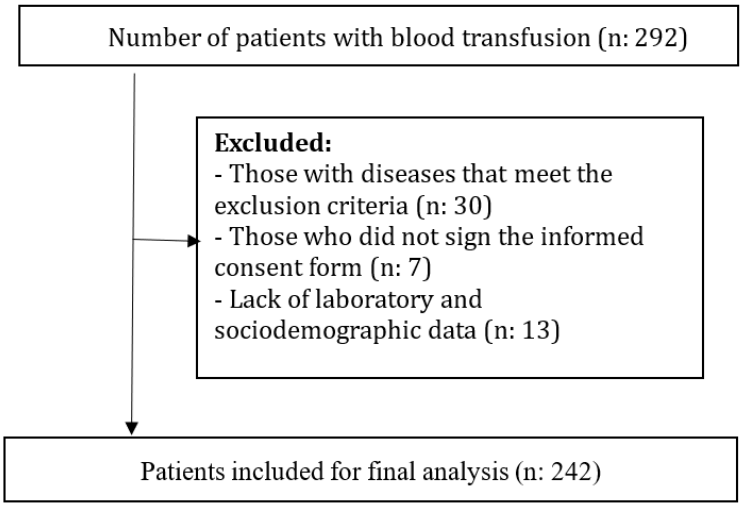

Figure 1: Flowchart of patients' inclusion in the study.

Table 1: Baseline characteristics as well as outcomes of participants (n = 242)

Characters	Values	Characters	Value
Age (year)		**Sex**	
Mean ± SD	67.3 ± 16.9	Male	139 (57.4)
Comorbid disease		Female	103 (42.6)
Hypertension	92 (38.1)	**Amount of blood product**	
Diabetes mellitus	53 (21.9)	Mean ± SD	3.88 ± 1.75
Atrial fibrillation	17 (7.0)	**Cause of transfusion**	
Chronic obstructive lung disease	16 (6.6)	Trauma	47 (19.5)
Asthma	14 (5.7)	Non-trauma	195 (80.5)
Heart failure	12 (4.9)	**Sign and symptom**	
Chronic liver disease	9 (3.7)	Weakness	123 (58.8)
Others	55 (22.7)	Hypotension	44 (18.2)
Type of blood product		Dizziness	41 (16.9)
Platelet	4 (1.7)	Heart failure symptoms	29 (12.0)
Apheresis	6 (2.5)	Palpitations	14 (5.8)
Erythrocyte suspension	223 (92.1)	Paresthesia	7 (2.9)
Fresh frozen plasma	23 (9.5)	Chvostek	1 (0.01)
Outcome		Trousseau	1 (0.01)
Discharge	149 (61.5)	Muscle spasm	1 (0.01)
Service hospitalization	41(16.9)	**Indication of transfusion**	
ICU hospitalization	33 (13.6)	Anemia	186 (76.8)
Discharge against medical advice	10 (4.1)	Bleeding (shock)	60 (24.8)
Dead in emergency department	9 (3.7)	Factor deficiency	17 (7.0)
		Thrombocytopenia	11 (4.5)

Data are presented as mean ± standard deviation (SD) or frequency (%). ICU: intensive care unit.

Table 2: Indications of blood and blood products transfusion for studied cases

Indication	Erythrocyte#	FFP	Apheresis	Platelet *
Anemia	179 (80.6)	3 (13.0)	2 (33.3)	2 (50.0)
Factor deficiency	3 (1.4)	14 (60.9)	0 (0.0)	0 (0.0)
Bleeding shock	47 (21.2)	12 (52.2)	1 (16.7)	0 (0.0)
Thrombocytopenia	3 (1.4)	0 (0.0)	5 (83.3)	3 (75.0)

Data are presented as frequency (%). #: Erythrocyte suspension; *: Pooled Platelet Concentrates;
FFP: Fresh Frozen Plasma.

Table 3: Comparison of patients' signs and symptoms as well as their laboratory parameters before and after blood transfusion (n = 242)

Values	Transfusion		P value
	Before	After	
Signs and symptoms	n (%)	n (%)	
Weakness	123 (58.8)	75 (31.0)	<0.001
Hypotension	44 (18.2)	20 (8.3)	<0.001
Dizziness	41 (16.9)	23 (9.5)	<0.001
Heart failure symptoms	29 (12.0)	21 (8.7)	0.077
Palpitations	14 (5.8)	12 (4.9)	0.687
Paresthesia	7 (2.9)	7 (2.9)	1
Chvostek	1 (0.01)	1 (0.01)	1
Trousseau	1 (0.01)	1 (0.01)	1
Muscle spasm	1 (0.01)	2 (0.01)	1
Laboratory parameters			
pH	7.38 ±0.08	7.38 ±0.08	0.609
Sodium (mEq/L)	136.04 ±6.19	137.16 ±5.93	<0.001
Potassium (mEq/L)	4.26 ±0.71	4.22 ±0.70	0.304
Albumin (gr/dL)	3.25 ±1.74	3.08 ±0.65	0.117
BUN (mg/dL)	29.65 (6-169)	29.00 (5-172)	0.005
Creatinine (mg/dL)	1.03 (0.23-14.20)	1.02 (0.23-20.40)	0.031
PT (sec)	16.40 (1.6-167.0)	16.35 (12.0-157.0)	0.853
PTT (sec)	28.75 (12.3-153.0)	29.25 (13.0-288.1)	0.026
INR	1.21 (0.74-100.00)	1.22 (0.80-100.00)	0.775
Serum calcium changes			
Total (mg/dL)	8.41 ±0.76	8.34 ±0.71	0.012
Ionized (mmol/L)	1.16 ±0.10	1.15 ±0.11	0.077
Corrected (mg/dL)	9.09 ±0.57	9.07 ±0.51	0.442
Hypocalcemia; n (%)	118 (48.8)	132 (54.5)	-

Data are presented mean ± standard deviation. frequency (%), or median (minimum-maximum).
BUN: blood urea nitrogen; PT: prothrombin time; PTT: partial thromboplastin time; INR: international normalized ratio.

Table 4: Comparison of calcium level before and after blood or blood product transfusion based on different demographic characteristics and type of transfused material

Variable	Corrected calcium level		P value	Ionized calcium level		p-value
	Before	After		Before	After	
Sex						
Male (n=139)	9.02 ± 0.59	9.01 ± 0.53	0.8819	1.16 ± 0.10	1.14 ±0.12	0.1323
Female	9.19 ± 0.52	9.16 ± 0.48	0.6675	1.16 ± 0.12	1.16 ±0.10	1.0000
P value	0.074	0.03		0.924	0.126	
Age group (year)						
< 65 (n=81)	8.99 ± 0.62	8.96 ± 0.53	0.7411	1.15 ± 0.11	1.14 ±0.12	0.5811
65-84 (n=136)	9.17 ± 0.53	9.12 ± 0.51	0.4286	1.17 ± 0.11	1.15 ±0.11	0.135
85 (n=25)	9.08 ± 0.59	9.16 ± 0.49	0.6044	1.19 ± 0.08	1.19 ±0.09	1.0000
P value	0.954	0.057		0.229	0.116	
Comorbid disease						
Yes (n=147)	9.12 ± 0.58	9.10 ± 0.52	0.7558	1.16 ± 0.10	1.15 ± 0.10	0.392
No (n=95)	8.85 ± 0.41	8.76 ± 0.39	0.1228	1.16 ± 0.10	1.12 ± 0.18	0.0598
P value	0.565	0.004		0.857	0.168	
Drug use						
Yes (n=171)	9.13 ± 0.53	9.10 ± 0.52	0.5976	1.17 ± 0.11	1.15 ± 0.10	0.0794
No (n=71)	9.01 ± 0.67	8.99 ± 0.50	0.8405	1.15 ± 0.12	1.14 ± 0.13	0.6346
P value	0.967	0.164		0.334	0.298	
Type of transfused material						
Platelet (n=4)	9.24 ± 0.63	9.25 ± 0.43	0.9799	1.21 ± 0.04	1.22 ± 0.06	0.7908
Apheresis (n=6)	9.09 ± 0.49	8.26 ± 0.41	0.0098	1.15 ± 0.09	1.04 ± 0.08	0.049
Erythrocyte suspension						
1 unit (n=83)	9.08 ± 0.62	9.09 ± 0.52	0.9105	1.17 ± 0.12	1.16 ± 0.13	0.6073
2 units (n=105)	9.16 ± 0.55	9.09 ± 0.51	0.34	1.17 ± 0.09	1.15 ± 0.11	0.1508
3 units (n=29)	8.94 ± 0.52	8.99 ± 0.44	0.1439	1.16 ± 0.07	1.15 ± 0.07	0.5886
4 units (n=6)	8.81 ± 0.52	8.70 ± 0.70	0.7637	1.13 ± 0.06	1.13 ± 0.09	1.0000
P value	0.483	0.262		0.849	0.846	
Fresh Frozen Plasma						
1 unit (n=2)	8.67 ± 1.06	8.77 ± 1.25	0.9391	1.12 ± 0.19	1.16 ± 0.25	0.8736
2 units (n=11)	9.05 ± 0.64	9.08 ± 0.73	0.9194	1.16 ± 0.17	1.13 ± 0.09	0.6106
3 units (n=7)	9.06 ± 0.33	8.98 ± 0.46	0.715	1.12 ± 0.08	1.02 ± 0.05	0.0159
4 units or more (n=3)	9.32 ± 0.40	9.03 ± 0.21	0.3285	1.14 ± 0.06	1.01 ± 0.05	0.0449
P value	0.677	0.936		0.952	0.024	

Data are presented as mean ± standard deviation (SD).