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Original article

Outcome of 1:1:1 Transfusion Ratio of Blood Products in Critical Bleeders Either Traumatic, Medical or Surgical

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Abstract:

Background: Blood transfusion is a critical intervention in the management of patients with severe bleeding. However, the optimal ratio of blood products to be transfused remains a topic of debate. Aim: to evaluate the outcomes of using a 1:1:1 blood transfusion ratio in patients with critical bleeding and compare its effectiveness and safety with other ratios. **Patients and Methods:** patients admitted to the intensive care unit (ICU) at Benha University hospitals due to critical bleeding were included in this observational study. **Results:** The mean age of the patients was 41 ± 14 years, with equal gender distribution. Non-traumatic causes accounted for the majority (66%) of hemorrhagic shock cases. The analysis showed no significant differences in age, gender, or cause of hemorrhagic shock when classifying patients based on 24-hour mortality. However, non-survivors had significantly higher shock index values and longer hospital stays compared to survivors. When classifying patients based on 30-day mortality, non-survivors had a higher proportion of traumatic causes and received more red blood cell transfusions than survivors. There were positive correlations between the length of stay in the intensive care unit and blood product administration (red blood cells, fresh frozen plasma, and cryoprecipitate), as well as the shock index. **Conclusion:** the study highlights the importance of the shock index as a predictor of mortality in hemorrhagic shock patients. It also emphasizes the impact of factors such as shock severity, blood product administration, and the nature of the underlying cause on patient outcomes.

Key words: Transfusion ratio 1:1:1; hemorrhagic shock MTP; Fixed transfusion ratio.

Introduction

Massive transfusion is a crucial intervention for managing critical bleeding, which can occur in trauma, surgery, and obstetric cases. It involves the transfusion of large amounts of blood components, including red blood cells (RBCs), fresh frozen plasma (FFP), platelets, and cryoprecipitate. (1)

The MTP follows a standardized approach, typically using fixed ratios of these components, to restore volume, hemostasis, and oxygen delivery. Different criteria exist for defining massive transfusion, such as the number of RBC units transfused or the replacement of a specific volume of blood within a certain time frame. (2)

The timing and dosage of blood component therapy may be guided by laboratory tests or point-of-care testing. Recent observational data suggest that higher ratios of FFP to RBCs and platelets to RBCs are associated with better clinical outcomes in patients with trauma and critical bleeding. (3) However, there is a limited number of interventional studies comparing different ratios of blood components in the management of major bleeding, particularly in trauma cases. (4)

The objective of this study was to evaluate the effects of a high fixed transfusion ratio (1:1:1) of plasma, platelets, and red blood cells (RBCs) in patients with various types of critical non-traumatic and traumatic hemorrhage. The study also aimed to examine the associations between transfusion ratios and clinical outcomes.

Patients and Methods

This study was conducted as an observational study in the intensive care unit (ICU) in 50 patients of Benha University Hospitals. The study spanned a period of eight months, from May 1 to December 31, 2022. The study population included adult patients aged 18 years and older who presented with massive bleeding and required massive blood transfusion or experienced acute complications like hypovolemic shock. Patients with gynecological and obstetric cases were excluded from the study. The study obtained informed consent from the participants or their relatives and was approved by the ethics committee {M.S.23.2.2022}.

The study involved assessment of the effects of a high fixed transfusion ratio (1:1:1) of plasma, platelets, and red blood cells (RBCs) in patients with different types of critical non-traumatic and traumatic hemorrhage. Various parameters were evaluated, including the patients' age, shock index, ABC score for trauma assessment, critical administration threshold (CAT) criteria for bleeding severity, presence of comorbidities, anticoagulant therapy, Glasgow Coma Scale (GCS), vital signs, capillary refill time, central venous pressure (CVP), urine output (UOP), and various laboratory and radiological investigations. Additionally, scoring systems such as the Assessment of Blood Consumption (ABC) score and CHILD score were utilized to predict the need for massive transfusion and assess hepatic and upper GI bleeding, respectively.

The progress of each patient who received the high fixed transfusion ratio was closely monitored, documenting improvements, achievement of hemostasis, deterioration, or the need for intubation. The study also examined the impact of the transfusion ratio on overall mortality and 24-hour mortality.

ROC analysis was done for the shock index to predict 24-h mortality, it revealed that the best cutoff was > 4.2, at which sensitivity and specificity were 90.9% and 100%, respectively. For 30-day mortality, it revealed that the best cutoff was > 4.2, at which sensitivity and specificity were 83.3% and 100%, respectively.

Statistical analysis

Data management and statistical analysis for the study were conducted using SPSS version 28. Normality of the quantitative data was assessed using the Kolmogorov-

Smirnov and Shapiro-Wilk tests, as well as visual methods. Quantitative data were summarized using means and standard deviations or medians and ranges, depending on their distribution. Categorical data were summarized as numbers and percentages. The patients were classified based on 24-hour mortality, 30-day mortality, and the optimal cutoff point of the shock index. Statistical tests such as the independent t-test or Mann-Whitney U test were used to compare quantitative data between the different classifications.

The Chi-square test was employed for comparing categorical data. Correlation analysis was conducted to examine the relationship between the length of hospital stay and other variables using Pearson's or Spearman's correlation. Receiver operating characteristic (ROC) analyses were performed to assess the predictive ability of the shock index for 24-hour and 30-day mortality. Statistical significance was set at a p-value of less than 0.05.

Data management and statistical analysis:

The statistical analysis was conducted using the Software, Statistical Package for Social Science, (SPSS Inc. Released 2009-PASW Statistics for Windows Chicago: SPSS Inc.) The collected data were summarized in terms of mean ± Standard Deviation (SD) and range (minimum - maximum) for quantitative data and frequency and percentage for qualitative data. The collected data will be analysed using suitable statistical methods. Statistical significance will be accepted at P value <0.05. A P value <0.001 will be considered highly significant while a P value >0.05 was considered non-significant.

Results:

(Table 1) :In the current study, the mean age of the patients was 41 ± 14 years, with an equal distribution of males and females. The majority of cases (66%) had non-traumatic causes of hemorrhagic shock The average amounts of blood products administered were as follows: RBCs (7 ± 2 units), FFP (6 ± 2 units), and platelets (14 ± 4 units). The median cryoprecipitate received was 2 units, ranging from 1 to 6 units. The mean shock index, an indicator of the severity of shock, was 3.5 ± 1. The mean length of hospital stay was 6 ± 2 days.

(Table 2): When patients were classified based on 24-hour mortality, there were no significant differences observed in age, gender, or the cause of hemorrhagic shock. Likewise, no significant differences were found in the amounts of blood products administered. However, non-survivors had significantly higher shock index values (4.7 ± 0.3 vs. 3.1 ± 0.8) and longer hospital stays (9 ± 2 days vs. 5 ± 1 days) compared to survivors.

(Table 3): Similarly, when patients were classified based on 30-day mortality, non-survivors had a significantly higher proportion of traumatic causes (58.3% vs. 26.3%) compared to survivors. There were no significant differences in age and gender. Non-survivors received higher amounts of RBCs compared to survivors, but no significant differences were observed for other blood products. Non-survivors also had higher shock index values and longer hospital stays compared to survivors. The length of ICU stay showed positive correlations with the amounts of RBCs, FFP, and cryoprecipitate administered, as well as with the shock index.

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Table 1: General characteristics of the studied group.

General characteristics		
Age (years)	Mean ±SD	41 ±14
Gender		
Males	n (%)	25 (50)
Females	n (%)	25 (50)
Cause of hemorrhagic shock		
Traumatic	n (%)	17 (34)
Non traumatic	n (%)	33 (66)

Table 2: Shock index and length of stay according to the 24-h mortality.

		24-h mortality		
		Yes (n = 11)	**No (n = 39)**	**P-value**
Shock index	Mean ±SD	4.7 ±0.3	3.1 ±0.8	**<0.001***
ICU length of stay (days)	Mean ±SD	9 ±2	5 ±1	**<0.001***

Table 3: Shock index and length of stay according to the 30-day mortality.

		30-day mortality		
		Yes (n = 12)	**No (n = 38)**	**P-value**
Shock index	Mean ±SD	4.6 ±0.3	3.1 ±0.8	**<0.001***
ICU length of stay(days)	Mean ±SD	9 ±3	5 ±1	**<0.001***

The ROC analysis was conducted to assess the predictive ability of the shock index for 24-hour and 30-day mortality. The shock index demonstrated excellent predictive accuracy for both outcomes, with AUC values of 0.987 and 0.978, respectively. The best cutoff point for the shock index to predict mortality was > 4.2, with high sensitivity and specificity.

When patients were classified according to the best cutoff point of the shock index, no significant differences were observed in age, gender, or the cause of hemorrhagic shock. There were also no significant differences in the amounts of blood products administered. However, patients with a shock index > 4.2 had significantly longer ICU stays, higher 24-hour mortality rates (100% vs. 2.5%), and higher 30-day mortality rates (100% vs. 5%) compared to those with a shock index ≤ 4.2.

- ROC analysis for shock index to predict 24-hour mortality
- ROC analysis for shock index to predict 30-day mortality

Discussion

Critical bleeding is a significant cause of morbidity and mortality in various clinical contexts, such as trauma, surgery, and obstetrics. [5] The management of patients with critical or major bleeding often involves transfusion of red blood cells (RBCs) and non-RBC components, including fresh frozen plasma (FFP), platelets, and cryoprecipitate. The use of massive transfusion protocols (MTPs) has become a cornerstone of damage control resuscitation, aiming to rapidly restore volume, haemostatic activity, and oxygen transport through the administration of fixed ratios of blood components (plasma, RBCs, and platelets). [1]

Massive transfusion is typically defined as the transfusion of a large number of RBC units within a specified time frame. Various definitions exist, such as the transfusion of 10 or more units of PRBC in the first 24 hours after hospital admission or the replacement of the whole blood volume within a specific period. [4]

Determining the appropriate dose and timing of blood component therapy can be based on empirical ratios related to the number of RBC units transfused or guided by laboratory testing results, including activated partial thromboplastin time (aPTT), prothrombin time (PT), fibrinogen levels, and platelet count, once available. Point-of-care testing, such as viscoelastic analysis, can also aid in directing transfusion therapy. [6]

Recent observational data have suggested that higher ratios of FFP to RBC transfusion and platelets to RBC transfusion are associated with improved clinical outcomes, including reduced mortality and blood loss, in patients with trauma and critical bleeding. However, only a limited number of interventional studies have compared different ratios of FFP, platelets, and fibrinogen replacement in patients with major bleeding, primarily focusing on trauma cases. [7]

In the current study, the mean age of the patients was 41 ± 14 years, and approximately half of the patients were males. Non-traumatic causes accounted for the majority of cases (66%). The mean quantities of RBCs, FFP, platelets, and cryoprecipitate transfused were 7 ± 2, 6 ± 2, 14 ± 4, and 2 (median), respectively.

Patients were categorized based on 24-hour and 30-day mortality. No significant differences were found in age, gender, or cause of hemorrhagic shock between the survivor and non-survivor groups. Regarding blood product transfusion, no significant differences were observed in the quantities of RBCs, FFP, platelets, and cryoprecipitate between the two groups.

Several studies have compared 24-hour and 30-day mortality in patients with and without MTPs. While some studies did not find significant differences in 24-hour mortality [8,9], others reported significantly lower mortality rates in patients receiving MTPs. [10] Similarly, for 30-day mortality, some studies demonstrated significantly lower rates in the MTP group [10,11], while others did not find significant differences [8,9].

The shock index (SI), calculated as the ratio of heart rate to systolic blood pressure, was used as a prognostic indicator in the study. The mean shock index in the current study was 3.5 ± 1. Patients with a shock index greater than 4.2 showed significantly higher ICU length of stay, 24-hour mortality, and 30-day mortality compared to those with a lower shock index.

Consistent with the current study, previous research also found that an elevated shock index and modified shock index were associated with lower survival rates, increased rates of recurrent loss of circulation in the emergency department, and longer lengths of stay [12]. Additionally, other studies revealed that higher shock index values were associated with increased transfusion requirements, longer hospital stays, and higher mortality rates [13,14].

Moreover, the ratio of platelets to RBCs has been shown to impact mortality in massive transfusion patients. A retrospective review found that a high platelet to RBC ratio (≥ 1:2) was associated with greater 30-day survival compared to a low platelet to RBC ratio (< 1:2). A ratio of FFP: platelets: RBC of 1:1:1 was identified as effective in controlling bleeding and improving survival [15].

The current study also performed receiver operating characteristic (ROC) analysis to determine the optimal shock index cutoff for predicting 24-hour and 30-day mortality. A shock index greater than 4.2 showed high sensitivity and specificity for predicting both outcomes. Similar findings were reported, although they acknowledged the challenge of calculating the shock index in emergency situations [16]. Additionally, a pediatric-adjusted shock index, called the Shock Index Pediatric Adjusted (SIPA), has been developed for use in the pediatric population and has demonstrated improved

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reliability for this specific group of patients [14,17].

In conclusion, this observational study evaluated the impact of a high fixed transfusion ratio of plasma, platelets, and RBCs in patients with critical non-traumatic and traumatic hemorrhage. The study identified associations between the shock index, transfusion ratios, and clinical outcomes such as mortality and length of stay. However, it is important to consider the limitations of this study, including its observational nature, single-center design, small sample size, and limited follow-up period. Future research should aim to address these limitations and further investigate the optimal transfusion strategies and predictors of outcomes in patients with critical bleeding.

Conclusion:

The high fixed transfusion ratio of 1:1:1 for plasma, platelets, and RBCs may not have a significant impact on the clinical outcomes of patients with critical non-traumatic and traumatic hemorrhage. However, the implementation of a massive transfusion protocol may lead to better outcomes in terms of 30-day mortality. Further interventional studies are needed to confirm these findings.

Conflict of interest:

None of the contributors declared any conflict of interest.

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