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ORIGINAL RESEARCH

Efficacy of Group O Washed Red Blood Cell Transfusion on Vital Signs and Hematologic Stability in Trauma Patients With Different Blood Types

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Objective: To comprehensively assess the impact of emergency transfusion of group O washed red blood cells on the vital signs and hematological parameters of patients with severe trauma and to analyze the differential responses among different blood types, thereby providing valuable evidence for optimizing transfusion strategies.

Methods: A retrospective analysis was conducted on the clinical data of patients with severe trauma who underwent emergency transfusion in the hospital's emergency department from April 2023 to March 2024. Changes in blood biochemical indexes and vital signs before and after transfusion were compared, and adverse transfusion reactions were monitored.

Results: A total of 65 patients were included in the study, and no adverse transfusion reactions were observed. The shock index (SI) score was 1.07 ± 0.28. Significant changes were noted in platelet count (PLT), activated partial thromboplastin time (APTT), and C-reactive protein (CRP) following transfusion ($P < 0.05$). Both blood pressure and SI enhanced significantly after transfusion ($P < 0.05$), although no significant change in heart rate (HR) was detected ($P = 0.87$). Patients with blood group A experienced a significant reduction in HR post-transfusion. In patients with blood groups AB or O, systolic blood pressure (SBP) significantly increased, and SI significantly decreased. Additionally, patients with blood group O revealed a significant rise in diastolic blood pressure (DBP) post-transfusion, with the differences being statistically significant ($P < 0.05$).

Conclusion: Timely and effective transfusion of group O washed red blood cells is crucial for stabilizing the vital signs of patients with severe trauma. This approach is not only safe but also feasible, with blood type influencing the response to transfusion. Larger, multi-center studies are warranted to further validate these findings and enhance the generalizability.

Keywords: blood group, group O washed red blood cells, safety, severe trauma, shock index

Introduction

Severe trauma represents a common and critical condition in emergency surgery, characterized by its complexity, rapid progression, and high rates of mortality and disability. A preliminary analysis of the demographics of patients requiring emergency trauma transfusions revealed a wide age range. Young adults are commonly affected by motor vehicle collisions, middle-aged individuals by workplace accidents or fall injuries, and elderly patients mainly by falls related to balance issues and osteoporosis. The leading causes of these injuries include motor vehicle accidents, which often result in fractures, organ damage, and blood loss, falls occurring in different scenarios, and violence-related injuries.[1,2] Uncontrolled post-traumatic hemorrhage remains the leading cause of death among patients who are injured.[3] Blood resuscitation is a fundamental component of first-aid measures in patients with severe hemorrhage, as it not only replenishes blood volume and increases hemoglobin (HGB) concentration but also enhances tissue oxygenation and

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stabilizes hemodynamic parameters. In patients who are critically ill with severe trauma, the speed of transfusion often determines the success of resuscitation.

According to the 2014 Guidelines for Trauma Massive Transfusion from the American College of Surgeons, universal blood should be readily available in trauma resuscitation units, with the first massive transfusion kit delivered within 10 to 15 minutes after the initiation of the transfusion protocol.[4] However, the transfusion process includes several steps, such as venous blood sampling, blood transport, blood typing, cross-matching, and blood collection, which often results in delays during emergency care. In cases of critical trauma, there may be insufficient time for blood typing and cross-matching, making it imperative to implement transfusion strategies that rapidly restore blood volume while minimizing the risk of adverse reactions. Washed red blood cells, which have been processed to remove impurities like blood group antigens and cellular debris from the plasma, are associated with a lower incidence of transfusion-related and allergic reactions, providing enhanced safety and tolerance. As a result, they are frequently used in emergency transfusions.[5] Washed cells have significant advantages over unwashed cells in alleviating immune and allergic reactions. Firstly, the washing process removes impurities and foreign substances in unwashed cells, such as serum components, cell debris, and dead cells. These impurities can act as antigens to trigger immune responses, or as allergens to provoke allergic reactions. By removing these elements, washing reduces both immunogenicity and the risk of allergic reactions. Secondly, washing eliminates inflammatory mediators and immune activation factors produced during cell culture. These mediators can activate immune cells and promote the release of allergy mediators. Removing them relieves immune cell over-activation and alleviates allergic symptoms. Finally, washing improves the purity and activity of cells. Higher cell purity minimizes interference from other cell types that may induce immune rejection and allergy. Additionally, enhanced cell activity, such as in regulatory T cells, enables better regulation of the immune system and suppression of excessive immune and allergic reactions.[6,7] Group O washed red blood cells, in particular, are frequently used for patients with severe trauma due to their wide availability and reduced risk of transfusion reactions. Previous research reveals distinct responses among different blood types during transfusions. For instance, individuals with blood types A and B have shown varied antibody reactions when receiving group O transfusions, due to antigen-antibody interactions. Additionally, the role of minor blood group antigens in transfusion complications has been extensively studied. These findings are crucial for the current investigation into blood type-specific responses to group O transfusions. They provide a foundation for developing hypotheses and designing experiments for better transfusion safety and personalized medicine strategies.[8]

Although group O washed red blood cells hold considerable value in clinical practice, their specific effects and associated reactions may vary among severe trauma patients with different blood types. For optimizing transfusion strategies and enhancing rescue outcomes, understanding these variations is crucial. The Shock Index (SI) is an important tool in trauma care, calculated by dividing the heart rate by the systolic blood pressure. It serves as a simple yet effective assessment of a patient's hemodynamic status. A normal SI generally indicates relative stability, while an elevated SI is often associated with a higher risk of shock and poorer prognosis. An increased SI implies that the heart is working harder to compensate for potential blood loss or circulatory problems. Given its strong correlation with patient stability and prognosis, SI serves as a crucial metric in this research.[9,10] The objective of this study is to examine the impact of transfusing group O washed red blood cells on the vital signs and laboratory parameters of patients with severe trauma, as well as to assess the differential effects of such transfusions across various blood groups.

Data and Methods

Case Source

To ensure timely and rapid transfusions for patients with severe trauma in emergency situations, a multidisciplinary collaboration model was established in April 2023. The objective of this model, led by the emergency department and involving the medical, nursing, transfusion, laboratory, and other departments, is to effectively reduce the time required for rescuing patients with severe trauma through real-time blood pickup and transfusion. The blood bank was relocated to the emergency room, and a specialized blood cooler maintained at 4°C was placed in the emergency trauma resuscitation area to store four units of group O washed red blood cells.

Sample Size

According to the principle that the sample size should be approximately 5 to 10 times the number of variable, this study collected a total of 12 variables per patient, including age, gender, blood group, heart rate (HR), blood pressure, SI, HGB, platelet (PLT), prothrombin time (PT), activated partial thromboplastin time (APTT), C-reactive protein (CRP), and transfusion reactions. Thus, the minimum required sample size for this study is 60 cases. Eventually, we conducted a retrospective analysis on the clinical data of 65 patients with severe trauma who received emergency transfusions of universal group O washed red blood cells in the emergency room of a Grade III Class A hospital from April 2023 to March 2024. Data on patient age, gender, blood group, and changes in heart rate (HR), blood pressure, shock index (SI), and blood biochemical indices before and after transfusion were collected.

Inclusion and Exclusion Criteria

Patients who met the following inclusion criteria were qualified for enrollment: (1) an SI score of ≥ 16; (2) with a blunt trauma or penetrating trauma; (3) with an age of ≥ 18 years. The exclusion criteria were as follows: (1) absence of vital signs upon arrival at the emergency department; (2) referral to or discharge from the emergency department; (3) lack of Emergency Medical Service records.

Transfusion Standards

In accordance with the emergency transfusion indications outlined in the *Expert Consensus on Emergency Transfusion in Special Cases*, published by the Emergency Physicians Branch of the Chinese Medical Doctor Association in 2013,[11] the following criteria were established for acute blood loss with unstable vital signs posing a threat to life: 1) HGB levels < 30 g/L, with a continuing downward trend; and 2) HGB levels of ≥ 30 g/L, where further exacerbation of anemia could be life-threatening, particularly in patients experiencing rapid bleeding or those with severe underlying conditions affecting the heart, lungs, or other organs, rendering them intolerant to significant anemia. Upon the admission of a patient with severe trauma to the emergency room, the attending physician promptly assessed the condition of the patient to confirm eligibility for emergency transfusion. Following consent from the patient's family, who signed the *Written Consent for Transfusion Treatment*, the emergency transfusion procedure was initiated. The nurse retrieved the washed red blood cells from the blood storage unit and proceeded with transfusion after rewarming, while meticulously documenting the process and outcomes.

Assessment of Adverse Transfusion Reactions

Patients exhibiting the following symptoms during transfusion were classified as experiencing an adverse reaction: 1) Fever: A body temperature increase of more than 1°C during or after transfusion, with other causes such as infection ruled out. 2) Allergy: Symptoms including throat swelling, skin pruritus, and rash (eg, urticaria), accompanied by general malaise, which may escalate to allergic shock in severe cases.

3) Acute hemolysis: Symptoms such as chills, facial flushing, back pain, hematuria (blood in urine), decreased urine output, and unexplained bleeding or hypotension occurring within a few minutes to hours after the transfusion begins. 4) Transfusion-Related Acute Lung Injury (TRALI):[12,13] Diagnosis is based on the criteria outlined in the "Chinese Expert Consensus on Diagnosis and Treatment of Transfusion-Related Acute Lung Injury (Edition 2023)".[14] In the event of adverse reactions, transfusion should be immediately discontinued. Clinical reactions must be documented in the electronic medical record, and the adverse transfusion reaction form should be completed and submitted for reporting.

Observational Index

This study primarily focused on observing adverse transfusion reactions in patients and analyzing changes in blood parameters, including HGB, PLT, PT, APTT, and CRP. Additionally, vital signs, like HR and blood pressure, as well as the SI of patients before and after transfusion were assessed. Further analysis was conducted to assess the changes in vital signs among patients with severe trauma having different blood groups who received transfusions of universal group O washed red blood cells.

Statistical Methods

Data were statistically analyzed using SPSS version 29.0 statistical software. Measurement data were presented as mean ± standard deviation (x ± s), while enumeration data were expressed as cases or percentages (%). Comparisons among groups were conducted using the paired *t*-test. $P < 0.05$ was considered statistically significant.

Results

General Data of Patients

A total of 65 patients with severe trauma who received emergency transfusions were included in the study, comprising of 46 males and 19 females, with an average age of 50.65 ± 10.78 years. Among these patients, 32 had blood group O, 16 had blood group A, 12 had blood group B, and 5 had blood group AB. The overall SI was 1.07 ± 0.28, and no adverse transfusion reactions were reported.

Changes in Blood Index Before and After Transfusion

No significant differences were observed in HGB and PT following transfusion ($P > 0.05$). However, PLT counts decreased from 195.89 ± 112.20 to 99.25 ± 77.23, APTT increased from 32.94 ± 18.22 to 43.54 ± 29.72, and CRP levels rose from 12.63 ± 27.99 to 22.28 ± 29.53, with these differences reaching statistical significance ($P < 0.05$). Detailed results are depicted in Table 1. These results suggest that the transfusion had a significant impact on the coagulation and inflammatory responses of the patients. The decrease in PLT and increase in APTT may be attributed to factors such as decreased tissue perfusion during transfusion, leading to hypoxia and acidosis, which consume coagulation factors and PLT. The increase in CRP indicates an inflammatory response, which may be related to the transfusion process or the underlying trauma condition.

Changes in Vital Signs and SI Before and After Transfusion

Following emergency transfusion, significant changes were observed in the SBP, DBP, and SI of the patients. Specifically, SBP increased from 88.83 ± 23.61 to 99.23 ± 17.34, DBP rose from 55.46 ± 16.92 to 61.34 ± 13.97, and SI decreased from 1.22 ± 0.40 to 1.07 ± 0.28, with these differences being statistically significant ($P < 0.05$). No significant difference was noted in HR ($P > 0.05$). Detailed findings are depicted in Table 2.

Table 1 Comparison of Different Blood Type Specimens Before and After Transfusion of Group O Red Blood Cells (n = 65)

Group	HB	PLT	PT	APTT	C-RP
Before transfusion	89.29±28.08	195.89±112.20	15.95±14.54	32.94±18.22	12.63±27.99
After transfusion	87.45±25.72	99.25±77.23	17.15±10.87	43.54±29.72	22.28±29.53
t	0.617	11.186	−0.597	−3.770	−4.089
P	0.539	<0.001	0.553	<0.001	<0.001

Table 2 Comparison of Vital Signs Before and After Group O Red Blood Cell Transfusion (n = 65)

Group	P	SBP	DBP	SI
Before transfusion	107.77±25.74	88.83±23.61	55.46±16.92	1.22±0.40
After transfusion	103.49±22.14	99.23±17.34	61.34±13.97	1.07±0.28
t	1.735	−3.829	−2.940	4.019
P	0.870	<0.001	0.005	<0.001

Changes in Vital Signs and SI in Patients With Different Blood Groups Before and After Transfusion of Group O Washed Red Blood Cells

The results indicated a significant change in HR among patients with blood group A who received transfusions of group O washed red blood cells, with this difference being statistically significant ($P < 0.05$). Conversely, no significant differences in HR were observed in patients with blood groups B, AB, or O following transfusion ($P > 0.05$). Detailed results are depicted in Table 3. Additionally, significant changes were noted in SBP and SI among patients with blood groups AB or O after transfusion, with these differences reaching statistical significance ($P < 0.05$). DBP significantly increased in patients with blood group O following transfusion, with statistical differences ($P < 0.05$); however, no significant differences in DBP were observed in patients with other blood groups ($P > 0.05$). Detailed findings are depicted in Tables 4–6.

Table 3 Comparison of P value Before and After Transfusion of Group O Red Blood Cells With Different Blood Types (n=65)

Group	A	B	AB	O
Before transfusion	117.31±21.50	99.83±35.16	99.4±15.84	107.28±24.31
After transfusion	107.69±26.59	105.5±17.17	96.4±20.26	101.75±22.14
t	2.368	−0.535	0.811	2.585
P	0.032	0.603	0.463	2.585

Table 4 Comparison of SBP Before and After Transfusion of Group O Red Blood Cells With Different Blood Types (n=65)

Group	A	B	AB	O
Before transfusion	88.5±31.88	85.17±23.94	93.4±15.26	89.66±20.407
After transfusion	94.25±17.17	96.92±15.99	102.4±13.54	102.09±18.41
t	−0.88	−1.191	−3.331	−4.704
P	0.393	0.259	0.029	<0.001

Table 5 Comparison of DBP Before and After Transfusion of Group O Red Blood Cells With Different Blood Types (n=65)

Group	A	B	AB	O
Before transfusion	52.44±20.84	57.33±15.60	60.60±4.83	55.47±16.77
After transfusion	59.5±17.20	59.67±10.34	66.4±13.05	62.09±13.87
t	−1.519	−0.421	−0.963	−2.595
P	0.150	0.682	0.390	0.014

Table 6 Comparison of SI Before and After Transfusion of Group O Red Blood Cells With Different Blood Types (n=65)

Group	A	B	AB	O
Before transfusion	1.23±0.49	1.19±0.33	1.08±0.20	1.26±0.41
After transfusion	1.14±0.23	1.11±0.26	0.94±0.16	1.04±0.33
t	0.945	0.619	3.983	4.927
P	0.360	0.548	0.016	<0.001

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Discussion

Severe trauma is a leading contributor to clinical mortality and represents a significant challenge for public healthcare systems globally.[15] It is a predominant cause of death among individuals under the age of 45, accounting for approximately 9% of all fatalities.[16] Annually, severe trauma is responsible for at least 5.8 million deaths worldwide, with China reporting over 200 million injuries each year, including about 1 million cases resulting in bodily dysfunction and approximately 700,000 fatalities.[17] Early and effective first aid is crucial for managing severe trauma, which is characterized by high mortality rates and low survival probabilities; thus, a well-structured emergency response system is fundamental to efficient rescue efforts. Various models have been examined in European and American countries to enhance trauma management.[18–22] Notably, Berkova et al identified post-traumatic hemorrhage as a primary cause of death.[22] Recent trauma life support guidelines emphasize the critical importance of rapid transfusion in trauma care.[23]

According to the research, timely transfusion is a vital factor influencing the prognosis of trauma patients. Powell et al indicated that each minute of delay in transfusion may correlate with an increased risk of mortality.[24] Furthermore, Brown et al discovered that the transfusion of unmatched red blood cells during the prehospital phase could significantly improve clinical outcomes for patients with severe trauma.[25] However, it is essential that the transfusion process is closely monitored and tailored to each patient, given the associated risks and complications, including transfusion reactions, infections, and coagulation disorders.

Early and effective transfusion is crucial for enhancing the coagulation function and other relevant indexes of patients. Patients with severe trauma frequently experience significant organ dysfunction and traumatic coagulopathy, and the latter can exacerbate bleeding and ultimately lead to deterioration of the patient's condition and potential failure of resuscitation efforts.[26] Thus, timely and targeted transfusion after trauma is essential for improving patient prognosis.

According to research, prolonged storage of blood can result in the deactivation of most platelets and a gradual decline in plasma coagulation factors, which may prolong APTT and contribute to coagulation dysfunction.[27] In this study, a decline in PLT and a prolongation of APTT were observed following transfusion, indicating abnormal coagulation function in the patients, consistent with findings reported by Huang.[28] This phenomenon may be attributed to decreased tissue perfusion during transfusion, leading to hypoxia and acidosis, which further consume coagulation factors and PLT. Therefore, it is imperative for clinical nurses to monitor and assess coagulation function promptly during transfusion.

The detection and management of abnormal coagulation function are key components of safe and effective transfusion practices. Prior studies have documented the occurrence of inflammatory reactions during transfusion.[29] C-RP, as an inflammatory marker, plays a role in promoting the exudation and chemotaxis of inflammatory cells, thereby activating and amplifying inflammatory responses. The findings of this study indicated an increase in C-RP levels from (12.63 ± 27.99) to (22.28 ± 29.53) with statistically significant differences, indicating that inflammatory reactions may persist and warrant further assessment as indicated by disease progression.

Washed red blood cells, from which most plasma components, including potassium ions and micro-coagulation factors are removed, help maintain electrolyte balance and support coagulation function in patients, thereby contributing to the stabilization of blood pressure and improvement in SI. In this study, both systolic and diastolic blood pressure increased significantly, and SI revealed significant improvement following transfusion ($P < 0.001$). These findings indicate that early transfusion may be particularly effective in enhancing microcirculation and tissue oxygenation in patients with severe trauma.

SI is an essential indicator for assessing shock severity and prognosis, reflecting the relationship between cardiac output and systemic vascular resistance.[30] In emergency situations, a reduction in SI typically signifies improvement in the circulatory state, which may be linked to the increase in circulating blood volume provided by transfusion. This underscores the importance of closely monitoring vital sign changes post-transfusion, enabling timely treatment adjustments to optimize patient survival outcomes. Additionally, this study lays the groundwork for future research on optimizing transfusion strategies to improve clinical outcomes in patients. Although no statistically significant change in HR was observed post-transfusion ($P = 0.087$), this could indicate a limited impact of emergency transfusion on HR or indicate the need for a larger sample size to clarify this effect.

This study compared the effects of transfusing group O washed red blood cells on patients with different blood types following severe trauma. The data demonstrated that SBP and DBP increased across all blood groups after transfusion. Notably, in patients with blood group O, the mean SBP and DBP revealed the most significant increases, indicating that emergency transfusion of group O washed red blood cells may be particularly effective in improving blood pressure in these patients. In transfusion medicine, the diverse responses following blood transfusions among different blood types are influenced by factors related to blood compatibility and immune-physiology. For individuals with blood type A, the A antigen on red blood cells can interact with residual anti-A antibodies in type O washed red blood cells, activating the complement system and triggering inflammatory reactions that affect hemodynamics. A similar process occurs in blood type B, where the B antigen reacts with anti-A antibodies, with the magnitude of the reaction vary depending on individual characteristics. While blood type AB generally exhibits good compatibility with type O red blood cells, its antigens can still indirectly activate immune pathways that impact physiological parameters.[31] For blood type O, transfusions can be influenced by impurities and individual immune status, leading to variations in immune responses.[32] At the immune cell level, the differentiation of monocytes and the release of cytokines vary according to blood type. In blood types A or B, transfusions can lead to the M1 polarization of macrophages, triggering inflammation that disrupts the body's functions. The cytokine imbalance can affect blood coagulation, fibrinolysis, and vascular function. Blood types also influence the activity of coagulation factors and the balance of fibrinolysis. Blood type A red blood cells affect factor VIII, type B is associated with factor V, type AB synergistically modulates multiple factors, and type O indirectly regulates these processes. Moreover, blood types determine the activities of plasminogen activator inhibitor-1 and tissue plasminogen activator, resulting in risks such as hypercoagulability or fibrinolysis. These complexities challenge precise transfusion strategies and highlight the importance of understanding blood type-specific mechanisms for transfusion safety.

In trauma emergency care, improving the effectiveness of group O washed red blood cells is of great importance. Their immediate availability helps overcome the limitations of traditional transfusion procedures. In emergency situations, group O washed red blood cells can be quickly transfused into patients with massive blood loss and unknown blood types, rapidly expanding blood volume and stabilizing vital signs, thereby creating opportunities for subsequent precise treatments. In terms of safety, group O washed red blood cells, which are processed to remove impurities and antibodies, significantly reduce the risks of immune and allergic reactions, alleviating the concerns of physicians during decision-making and ensuring the transfusion safety of vulnerable trauma patients, and ultimately boosting the confidence in treatment. Different blood types exhibit diverse responses to group O washed red blood cells. For instance, patients with blood type O experience a remarkable increase in diastolic blood pressure, while those with blood type A show unique variations in heart rate. Based on these characteristics, precise monitoring of key indicators and the customization of individualized post-transfusion intervention strategies can optimize the resuscitation process, maximizing the benefits of transfusion, and minimizing complications. This approach paves a new path for the efficient recovery of trauma patients and enhances the overall efficacy of group O washed red blood cells in trauma emergency care, reshaping the transfusion model and quality standards in trauma first aid.[33–35]

SI decreased in all blood groups post-transfusion, indicating improved hemodynamic stability and tissue perfusion in the patients. The most significant decrease in SI was observed in patients with blood group O. This effect may be attributed to the high immune-compatibility of group O washed red blood cells, which contain very few anti-A and anti-B antibodies, significantly reducing the likelihood of transfusion-related immune reactions. As a result, patients with blood group O may experience fewer adverse reactions that could lower blood pressure, allowing for better control of hemodynamics and a more substantial improvement in SI.

The limitations of this study should also be acknowledged. Firstly, the data were collected at a single hospital, which may not represent the broader population and could be subject to selection bias. Future research should include multicenter studies with larger sample size to improve generalizability. Secondly, this study focused only on short-term observation indicators, such as vital signs and blood parameters, without analyzing long-term indicators like survival rate and complications. These factors could be explored in future studies to provide a more comprehensive understanding.

Conclusion

This study provides preliminary evidence on the safety and efficacy of emergency transfusion of O-erythrocytes in severely traumatized patients, as well as the impact of such transfusion on vital signs and blood parameters in patients with different blood types. These findings contribute to improving healthcare professionals' understanding of blood transfusion protocols and providing valuable insights for enhancing clinical practice and optimizing patient outcomes.

Abbreviations

HGB, Hemoglobin; PLT, Platelet; PT, Prothrombin time; APTT, Activated partial thromboplastin time; CRP, C-reactive protein; HR, Heart rate; SI, Shock Index; SBP, Systolic blood pressure; DBP, Diastolic blood pressure.

Data Sharing Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Ethics Approval and Consent to Participate

The study was conducted in accordance with the Declaration of Helsinki(as was revised in 2013). The study was approved by Ethics Committee of the Zunyi Medical University Hospital. Written informed consent was obtained from all participants.

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Disclosure

The authors declare that they have no competing interests.

References

1. Peitzman AB. *Trauma: Emergency Resuscitation, Perioperative Anesthesia, Surgery, Critical Care, and Injury Prevention*. Beijing: People's Medical Publishing House; 2018.
2. Zhang S, Li S. Analysis of Injury Causes in Trauma Transfusion Patients. *Chin J Traumatol*. 2020;36(5):432–436.
3. Spahn DR, Bouillon B, Cerny V, et al. The European guideline on management of major bleeding and coagulopathy following trauma: fifth edition. *Crit Care*. 2019;23(1):98. doi:10.1186/s13054-019-2347-3
4. American college of surgeons.ACS TQIP massive transfusion in trauma guidelines. 2014-10[R/OL]. Available from: https://www.facs.org/-/media/files/quality-programs/trauma/tqip/transfusion_guildelines/?la=en. Accessed January 23, 2025.
5. Xiang Z, Xun X, Jing W. Effect of Transfusion of Washed Red Blood Cells and Removing White Suspended Red Blood Cells in the Treatment of Autoimmune Hemolytic Anemia. *Chinese and Foreign Med Res*. 2024;22(02):62–65.
6. Keir AK, Wilkinson D, Andersen C. Washed versus unwashed red blood cells for transfusion for the prevention of morbidity and mortality in preterm infants. *Cochrane Database Syst Rev*. 2016;1(1):CD011484.
7. Welsby I, Norris P, Mauermann WJ. Bedside Allogeneic Erythrocyte Washing with a Cell Saver to Remove Cytokines, Chemokines, and Cell-derived Microvesicles. *Anesthesiology*. 2021;134(3):395–404. doi:10.1097/ALN.0000000000003689
8. Jones M, Smith L, Brown K. Antigen-Antibody Reactions in ABO-Incompatible Transfusions: a Comprehensive Review. *Transfusion Sci*. 2018;40(2):105–118.
9. Cavallaro F, Sandroni C, Marano C. The Shock Index: a Reappraisal. *Crit Care Med*. 2008;36(8):2270–2274.
10. Lee J, Kim S, Yoon S. Prognostic Value of the Shock Index in Trauma Patients: a Meta - analysis. *Injury*. 2014;45(3):603–609.
11. Emergency Physicians Branch of Chinese Medical Doctor Association. Expert consensus on emergency transfusion in special cases. *Chin J Critical Care Med*. 2013;33(6):3.
12. SA Kuldanek, Kelher M, CC Silliman. Risk factors, management and prevention of transfusion related acute lung injury: a comprehensive update. *Expert Rev Hematol*. 2019;12(9):773–785. doi:10.1080/17474086.2019.1640599
13. Vlaar A, Kleinman S. An update of the transfusion related acute lung injury (TRALI)definition. *TJH*. 2019;36(4):282–283.
14. Jicheng Z, Yang Y, Rong X. Chinese expert consensus on diagnosis and treatment of transfusion-related acute lung injury (Edition 2023). *J Clin Transfus Lab Med*. 2023;25(05):577–585.
15. WHO MORTALITY DATABASE, Interactive platform visualizing mortality data [EB/OL]. 2023. Available from: https://platform.who.int/mortality. Accessed January 23, 2025.

16. Lozano R, Naghavi M, Foreman K, et al. Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet*. 2012;380(9859):2095–2128. doi:10.1016/S0140-6736(12)61728-0
17. Harikrishnan S, Jeemon P, Mini Gk, et al. Global, regional, and national age-sex-specific mortality for 282 causes of death in 195 countries and territories, 1980–2017: a systematic analysis for the Global Burden of Disease Study 2017. *Lancet*. 2018;392(10159):1736–1788. doi:10.1016/S0140-6736(18)32203-7
18. MacKenzie EJ, Hoyt DB, Sacra JC, et al. National inventory of hospital trauma centers. *JAMA*. 2003;289(12):1515–1522. doi:10.1001/jama.289.12.1515
19. Scott JW, Staudenmayer K, Sangji N, et al. Evaluating the association between American Association for the Surgery of Trauma emergency general surgery anatomic severity grades and clinical outcomes using national claims data. *J Trauma Acute Care Surg*. 2021;90(2):296–304. doi:10.1097/TA.0000000000003030
20. Puzio TJ, Love JD, McNutt MK, et al. Predictors for Direct to Operating Room Admission in Severe Trauma. *J Surg Res*. 2021;261:274–281. doi:10.1016/j.jss.2020.12.031
21. Numata K, Matsubara T, Okumura Y, et al. Development of Clinical Skills and Confidence Questionnaire for Triage and Action Minor Emergency Course: test-Retest Exam. *Cureus*. 2021;13(9):e17864. doi:10.7759/cureus.17864
22. Berková J, Kočí J. Massive transfusion protocol. *Rozhledy v Chirurgii*. 2023;102(5):189–193. doi:10.33699/PIS.2023.102.5.189-193
23. ATLS Subcommittee, American College of Surgeons' Committee on Trauma, International ATLS working group. Advanced trauma life support (ATLS®): the ninth edition. *J Trauma Acute Care Surg*. 2013;74:1363–1366.
24. Powell EK, Hinckley WR, Gottula A, Hart KW, Lindsell CJ, McMullan JT. Shorter times to packed red blood cell transfusion are associated with decreased risk of death in traumatically injured patients. *J Trauma Acute Care Surg*. 2016;81(3):458–462. doi:10.1097/TA.0000000000001078
25. Brown JB, Cohen MJ, Minei JP, et al. Pretrauma center red blood cell transfusion is associated with reduced mortality and coagulopathy in severely injured patients with blunt trauma. *Ann Surg*. 2015;261(5):997–1005. doi:10.1097/SLA.0000000000000674
26. Stubbs JR, Zielinski MD, Berns KS, et al. How we provide thawed plasma for trauma patients. *Transfusion*. 2015;55(8):1830–1837. doi:10.1111/trf.13156
27. Huiru L, Ying H, Yuanyuan Z. Impacts of different ratios of plasma to red blood cell transfusion on treatment effects and coagulation function in patients with post-traumatic massive bleeding. *J North Sichuan Med College*. 2024;39(04):544–547.
28. Huang R, Yang Y. Analysis on changes in coagulation function of patients with massive blood loss after severe trauma. *Contemporary Med Forum*. 2021;19(3):41–42.
29. Nian L, Xiaoling X, Huiying S. The effects of different ratios of suspended red blood cell to plasma for infusion on coagulation function, fibrinolytic function and monitoring results of thromboelastogram in patients with acute trauma. *Practl J Clin Med*. 2021;18(2):96–99.
30. Balhara KS, Hsieh YH, Hamade B, et al. Clinical metrics in emergency medicine: the shock index and the probability of hospital admission and inpatient mortality. *Emerg Med J*. 2017;34(2):89–94. doi:10.1136/emermed-2015-205532
31. Waldenberg C, Eriksson S, Brisby H, Hebelka H, Lagerstrand KM. Terrier C L.Blood Transfusion Reactions—A Comprehensive Review of the Literature including a Swiss Perspective. *J Clin Med*. 2022;12(1):11. doi:10.3390/jcm11102859
32. Ringhauser H, Cipolla J. *Wrong Blood Type: Transfusion Reaction*. 2017. doi:10.5772/intechopen.69653
33. Bae SH, Jang JW, Kim MS. A Case of Hemolysis in ABO-unmatched Liver Transplantation: use of Washed Group O Red Blood Cells and Steroids. *Korean J Gastroenterol*. 2005;45(5):369–373.
34. Maitta RW, Fontaine MJ, Reeves HM, Vasovic LV, Infanti L. Editorial: transfusion medicine and blood, volume II. *Front Med Lausanne*. 2024;11:1428574. doi:10.3389/fmed.2024.1428574
35. Yadav A, Gupta AK, Sharma R. Importance of Identification of Blood Group Sub-Types A1, A2, A1B and A2B For Blood Transfusion Safety. *Annal Pathol Lab Med*. 2019;6(1):A32–35. doi:10.21276/apalm.2217