Insights on an integrated approach to blood component transfusion in pre-hospital aeromedical care

Abstract

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| **Aims:** Blood products have been increasingly used in aeromedical transport, considering the potential benefits of their early use. Within this scope, this study aims to analyze the current situation and future perspectives related to blood transfusion and its application in the aeromedical transport of critically ill patients.  **Study design:** descriptive, qualitative, and retrospective observational approach, utilizing a methodological framework grounded in a bibliographic examination of publications featured in indexed journals.  **Methodology:** An exploration was conducted on the academic search platform PubMed, using the search terms "blood components", "transfusion", "aeromedical" and "pre-hospital", with a chronological filter spanning the last 10 years. This search yielded 34 articles, which then underwent a screening and sorting process using the platform's tools to categorize documents based on their thematic relevance.  **Results:** Enhancing care optimization and facilitating effective hemodynamic management, prehospital blood transfusion (PHBT) has been documented as a safe procedure applied to trauma patients. Although accurate patient selection remains a challenge in the decision-making process for transfusions, strategies such as massive transfusion, coupled with hemorrhage control and surgical prioritization, demonstrate significant benefits. Studies underscore favorable outcomes associated with PHBT, underscoring the imperative for its efficient integration, particularly within aeromedical services. This necessitates meticulous attention to logistics, patient selection criteria, and comprehensive assessment of clinical endpoints outcomes.  **Conclusion:** Preliminary data suggests positive outcomes in the increasing use of blood transfusion during prehospital transport, including aeromedical contexts, highlighting the necessity for research to inform evidence-based protocol development. |

*Keywords: blood products, blood transfusion, air rescue, emergency medicine.*

1. INTRODUCTION

Trauma is the most frequent cause of death in patients under 45 years old, posing a significant public health challenge in various countries (BEIRIGER et al., 2023; PLODR et al., 2023; MITRA et al., 2023; ROSSAINT et al., 2023; YAZER et al., 2023; LIMA et al., 2021). Hemorrhage, in turn, is the leading cause of preventable death, with 33 to 56% of these deaths occurring during pre-hospital care (PLODR et al., 2023; NASCIMENTO et al., 2022; LEVIN et al., 2022; LIMA et al., 2021). Rapid and effective medical assistance in hemorrhage control is essential, as massive bleeding can lead to death within minutes (CERTAIN et al., 2023; CARROL et al., 2020).

For many years, historical resuscitation protocols have focused on the early and aggressive use of crystalloids such as saline and lactated Ringer's solution (CERTAIN et al., 2023; YAZER et al., 2023). According to Griggs et al. (2018), this technique is associated with higher immediate mortality (within six hours) due to blood loss, and delayed mortality (within 28 hours) due to complications like multiple organ failure and dilutional coagulopathy compared to blood transfusions. Regarding acute traumatic coagulopathy, affected patients are eight times more likely to die within the first 24 hours (MITRA et al., 2023).

Modern concepts in pre-hospital trauma resuscitation have focused on permissive hypotension, limiting crystalloid administration (YAZER et al., 2023; LEVIN et al., 2022). Current data indicate that the use of blood components in the pre-hospital setting can lead to favorable outcomes, increasing the implementation of blood transfusion programs in mobile units for more effective hemodynamic control and lower complication rates (CERTAIN et al., 2023; YAZER et al., 2023; LEVIN et al., 2022). Furthermore, recent studies associate pre-hospital administration of blood products with lower mortality rates (CORNELIUS et al., 2023; LAMMERS et al., 2023; PLODR et al., 2023; NASCIMENTO et al., 2022; LEVIN et al., 2022).

Due to the hemodynamic and metabolic complexities impacting clinical progression, massive transfusion requires a meticulous approach, considering factors such as circulating blood volume, tissue oxygenation adequacy, coagulation changes, and metabolism (NASCIMENTO et al., 2022; LIMA et al., 2021).

In the context of emergency medicine, blood transfusion plays a key role in optimizing pre-hospital care (LAMMERS et al., 2023). Thoughtful implementation of blood component transfusion in pre-hospital care represents a significant advancement in critical patient management, especially in aeromedical transport scenarios (NASCIMENTO et al., 2022). Additionally, aeromedical services can enhance access to blood products, benefiting pre-hospital care (CORNELIUS et al., 2023).

Providing blood products during intensive care aeromedical transport is a complex task, requiring adherence to aircraft weight limits, storage of blood components, and the scarcity of universal donor blood components, necessitating organization and innovation (LATIMER et al., 2021). Currently, there remains a gap in specific studies addressing blood component transfusion during aeromedical transport, highlighting the need for thorough investigation to better understand the clinical effectiveness and logistical and operational aspects influencing the applicability of this intervention in emergency situations (NASCIMENTO et al., 2022; PETERS et al., 2019).

In this context, this study proposes an analysis of blood component transfusion in pre-hospital care, with a special focus on its integration in aeromedical transport. The critical analysis of methods, results, and implications discussed aims not only to consolidate existing knowledge but also to stimulate discussion on the effective implementation of blood component transfusion, promoting advances in emergency medicine.

2. metHODOLOGY

This study is an observational, descriptive, qualitative, and retrospective investigation, employing a methodological approach grounded in a bibliographic survey of publications from indexed journals. Data were gathered through searches of PubMed, SciELO, and the Virtual Health Library databases using the search terms "blood components," "transfusion," "aeromedical," and "prehospital." Retrieved articles underwent screening and sorting based on inclusion criteria, including publication date (last 10 years), relevance to the scope of this narrative review, technical quality, and journal impact factor. Exclusion criteria deliberately omitted studies lacking pertinent information to the present study. The search yielded 27 articles, subsequently subjected to a critical analysis and synthesis of the gathered information, culminating in the development of this current document.

3. resultS AND DISCUSSION

Pre-hospital blood transfusion (PHBT) has significantly evolved over the past three decades, becoming a safe and gradually expanding procedure applied to trauma patients (BEIRIGER et al., 2023; PLODR et al., 2023). Based on military experiments, pre-hospital services worldwide have optimized their care by implementing transfusion therapy in mobile units to achieve more effective hemodynamic control and lower complication rates (CERTAIN et al., 2023). However, the rate of preventable mortality due to exsanguinating injuries remains high worldwide (THIES et al., 2020).

Resuscitation goals for damage control in severely traumatized patients focus on restoring intravascular volume and preventing or reversing acidosis, hypothermia, and coagulopathy (CHAN et al., 2023; NASCIMENTO et al., 2022), which result from endothelial cell activation potentiated by tissue hypoxia due to low blood volume (LIMA et al., 2021). Recent hemostatic approaches concentrate on adequate perfusion of critical organs and tissue oxygenation until hemostasis is achieved (BEIRIGER et al., 2023).

One strategy for damage control resuscitation is massive transfusion, coupled with measures such as restricted use of crystalloids, control of compressible hemorrhages, and prioritization of surgical control (LIMA et al., 2021). Intravascular volume replacement with blood components in victims requiring massive transfusions is targeted at a 1:1:1 ratio of packed red blood cells, plasma, and platelets, with the addition of cryoprecipitate or fibrinogen concentrate to increase fibrinogen content in plasma. Although this ratio attempts to replicate whole blood, a massive transfusion of blood components cannot precisely replicate physiological ratios due to dilutions in hematocrit, platelet count, and fibrinogen (CHAN et al., 2023). Furthermore, blood transfusion is recommended for volumetric loss exceeding 25% to 30% of total volume, or class III or IV hypovolemic shock, which can progress to multiple organ failure leading to death if not subjected to resuscitation schemes within the first hour (NASCIMENTO et al., 2022).

The appropriate decision-making regarding transfusion, given limited diagnostic options at the scene of an incident, poses a challenge for pre-hospital teams (PLODR et al., 2023; BROWN et al., 2016). Identification criteria differ, with European countries primarily identifying the need for PHBT in severe trauma, shock, and prolonged entrapment in unstable patients (THIES et al., 2020). Brown et al. (2016) suggest that those benefiting from blood transfusion are patients with significant hypotension (SBP ≤80mmHg) and tachycardia (HR >110bpm), occurring at least once during transport.

Shand et al. (2019) conducted a review involving 22 studies, 16 civilian and 6 military. The review indicates that the most frequently assessed physiological criteria include systolic blood pressure (ranging from < 70 to < 90 mmHg), tachycardia (ranging from > 108 to > 130/min), or absence of radial pulse. Additionally, injury mechanism (penetrating injury or amputation above the knee/elbow) was included in 5 studies as an indication criterion. Plodr et al. (2023) state that shock index and pulse pressure are parameters showing higher sensitivity/specificity relationships, suitable tools for predicting the need for PHBT in trauma patients.

A study by Certain et al. (2023) evaluated vital signs and shock index of patients before and after blood transfusion. Mean systolic blood pressure on arrival at the accident scene was 52.6 mmHg (range: 0-110), and mean heart rate before the procedure was 114 beats per minute (range: 0-160). Thus, the initial mean shock index was 2.16. Following packed red blood cell transfusion, mean systolic blood pressure was 85.2 mmHg (range: 0-120) and mean heart rate was 93.7 beats per minute (range: 0-150). Consequently, the final mean shock index dropped to 1.1.

Hanlin et al. (2023) conducted a 5-year retrospective analysis of adult trauma patients transported by helicopter aeromedical services to hospital, using the Assessment of Blood Consumption (ABC) score. Pre-hospital, the score was 51% sensitive and 85% specific for predicting massive transfusion, with 83% correctly classified. In the emergency department, the ABC score was 60% sensitive and 84% specific, with 83% correctly classified. Therefore, the authors argue that the ABC score is a useful pre-hospital tool to identify those needing massive transfusion.

While intuitively PHBT may be presumed to improve survival, published data on this topic remain ambiguous in the literature. Two recent randomized trials compared the effect of pre-hospital administration of blood products and standard fluid resuscitation (0.9% saline). Moore et al. (2018) claim that pre-hospital plasma use was associated with a survival benefit, whereas Sperry et al. (2018) demonstrated that in patients at risk of hemorrhagic shock, pre-hospital thawed plasma administration is safe and results in lower 30-day mortality.

Young et al. (2014) conducted a randomized, double-blind, parallel-group study of adult trauma patients requiring blood transfusion, intubation, or operation within 60 minutes. Based on a computer-generated blocked sequence, individuals received either 0.9% saline or Plasma-Lyte A for resuscitation. Compared to 0.9% saline, resuscitation with Plasma-Lyte A in traumatized patients resulted in improved acid-base status and lower hyperchloremia rates 24 hours post-injury.

Brown et al. (2016) conducted a retrospective cohort study of traumatized patients transported by helicopter, where patients receiving packed red blood cell transfusion were matched with control patients (who did not receive packed red blood cell transfusion during transport) at a ratio of 1:2 (240 treated patients were matched with 480 control patients who did not receive packed red blood cell transfusion). Packed red blood cell transfusion was associated with higher odds of survival at 24 hours, reduced odds of shock, and decreased need for packed red blood cells within 24 hours, highlighting the benefit of using these components during aeromedical transport of severely injured trauma patients.

A significant aspect to emphasize is that aeromedical evacuation for definitive care may exacerbate post-injury morbidity due to inherent hypoxic and hypobaric environments. Given this premise, Wallen et al. (2022) conducted a study with 42 pigs to evaluate whether resuscitation with blood products could mitigate adverse physiological effects of post-injury flight, with control groups receiving lactated Ringer's or blood, exposed to varying altitudes. The authors found that cerebral perfusion, tissue oxygenation, and intracranial pressure remained unchanged between study groups. Moreover, crystalloid resuscitation during aeromedical transport can cause prolonged lactic acidosis and a pro-inflammatory response that may predispose multiply injured patients to secondary cellular injury. The study also suggests that this physiological insult can be avoided through resuscitation strategies involving blood products.

In turn, transfusion reactions, when they occur, are usually evident early in infusion. In cases of suspected reaction, transfusion should be immediately suspended, venous access maintained with 0.9% saline, vital signs assessed, reactions treated with medication therapy, the blood center notified, and the suspended bag forwarded for examination (NASCIMENTO et al., 2022).

Research involving pre-hospital data is challenging, not only due to clinical and logistical variability that impedes precise cohort matching, but also due to sample size and data collection issues. Isolated assessment of pre-hospital blood transfusion (PHBT) is particularly difficult, as multiple factors and developments in clinical practice impact patient outcomes, rendering samples susceptible to biases (Shand et al., 2019). Maximum attention must be given to accurately identifying patients requiring PHBT; however, with available tools for pre-hospital teams often limited, this identification remains complex (Plodr et al., 2023).

The shock index, defined as the ratio of heart rate to systolic blood pressure, is highlighted as a superior predictor of trauma outcome compared to vital signs alone (Plodr et al., 2023). According to the European Guideline on the treatment of severe bleeding and coagulopathy after trauma, the shock index can assess the severity of hypovolemic shock (Plodr et al., 2023). El-Menyar et al. (2018) established the optimal cutoff at 0.81 to predict massive transfusion in trauma patients (85% sensitivity, 64% specificity). Pulse pressure (PP), in turn, is defined as the difference between diastolic and systolic blood pressure. PP values decrease in bleeding patients in response to decreased intravascular volume (Plodr et al., 2023).

Parameters during the pre-hospital phase exhibit dynamics and variability, such as age, complicating final decision-making. This raises questions about the possibility of developing a unified algorithm for PHBT. Nevertheless, using the shock index and PP, which are easily calculable, can optimize decision-making processes and minimize the risk of unnecessary administration of a costly and rare product (Plodr et al., 2023).

The ABC score is a previously validated scoring system designed to predict which severely traumatized patients will require massive transfusion, considering injury type, systolic blood pressure, heart rate, and results from Focused Assessment with Sonography for Trauma (FAST) (Lima et al., 2021). According to Hanlin et al. (2023), implementation of the ABC score resulted in a 23% decrease in mortality. However, the authors note that the ABC score was developed and validated using hospital emergency department data, necessitating further studies to verify its sensitivity and specificity using pre-hospital data.

Regarding the use of crystalloids, previous practices advocating for rapid infusion in trauma have been associated with inflammatory disturbances resulting in systemic acquired coagulopathy with hemodilution, hypothermia, and hyperchloremic acidosis. Crystalloid use in the pre-hospital setting has also been linked to hyperfibrinolysis and increased mortality, prompting recommendations to restrict crystalloid use in favor of early administration of blood products (Brown et al., 2016). Red blood cell transfusion serves both as a volume expander and enhances oxygen-carrying capacity critical for cellular metabolism during hypoperfusion. It is increasingly evident that early intervention in the post-injury inflammatory cascade can have profound beneficial effects on outcomes (Brown et al., 2016).

Studies indicate that early activation of massive transfusion protocols can improve survival in trauma patients by up to 25%, with aeromedical services enhancing access to blood products (Cornellius et al., 2023). However, when covering large geographic areas, aeromedical services directly impact the time needed for support teams to reach the accident scene (Certain et al., 2023). A randomized study by Meyer et al. (2017) concluded that for each minute delay in blood product administration, there is a 5% increase in mortality risk. It is noteworthy that in regions where pre-hospital procedures have not been implemented, patients receive blood products only upon hospital admission, resulting in delays averaging 25 minutes (range: 12-59), not accounting for on-scene time (average: 43 minutes) and possible transfusion delays. Moreover, a 15-minute reduction in hemostasis time is associated with a decrease in 30-day mortality, underscoring the importance of early transfusion, which may be associated with increased survival (Certain et al., 2023).

Importantly, the direct use of low-titer group O whole blood or thawed plasma in pre-hospital transfusions is not provided for in current Brazilian legislation. According to Certain et al. (2023), the distribution of whole blood by blood centers necessitates restructuring of production and storage logistics, contingent on future governmental action. Furthermore, improving operational capacity and blood product storage would support this process (BEIRIGER et al., 2023).

4. ConclusION

Hemorrhage is the leading cause of preventable death in trauma victims, driving the increasingly frequent use of resuscitation strategies, including blood transfusion, in pre-hospital transport, including aeromedical services, where preliminary data suggest a positive impact on severely injured trauma victims.

The volume and strength of available evidence hinder precise evaluation of the intervention and definitive practical recommendations; however, transfusion of blood components during air transport has proven to be logistically feasible. Moreover, current studies suggest that a number of potentially preventable deaths could benefit from advanced volume resuscitation interventions. Thus, this study underscores the importance of conducting specific research for pre-hospital practice, necessary to guide evidence-based protocol development.

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