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Severe out-of-hospital hemorrhagic shock: experience of the first helicopter emergency medical service equipped for transfusions in Andalusia

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BACKGROUND. Early transfusion of packed red blood cells (PRBCs) could improve survival rates in hemorrhagic shock, but more evidence of safety and efficacy in prehospital settings is needed.

OBJECTIVE. To describe the experience of Andalusia's first helicopter emergency medical service (HEMS) equipped to give prehospital transfusions to patients with hemorrhagic shock.

MATERIAL AND METHODS. Retrospective observational study of 13 cases in which patients were transfused with type-O PRBCs during transport by the HEMS sent from the 061 emergency dispatchers of Malaga, Spain, between March 2022 and March 2024. We analyzed demographic and clinical variables, including severity scale assessments and mortality.

RESULTS. The mean patient age was 43 years, and 92.3% were men. The majority of injuries (69.2%) occurred during traffic accidents. Most patients had severe hemorrhagic shock (initial shock index, 1.56) secondary to multiple injuries involving the thorax, abdomen, and head. A median (interquartile range) of 1 unit (1-2 units) of type-O PRBCs was transfused before arrival at the hospital in each case. The shock index improved significantly to 1.02 (P = .0027) after prehospital transfusion, and no adverse events were registered. Overall mortality was 46.1%. The only significantly different variable between survivors and nonsurvivors was the trauma score (P = .0143). All the unused units of type-O PRBCs were reintroduced into the care circuit by the attending hospital.

CONCLUSIONS. Early prehospital transfusion of type-O PRBCs in patients in hemorrhagic shock due to severe trauma seems to be safe and potentially effective for initially stabilizing the patient and improving physiological parameters. More studies in larger cohorts are needed to confirm these preliminary findings.

Keywords: Hemorrhagic shock. Out-of-hospital/prehospital transfusion. Hemodynamic response. Survival. Safety. Helicopter emergency medical service. Wounds and injuries.

Transfusión extrahospitalaria en el shock hemorrágico grave: experiencia inicial del primer helicóptero medicalizado con capacidad transfusional de Andalucía

INTRODUCCIÓN. La transfusión precoz de concentrados de hematíes (CH) podría mejorar la supervivencia en *shock* hemorrágico, pero se requiere más evidencia sobre su seguridad y eficacia en el ámbito extrahospitalario.

OBJETIVO. Describir la experiencia inicial con la transfusión extrahospitalaria de CH en pacientes con *shock* hemorrágico severo secundario a traumatismo, atendidos por el primer helicóptero medicalizado andaluz con capacidad transfusional.

MATERIAL Y MÉTODOS. Estudio observacional retrospectivo de pacientes transfundidos con concentrados de hematíes 0– (CH0–) por el helicóptero medicalizado 061 de Málaga (HELMA) del Centro de Emergencias Sanitarias 061 (CES-061) de Andalucía, entre marzo de 2022 y marzo de 2024. Se registraron variables demográficas, clínicas, escalas de gravedad –Índice de *shock* (IS), *Trauma Score* y *Assessment of Blood Consumption* (ABC)– y mortalidad global.

RESULTADOS. Se registraron 13 casos, con una media de 43 años y un 92,3% varones. El mecanismo lesional predominante fueron los accidentes de tráfico (69,2%), presentando *shock* hemorrágico grave (IS inicial 1,56) secundario a politraumatismos con afectación toracoabdominal y traumatismo craneoencefálico. Se transfundió una mediana de 1 CH0– (RIC 1-2). Hubo una mejoría significativa del IS tras la transfusión prehospitalaria (IS 1,02 al ingreso hospitalario; p = 0,0027). No se registraron reacciones adversas postransfusionales. La mortalidad global fue del 46,1%. El *Trauma score* corregido fue significativamente menor en pacientes fallecidos (p = 0,0143). El 100% de los CH0– no transfundidos por HELMA fueron reintroducidos en el circuito asistencial hospitalario.

CONCLUSIONES. La transfusión precoz de CH0– en el ámbito extrahospitalario en pacientes con *shock* hemorrágico secundario a traumatismo grave es segura y potencialmente efectiva para la estabilización inicial, mejorando los parámetros fisiológicos. Se requieren estudios con mayor tamaño muestral para confirmar estos hallazgos preliminares.

Palabras clave: *Shock* hemorrágico. Transfusión extrahospitalaria/prehospitalaria. Respuesta hemodinámica. Supervivencia. Seguridad transfusional. Helicóptero medicalizado. Trauma.

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Introduction

Severe hemorrhagic shock due to trauma or exsanguinating hemorrhage is a life-threatening emergency that requires urgent interventions to restore blood volume, tissue oxygenation, hemodynamic stability, and to address potentially reversible causes of death.[1] Coagulopathy associated with massive hemorrhage is the main cause of multiple organ failure and death, which is potentially preventable if diagnosed and treated early.[2] It is estimated that nearly half of patients die before reaching the hospital,[3] making prehospital care crucial for the early identification and appropriate management of blood loss.[4,5]

In this context, it is a priority to control the source of bleeding via use of tourniquets or direct pressure, as well as to replace lost volume. Several studies have demonstrated higher mortality associated with aggressive infusion of crystalloids compared to early transfusion of blood components.[6-8]

Current evidence indicates that early replacement of red blood cells (RBCs) and coagulation factors may significantly improve survival in cases of hemorrhagic shock.[1,2,4] Deeb et al., in a randomized controlled trial, concluded that prehospital administration of packed RBC concentrates (PRBCs) and tranexamic acid was associated with reduced 30-day mortality, while the use of PRBCs alone was linked to decreased early mortality.[8] Other studies by Lyon *et al.*, Holcomb *et al.*, and Rehn *et al.* found that patients receiving prehospital RBC transfusions were significantly less likely to require in-hospital transfusions and that administration of this blood component in the prehospital setting was associated with greater survival upon hospital arrival.[9-11] However, recent clinical trials have yielded inconclusive results regarding optimal selection criteria for patients eligible for prehospital transfusion.[12] More studies are therefore needed to confirm its long-term efficacy and to identify individualized administration criteria.[8-13]

Despite this ongoing controversy, an increasing number of emergency systems are incorporating prehospital transfusion protocols for selected cases of massive hemorrhage, particularly when hospital transport times are prolonged.[14-17] Medical helicopters (HEMS) represent the ideal option due to their coverage and rapid response capability.

Following this trend, in 2021, the TREX project was created through collaboration between the Emergency Medical Services 061 (CES-061) of Andalusia and the Andalusian Network of Transfusion Medicine, establishing the Málaga HEMS unit as the first prehospital resource in Andalusia with transfusion capability. This unit began administering group O Rh-negative packed red blood cells (O_2 PRBCs) in the spring of 2022. Currently, efforts are underway to equip the remaining four HEMS units in Andalusia with the same transfusion capacity.

Endpoints

The primary endpoint of this study was to describe the clinical and outcome characteristics of patients who received prehospital O_2 PRBC transfusion for severe hemorrhagic shock in Andalusia to provide data to optimize protocols and patient selection.

Secondary endpoints:

– To evaluate the early hemodynamic response to transfusion as an indirect marker of procedure effectiveness and safety.

– To estimate in-hospital survival following prehospital O_2 PRBC transfusion.

– To identify potential complications associated with prehospital blood transfusion.

Materials and methods

Study design

We conducted a retrospective, observational, descriptive case series of patients requiring prehospital O_2 pRBC transfusion provided by the Málaga HEMS between March 2022 and March 2024.

Study population

All patients treated by HEMS Málaga 061 (HELMA061) who received prehospital O_2 pRBC transfusion for massive hemorrhage secondary to major trauma, aortic aneurysm, gastrointestinal hemorrhage, or obstetric bleeding were included.

Inclusion criteria: Patients with clinical and anatomical evidence of active severe bleeding, defined by:

– Shock Index (SI) > 0.9,[18] associated with anatomical findings indicative of massive hemorrhage, including visible profuse bleeding or other signs of exsanguination.

– "Assessment of Blood Consumption" (ABC) score > 2 points.[19] The ABC score predicts the need for massive blood transfusion in trauma patients based on objective clinical criteria: systolic blood pressure (SBP) > 90 mmHg, heart rate (HR) < 120 bpm, penetrating trauma, and positive FAST ultrasound. The total score correlates with the likelihood of requiring massive transfusion, providing a useful tool for rapid decision-making in emergencies (Figure 1).

Additionally, for patients without clear evidence of exsanguinating hemorrhage, persistent shock (SI > 0.9) after receiving up to 1,000 mL of 0.9% normal saline at body temperature was required before proceeding with transfusion.

Variables analyzed

The following variables were analyzed: age, sex, initial SI prior to transfusion, SI after transfusion, ABC predictive transfusion scale, blood test data (pH, calcium,[20] lactate,[21] hemoglobin, and hematocrit), severity scales (Modified Trauma Score, Glasgow Coma Scale), continuation of transfusion in the hospital, transfusion reaction, injury mechanism, diagnosis, and in-hospital survival.

Prehospital transfusion procedure

The Málaga 061 HEMS covers a region with approximately 2 million inhabitants, encompassing the entire province of Málaga and the western quadrant of Granada. It

Figure 1. Assessment of Blood Consumption (ABC) scale for evaluating the need for massive transfusion in trauma patients.


Figure 2. Passive transport cooler with six +4 °C cold stabilizers, monitored by a Data Logger with probe, positioned between both O_2 PRBCs.

carries 2 units of O_2 PRBCs stored in a passive portable cooler with continuous temperature monitoring, housed within a dedicated storage refrigerator (Figure 2). Upon activation, the team transfers the cooler to the helicopter before deployment. The transport cooler maintains a constant internal temperature between 2 °C and 6 °C. All O_2 PRBCs are supplied by the *Centro de Transfusiones, Tejidos y Células* (CTTC) (Málaga, Spain), without low-titer anti-A or anti-B testing, and are reverified upon arrival at the HEMS base.

This prehospital transfusion process follows a protocol jointly developed by the 061 Emergency Service and the Andalusian Transfusion Medicine Network, ensuring compliance with quality standards and current regulations.[22] Implementation required 2 stages: Validation: The CTTC Málaga provided blood solely for storage and transport testing, performing subsequent quality control and temperature certification, including contingency planning for power outages. Health Authorization: Granted by a medical inspector from the Andalusian Regional Ministry of Health, following an audit of agreements, documentation, staff training, and all transfusion process phases.

The protocol includes storage, preservation, and transport procedures, with input/output and temperature logs, administration guidelines (emphasizing predictive transfusion scales and checklists), traceability via Gricode wristbands, delivery of pretransfusion documentation to the designated hospital transfusion service, and replacement of units before expiration, ensuring the reintegration of unused O_2 PRBCs into the hospital circuit to avoid blood wastage.

Before transfusion, 1 g of tranexamic acid is administered,[23] and blood units are warmed using a validated portable heater (Belmont Buddy Lite). Routine measures to prevent hypothermia and activation of the Trauma Code are also performed. For the statistical analysis, SPSS software version 24.0 for Windows (SPSS Inc., Chicago, USA) was used. Qualitative variables were described using frequencies and percentages, and quantitative variables with the median and interquartile range. The analysis of qualitative variables was performed using the chi-square test or Fisher's exact test, as appropriate, and that of quantitative variables using the Mann–Whitney U test. Differences were considered statistically significant when the *P*-value was less than .05.

Results

A total of 13 cases were analyzed, with a median age of 43 years (IQR, 22–80); most patients were male (n = 12; 92.3%). No post-transfusion adverse reactions were recorded (Table 1).

The main mechanism of injury was traffic accidents (n = 9; 69.2%), including vehicle collisions, pedestrian impacts, and rollovers requiring extrication maneuvers in several cases.

The ABC score for most patients (n = 8; 61.5%) was 2 or 3, indicating a moderate risk of massive transfusion, while 4 patients (30.8%) were classified as high risk (ABC = 4).

All patients received fluid therapy with normal saline and RBC transfusion. A median of 1 RBC unit (IQR, 1–2) was transfused in the prehospital setting.

Physiological and severity parameters upon hospital admission reflected effective initial control of hemorrhagic shock, with adequate tissue perfusion in all cases. The mean initial SI was 1.56, decreasing to 1.02 upon hospital arrival, demonstrating effective early shock management (Figure 3). Comparison of SI values before and after prehospital transfusion showed a significant reduction (*P* = .002).

Of the 13 cases, 7 patients (53.9%) survived and were discharged from the hospital. Among the 6 deaths, four occurred during the early phase of care (at the scene, in the hospital critical care bay, or within the first 24 hours).

Comparative analysis between deceased and surviving patients revealed notable differences in several demographic and clinical variables (Figure 4). The deceased patients were older and had a lower corrected Trauma Score vs survivors, suggesting greater initial severity. In addition, the Glasgow Coma Scale (GCS) scores were higher among survivors. Although the initial SI was similar in both groups, a greater reduction was observed after pRBC transfusion in survivors (Figure 5). No differences were found in the ABC score across groups.

Only the corrected Trauma Score showed a statistically significant difference (U = 33, *P* = .0143), with mean values of 9.57 in survivors vs 5.00 in deceased patients (Table 2). Age, although notably higher in the deceased group (56 years) vs survivors (38.57 years), did not reach statistical significance (U = 10.50, *P* = .1526). The ABC score, initial and hospital SI, SI improvement rate, and GCS did not show significant differences. These data underscore the

Table 1. Demographic characteristics, initial status, and evolution of the 13 patients in the series

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9	Case 10	Case 11	Case 12	Case 13
Sex	Male	Male	Male	Female	Male	Male	Male	Male	Male	Male	Male	Male	Male
Age (years)	30	29	37	36	61	77	30	43	32	72	22	52	80
Injury mechanism	Run over. Supracondylar amputation of the left upper limb.	Stab wound to the neck involving the internal and external jugular veins.	Traffic accident: head-on collision with a car. Motorcyclist.	Traffic accident: road departure. Trapped.	Traffic accident: fall of vehicle from 4 meters. Trapped.	Work accident: fall-crush by tractor.	Fall from 15 meters.	Stab wounds to neck and chest.	Traffic accident: high-speed truck–car impact. Two fatalities.	Run over.	Traffic accident: vehicle fell from 2 meters.	Traffic accident: head-on collision with a car. Motorcyclist.	Traffic accident: frontolateral collision—car–truck rear-end. Trapped.
Initial status and actions by first emergency responder	Uncontrolled hemorrhage, ineffective tourniquet. IV fluids, 500 mL saline, 0.15 mg fentanyl.	Exsanguinating uncontrolled hemorrhage. IV fluids and direct compression.	Right pneumothorax, bilateral hemothorax, cervical and thoracic fractures, upper and lower right limb fractures. Positive EFAST (splenorenal). IV fluids, saline, 1 g tranexamic acid, sedation + intubation/ mechanical ventilation.	Trapped inside vehicle. Difficult extrication. Catastrophic leg with severe bleeding, head trauma, abdominal and pelvic injury.	Flail chest, pelvic and long bone fractures. Trapped in vehicle. Complicated extrication.	Unconscious and breathing with difficulty. Bleeding from multiple wounds. Open thoracic and abdominal trauma, open fractures of left femur and humerus. Witnessed CA due to PEA, CPR performed.	Bilateral pneumothorax, head trauma, pelvic and lower limb fractures. SI, 1.26; ABC, 21; GCS, 3; RTS, 4. IV fluids, 1 g tranexamic acid, sedation-analgesia and relaxation + OTI/ventilation.	Right pneumothorax. 2 IV fluid boluses, 1 g tranexamic acid.		Open fracture of right lower limb, crush fracture of both lower limbs, pelvic fracture. 2 IV fluid boluses, 1 g tranexamic acid.	Head trauma, open fracture of left upper limb. IV fluids, immobilization. PCR performing CPR maneuvers for 25 minutes.	Tension pneumothorax, hemothorax, flail chest. Positive abdominal EFAST.	
Initial status and actions performed by HELMA061	Tachypneic, SpO_2 91%, HR 140 bpm, BP 70/40 mmHg. SI, 2, ABC 4, GCS 8 (E2, V2, M4), RTS 9. 2nd tourniquet applied for bleeding control. Second IV line inserted. 1 g tranexamic acid, sedation + OTI/MV. Transfusion: 1st unit PRBC on site; 2nd during air transfer.	Tachypneic, SpO_2 89%, HR 136 bpm, BP 90/60 mmHg. SI, 1.51, ABC 4, GCS 11 (E3, V4, M4), RTS 11. Peripheral IV line and direct compression applied. Laboratory results: pH 7.2, lactate 7.46, hematocrit 37, hemoglobin 12.45. Treatment: 1 g tranexamic acid, fentanyl, sedation, airway secured. Transfusion: 1st unit of PRBCs on site; 2nd during air transfer.	No exsanguinating hemorrhage. Orotracheal intubation/ mechanical ventilation. SpO_2 91%, $EtCO_2$ 40 mmHg, HR 118 bpm, BP 75/55 mmHg. SI, 1.57, ABC 3, GCS 3, RTS 9. Laboratory results: pH 7.6, lactate 2.1, potassium 2.6, calcium 0.81, hematocrit 32.5, hemoglobin 10.6. Treatment: 1 g tranexamic acid. Transfusion: 2 units of PRBCs	Tachypneic (female), SpO_2 87%, HR 121 bpm, BP 70/40 mmHg. SI,1.7, ABC 3, GCS 3, RTS 4. Treatment: Peripheral IV line, sedation–analgesia and muscle relaxation, followed by orotracheal intubation/ mechanical ventilation. 1 g tranexamic acid. Transfusion: 1 unit of PRBCs	SpO_2 91%, HR 129 bpm, BP 79/35 mmHg. SI,1.61, ABC 2, GCS 8, RTS 8. Cardiac arrest during care due to PEA, with ROSC after advanced CPR. 2 peripheral IV lines established, 1 g tranexamic acid administered. Transfusion: 1 unit of PRBCs	Advanced CPR continued. 2 peripheral IV lines and 1 intraosseous access established. 1 g tranexamic acid administered. Transfusion: 1 unit of PRBCs. Bilateral thoracotomy and pericardiocentesis performed.	SI and ABC unchanged after infusion of warm saline. Laboratory results: pH 7.04, lactate 10.8, hemoglobin 14.3, hematocrit 42. Transfusion: 1st unit of PRBCs on site; 2nd during air transfer.	SI,1.02, ABC 2, GCS 15, RTS 12. Transfusion: 1 unit of PRBCs during air transfer.	Polytrauma: head, abdominal, and pelvic trauma; bilateral femur fractures. SI, 1.48, ABC 3, GCS 3, RTS 10. Two peripheral IV lines; sedation–analgesia and muscle relaxation followed by orotracheal intubation/ mechanical ventilation (SpO_2 98%, $EtCO_2$ 35 mmHg). 1 g tranexamic acid administered. Transfusion: 2 units of PRBCs	SI, 1.2, ABCE 4, GCS 14, RTS 10. Transfusion: 2 units of PRBCs.	SI, 1.14, ABC 3, GCS 7, RTS 10. Sedation–analgesia and muscle relaxation followed by OTI/MV (SpO_2 99%, $EtCO_2$ 36 mmHg). Transfusion: 1 unit of PRBCs. 1 g tranexamic acid administered.	Advanced CPR continued, with ROSC at 25 minutes (total arrest time: 50 minutes). Pneumothorax drainage performed. Norepinephrine infusion initiated. SI 1.38, ABC 4, GCS 3, RTS 2. Laboratory results: pH 6.9, lactate 19.59, calcium 1.26, hemoglobin 16.3, hematocrit 48.	Trapped; difficult extrication. Left-sided otorrhagia, thoracic and abdominal trauma. Shock Index 2.62, ABC 2, GCS 4, RTS 10. Peripheral IV line; warm saline infusion; 1 g tranexamic acid; sedation–analgesia and muscle relaxation followed by OTI/MV. Transfusion: 2 units of PRBCs.

Condition on hospital admission	OTI/MV, SpO_2 > 95%, $EtCO_2$ 32 mmHg, HR 100 bpm, BP 110/70 mmHg, SI 0.9. 1 g tranexamic acid + TV + antibiotics. Required transfusion of 4 PRBC units during hospital stay.	OTI/MV, SpO_2 100%, $EtCO_2$ 33 mmHg, HR 120 bpm, BP 130/90 mmHg, SI 0.92. 1 g tranexamic acid + 2 g fibrinogen + antibiotics. Required 1 PRBC unit during hospital stay.	OTI/MV, SpO_2 98%, $EtCO_2$ 40 mmHg, HR 120 bpm, BP 110/67 mmHg, SI 1.09. Transfusion: 1 PRBC + 1 FFP in critical care unit. Whole-body CT without bleeding source —> spinal shock.	OTI/MV, SpO_2 90%, $EtCO_2$ 32 mmHg, HR 87 bpm, BP 98/68 mmHg, SI 0.88. Transfusion: 1 PRBC in critical care unit.	New CA due to PEA in the critical care unit. Advanced CPR performed, along with transfusion of 1 unit of PRBC, 1 g tranexamic acid, and 1 ampoule of calcium chloride.		OTI/MV, HR 120 bpm, BP 110/70 mmHg, SI 1.09.	HR 100 bpm, BP 110/60 mmHg, SI 1.0. Antibiotics administered. Transfusion: 1 PRBC in critical care unit.	HR 100 bpm, BP 120/40 mmHg, SI 1.0. Transfusion: platelets and plasma + 1 g tranexamic acid + 2 g fibrinogen in critical care unit. During hospitalization, transfusion of 2 PRBC units.	SI 0.61. Antibiotics administered. Transfusion: 2 PRBC units + plasma, 1 g tranexamic acid, 2 g fibrinogen, and calcium chloride in critical care unit.	OTI/MV, HR 115 bpm, SBP 140 mmHg, SI 0.82. Transfusion: 1 PRBC + 1 g tranexamic acid. During hospitalization, 2 additional PRBC units transfused.	OTI/MV, HR 121 bpm, BP 60/30 mmHg, SI 2.01. New CA in ICU. Advanced CPR + transfusion (2 PRBC + 1 g tranexamic acid + 2 g fibrinogen + prothrombin complex). Bilateral hemopneumothorax drainage (ineffective).	OTI/MV, HR 130 bpm, SBP 70 mmHg, SI 1.85. Antibiotics administered. Transfusion: 1 PRBC + 2 g fibrinogen + 1 g tranexamic acid in critical care unit. Left pneumothorax drainage performed.
Outcome	Alive at discharge.	Alive at discharge.	Alive at discharge.	Death within 24 hours.	Death in critical care unit.	*Death on site.*	Death one month after admission.	Alive at discharge.	Alive at discharge.	Alive at discharge.	Alive at discharge.	Death in critical care unit.	Death one month after admission.

The text in red indicates the administration of packed red blood cells (PRBC) and the text in orange indicates the transfusion of other blood products. The patients treated were referred to the appropriate trauma hospital: Virgen de la Victoria University Hospital in Malaga (3 cases), Malaga Regional University Hospital (4), Virgen del Rocío University Hospital in Seville (1), and Neurotraumatology and Rehabilitation Hospital in Granada (4).
CA: cardiac arrest; PEA: pulsed electrical activity; CPR: cardiopulmonary resuscitation; IV: intravenous; OTI: orotracheal intubation; HR: heart rate; BP: blood pressure; MV: mechanical ventilation; SpO_2: oxygen saturation; $EtCO_2$: End-Tidal Carbon Dioxide; ROSC: return of spontaneous circulation; TV: tetanus vaccination; FFP: fresh frozen plasma; SBP: systolic blood pressure; ICU: intensive care unit.

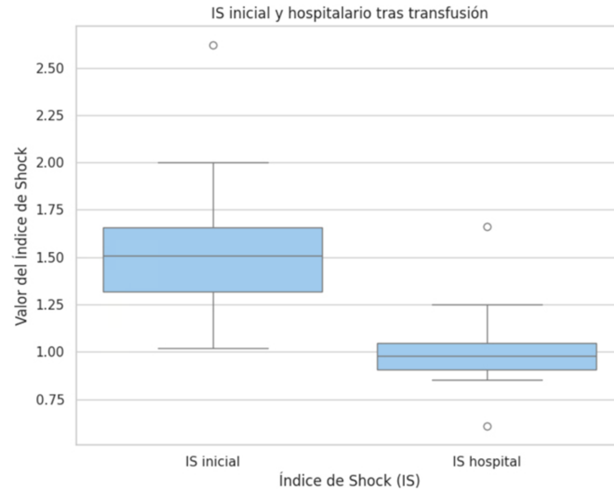

Figure 3. Impact of transfusion on Shock Index (SI) values at baseline and upon hospital arrival.

importance of the corrected Trauma Score as a predictor of mortality in this cohort and suggest that the other variables, although showing observable trends, lack the same discriminative power for survival outcomes in this specific context.

During the implementation of the prehospital transfusion program, several operational improvement points were identified, leading to the following modifications:

– Case 1: No pretransfusion bloodwork was performed, and there was a delay in the replenishment of RBC units at the Málaga CTTC, temporarily limiting helicopter availability. To optimize this process, transfusion center contact information was added to the operational checklist, enabling the team to report RBC use and request replacements more efficiently.

– Case 3: The patient had neurogenic shock, not hemorrhagic, and therefore probably did not require transfusion. However, the patient met criteria for early transfusion therapy due to hemodynamic instability and severe injury mechanism.[18,19,24-26]

– Case 4: The first O_2 PRBC unit was transfused while entering the hospital critical care bay, leaving the second unit in the helicopter. This caused a delay in in-hospital transfusion continuity because new blood had not yet arrived from the blood bank. To ensure continuity of care, the protocol was modified so that any unused second O_2 unit is left in the critical care bay.

– Case 5: A failure to replace PRBC units occurred after their use in another transfusion the previous day. As a result, logistics were updated to ensure replenishment immediately after each transfusion.

– Case 10: The helicopter acted as a mobile blood bank, transporting blood products requested by a ground emergency unit of CES-061 attending the same incident.

Discussion

The implementation of early PRBC transfusion in prehospital settings for patients with hypovolemic shock secondary to major trauma represents a significant logistical

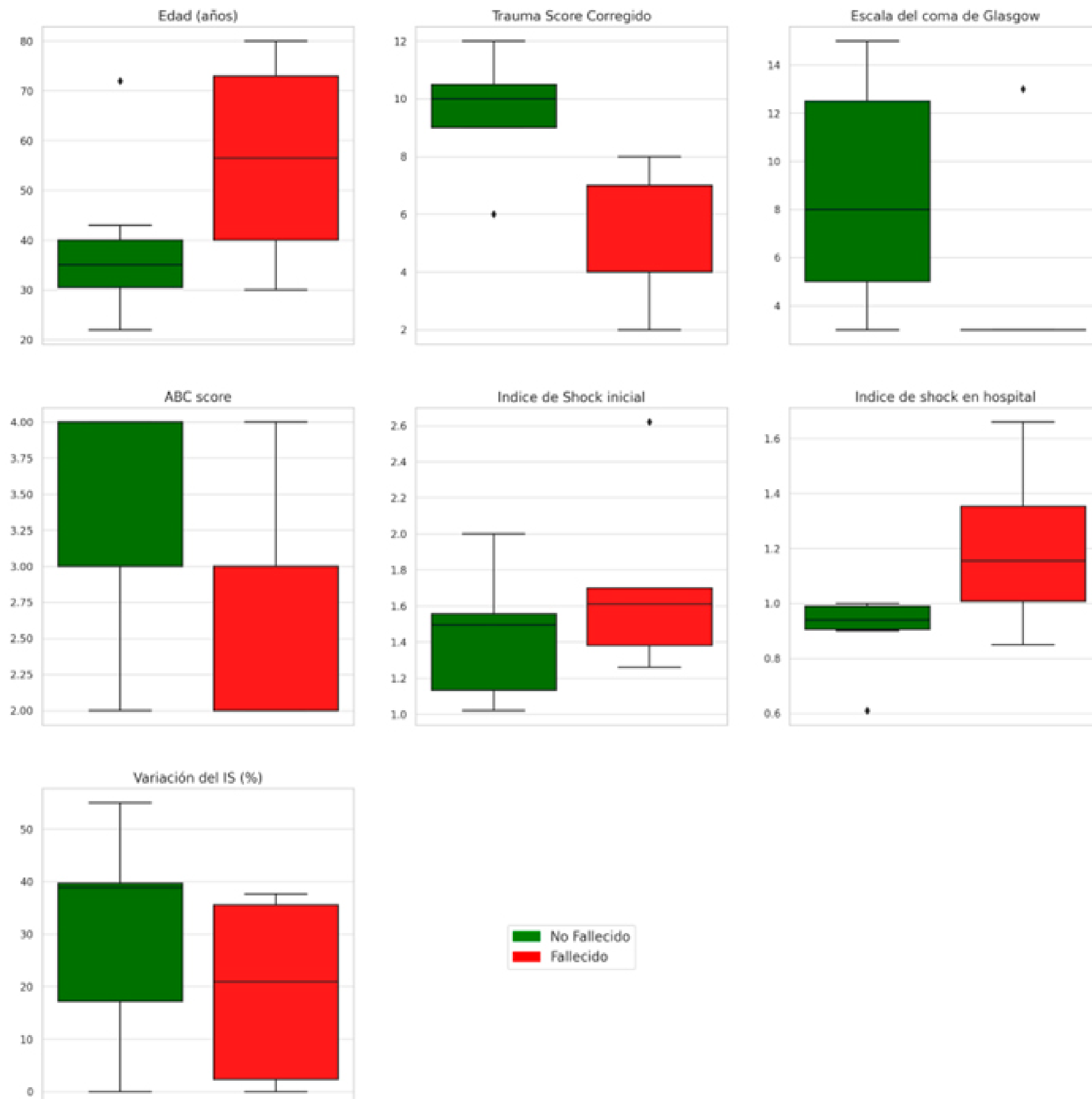

Figure 4. Comparison of clinical parameters in patients with hemorrhagic shock who received prehospital transfusion: survivors vs deceased.

and clinical challenge, yet it is crucial for initial management of these emergencies. The results of this series demonstrate the feasibility and potential benefit of this intervention, with no associated post-transfusion adverse reactions, highlighting its safety in prehospital conditions. In Spain, there is currently no formal regulation for prehospital transfusions in emergencies, only certain recommendations for planned home transfusions,[27] which equires the development of specific agreements and protocols between prehospital emergency services and regional health authorities, resulting in some variability among regions.

The main limitation of this descriptive study is its small sample size. Nevertheless, the findings are consistent with those published by other HEMS services with greater experience.[9,25,28,29] This study contributes a real-world Spanish perspective on the effectiveness of early PRBC transfusion in prehospital emergency settings for trauma-induced hypovolemic shock. Despite its limitations, the data are valuable for identifying areas for improvement in prehospital critical care, although generalization awaits larger, multicenter studies.

The predominance of young male patients, with a median age of 43 years, reflects known epidemiological patterns of severe trauma, typically associated with traffic accidents. This demographic profile underscores the importance of rapid, efficient response systems to mitigate the impact of traumatic injuries in this population, which carries high morbidity and mortality.

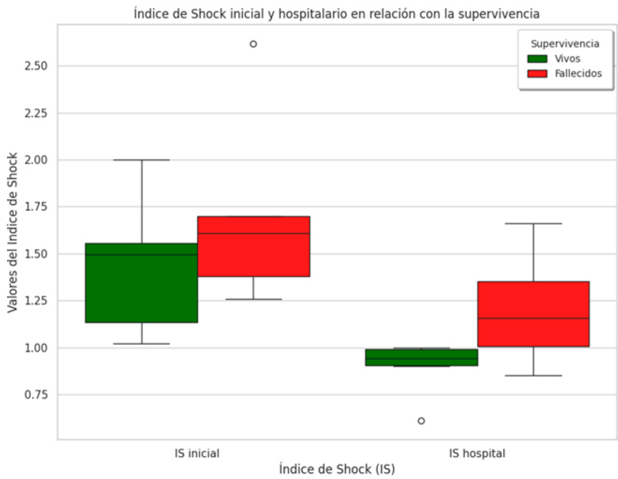

Figure 5. Shock Index dynamics during initial assessment and upon hospital arrival after prehospital transfusion: comparison between survivors and deceased patients.
The figure shows the distribution of Shock Index (SI) values during the initial on-site assessment and upon hospital arrival following prehospital transfusion of packed red blood cells, comparing surviving (green) and deceased (red) patients. The box plots display the median, quartiles, and outliers (indicated as dots beyond the whiskers), providing a visual interpretation of the data spread and central tendency.

The corrected Trauma Score emerged as a significant predictor of mortality, distinguishing survivors from non-survivors where other clinical or demographic variables did not reach statistical significance. The significantly higher corrected Trauma Scores among survivors reinforce its predictive value and emphasize the importance of aggressive management in patients with low scores. This finding supports the use of clinical assessment tools to guide therapeutic decisions in prehospital care. Nonetheless, the development and validation of more robust predictive models integrating multiple variables could enhance risk stratification and personalized management in these critical scenarios.

The efficacy of early transfusion is suggested by the improvement in physiological and severity parameters, particularly the significant reduction in SI from the scene to hospital arrival. This early improvement is essential, as it establishes a bridge toward definitive stabilization and surgical management at the hospital, thereby reducing mortality and improving long-term outcomes. However, the 46.1% mortality rate in this series highlights the severity of trauma-related hypovolemic shock and the need for ongoing refinement of clinical management strategies.

The absence of post-transfusion adverse reactions is encouraging, indicating that early RBC transfusion in prehospital emergency conditions is safe. Continuous monitoring and systematic data collection on the safety and outcomes of these interventions are essential to confirm these preliminary findings and to support their inclusion in clinical practice guidelines.

Table 2. Comparison of parameters and evaluation of results between surviving and deceased patients

	Survivors		Deceased		Mann-Whitney U	
	Mean	Standard deviation	Mean	Standard deviation	U Statistic	P value
Age (years)	38.57	16.11	56.00	20.66	10.50	.1526
ABC score	3.29	0.76	2.60	0.89	25.50	.1980
Initial IS	1.43	0.37	1.71	0.54	10.00	.4102
Hospital IS	0.90	0.15	1.21	0.34	5.00	.1645
Increase rate IS (%)	29.64	20.74	19.38	18.19	30.00	.2221
Corrected Trauma Score	9.57	1.90	5.00	2.45	33.00	.0143
Glasgow Coma Scale	8.71	4.86	4.67	4.08	32.00	.1030
Transfused bags	1.71	0.49	1.50	0.55	25.50	.4990

ABC: Assessment of Blood Consumption; IS: Shock Index.

The operational observations and adjustments identified during implementation reflect a process of continuous learning and adaptation necessary to optimize prehospital emergency care. From PRBC replenishment logistics to coordination with transfusion centers and ensuring in-hospital care continuity, every detail must be meticulously managed to maximize the effectiveness of this life-saving intervention.

Currently, there is a growing trend toward the use of whole blood as the primary component for managing exsanguinating hemorrhage, associated with lower mortality rates.[30-32] The lack of whole blood use in our referral hospitals precludes its incorporation into the prehospital transfusion program, as unused units nearing expiration could not be reintroduced into hospital circulation, resulting in blood product loss. Joint hospital-prehospital programs are required to implement this approach—an initiative that is already underway in several neighboring countries.[33,34]

In conclusion, our experience with early prehospital O_2 PRBC transfusion demonstrates that, despite logistical and operational challenges, this can be a safe and potentially effective strategy—when based on a well-defined process—to improve survival in patients with trauma-induced hypovolemic shock. It also underscores the need for further research to overcome the limitations of small sample size and to deepen understanding of factors influencing fatal outcomes in these critically ill patients.

A multidisciplinary approach involving close collaboration among emergency, transfusion, and hospital services is essential to optimize outcomes. Future research should aim to expand the evidence base on the efficacy of this intervention, ideally through prospective, multicenter studies, to validate and refine clinical practice guidelines for this critical aspect of emergency medicine.

ARTICLE INFORMATION

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