Prehospital blunt traumatic arrest resuscitation augmented by whole blood: a case report

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BACKGROUND: Prehospital hemorrhagic shock accounts for approximately 25,000 civilian deaths annually in the United States. A balanced, blood-based resuscitation strategy is hypothesized to be the optimal treatment for these patients. Due to logistical constraints, delivering a balanced, blood-based resuscitation is difficult in the prehospital setting. A low titer O^+ whole blood (LTO^+WB) ground ambulance initiative, may help alleviate this capability gap.

CASE REPORT: A 37-year-old female was involved in a motor vehicle collision at approximately 16:30. While she was trapped inside the vehicle, her mental status deteriorated. The patient was successfully extricated at 17:04 and found to be in cardiac arrest. The paramedics and firefighters quickly secured her airway and applied a mechanical CPR device. The first responder team obtained return of spontaneous circulation, but the patient's blood pressure was 43/27 mmHg. The paramedics transfused one unit of LTO^+WB. Twenty-one minutes after the initial LTO^+WB transfusion, the air ambulance team transfused a second unit of LTO^+WB. Upon hospital arrival, the transfusion was completed, and the patient's shock index improved to 1.0. The trauma team identified a grade 5 splenic injury with active extravasation. Interventional radiology performed an angiogram and successfully embolized the tertiary branches of the inferior splenic pole. She was extubated on postinjury Day one and discharged to her home neurologically intact on postinjury Day 12.

CONCLUSION: The prehospital availability of LTO^+WB may enhance the resuscitation of critically ill trauma patients.

Prehospital hemorrhagic shock accounts for approximately 25,000 civilian deaths annually in the United States.[1] A balanced, blood-based resuscitation strategy is hypothesized to be the optimal treatment for these patients.[1,2] Unfortunately, providing a balanced, blood-based resuscitation in the prehospital setting is challenging. To mitigate this capability gap, the San Antonio Medical Foundation, South Texas Blood and Tissue Center (STBTC), UT Health San Antonio, University Hospital, San Antonio Military Medical Center, US Army Institute for Surgical Research and Southwest Texas Regional Advisory Council for Trauma collaborated to incorporate cold-stored low-titer ORhD-positive whole blood (LTO^+WB) into all phases of their trauma system, including both air and ground ambulances.[3]

In this paper, we discuss the case of a patient who received transfusions of LTO^+WB from both ground and air ambulance providers. The rapid prehospital transfusion of 2 units of LTO^+WB resulted in the patient arriving to the trauma bay hemodynamically stable despite a prehospital cardiac arrest. This case highlights the ability of a region-wide prehospital whole blood program to provide early, aggressive, balanced blood-based resuscitation to critically ill trauma patients with hemorrhagic shock. Our team utilized the CAse REport (CARE) guidelines to report this case, and the patient provided her informed consent.[4]

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CASE REPORT

A 37-year-old female with no relevant medical history was involved in a motor vehicle collision at approximately 16:30. Due to traffic delays, the EMS unit arrived at 16:44 and found firefighters attempting to gain access to a patient trapped inside her vehicle. The vehicle was laying passenger side down in a water-filled ditch. At this point, the firefighters had not performed any medical care on the patient. At 16:49, EMS conducted a limited assessment of the patient, determined her GCS to be 14, and noted the pallor of her face. The only visible injury at that time was a right facial laceration. Due to the suspected severity of her unseen injuries, projected duration of her extraction, and rush hour traffic, San Antonio Fire Department (SAFD) EMS requested a helicopter EMS (HEMS) unit to the scene.

The patient's mental status began to deteriorate during the extrication. By 16:57, the patient was unresponsive and started to have labored breathing that precipitously transitioned into agonal respirations. Due to the decline in her clinical condition, the focus of the firefighters and paramedics became rapid extraction from the vehicle. The prehospital team successfully extricated the patient at 17:04. On repeat examination, the paramedics determined the patient was in pulseless electrical activity (PEA) arrest. The prehospital team began to bag the patient and quickly secured her airway by direct laryngoscopy. Immediately after that, they applied a mechanical CPR device. The first responder team obtained return of spontaneous circulation, but the patient's blood pressure was 43/27 mmHg. At 17:09, the paramedics began transfusing one unit (approximately 520 mL) of LTO$^+$WB. During the transfusion, her blood pressure improved to 81/46 mm Hg, she began blinking her eyes, and she started to move her extremities. SAFD EMS finished transfusing the first unit of LTO$^+$WB and then transferred patient care to the AirLIFE HEMS team at 17:16.

By 17:24, the air ambulance was on the way to the trauma center. Although her blood pressure had improved to 99/61 mmHg, her pulse was 131 beats per minute, equating to a shock index of 1.3. According to the regional air ambulance whole blood protocol, the patient's pulse over 120 beats per minute in combination with a shock index of greater than 1.0 made her a candidate for whole blood transfusion. In response to these physiologic criteria, the air ambulance medical team transfused the second unit of LTO$^+$WB. The air ambulance team completed the transfusion prior to arriving at the trauma center. On arrival to the trauma bay at 17:35, the patient's blood pressure was 112/62 mmHg with a pulse of 108 beats per minute. Figure 1 provides a timeline of interventions and milestones during the prehospital resuscitation.

Upon hospital arrival, the trauma team identified that the patient had a Grade 5 splenic injury with active extravasation (Fig. 2). During her trauma bay resuscitation, the patient received one unit of RBCs and one unit of FFP. Interventional radiology performed an angiogram and successfully embolized the tertiary branches of the inferior splenic pole. During the procedure, the patient received one additional unit of RBCs, 3.3 liters of crystalloid, and 1 L of albumin. In addition to her Grade 5 splenic injury, the patient had multiple nonoperative facial fractures, multiple spinal fractures, a rib fracture, and a spinal epidural hematoma. The patient was successfully extubated on postinjury Day 1. On postinjury Day 12, the patient was discharged, neurologically intact, to her home. The patient's blood type was O$^+$.

DISCUSSION

Ground ambulance whole blood initiative setting and design

The SAFD is the sole emergency medical services provider for a population of approximately 1.5 million people spread over a

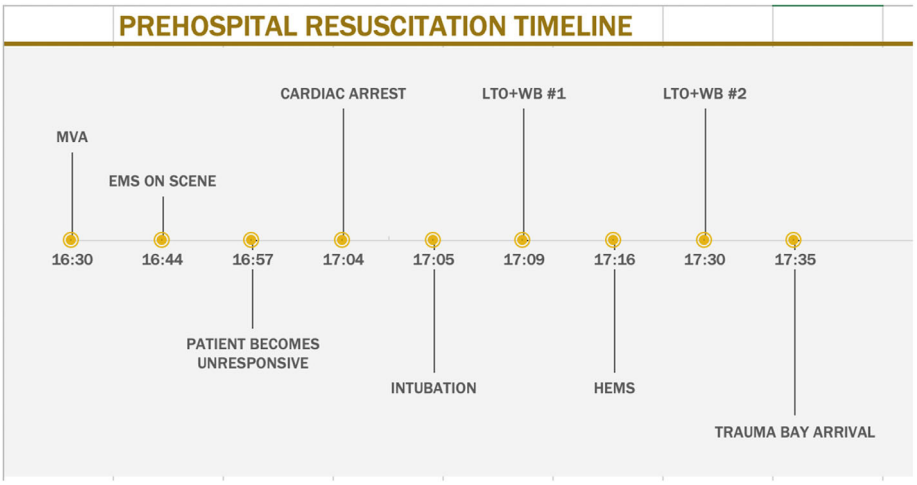

Fig. 1. Prehospital resuscitation timeline. [Color figure can be viewed at wileyonlinelibrary.com]

Fig. 2. Initial CT imaging. This figure depicts the patient's splenic injury that precipitated her hemorrhagic shock and eventual traumatic cardiac arrest.

460-square-mile area. The UT Health SA, Department of Emergency Health Services Office of the Medical Director (OMD), provides medical direction for the SAFD. The UT Health SA OMD reviews all trauma activations as part of an ongoing performance improvement project. The city of San Antonio has two Level 1 trauma centers and no Level 2 trauma centers.

The SAFD EMS operational plan to deliver LTO$^+$WB includes deploying one unit of LTO$^+$WB on EMS physician response vehicles, Medic Officer (MOF) vehicles, and Medical Special Operations Units (MSOU) mobile intensive care ambulances. In our system, a MOF is an SAFD Lieutenant tasked with supervising the EMS units in a quadrant of the city. Our two MSOUs are designed to deploy in support of law enforcement operations, hazardous materials exposure, and helicopter rescue operations. However, the vast majority of their day-to-day responsibilities remains responding to traditional emergency medical dispatches.

The supervisor vehicles that carry whole blood respond to trauma patients that meet predetermined inclusion criteria. The inclusion criteria are trauma activations (determined by local trauma triage guidelines) with signs of significant hypoperfusion. In our system, we define significant hypoperfusion as systolic blood pressure (SBP) < 70 mmHg OR SBP < 90 mmHg with a pulse of 110 beats per minute or greater OR end-tidal carbon dioxide ($ETCO_2$) < 25 mmHg. We include all witnessed traumatic cardiac arrests and patients with less than 5 minutes of traumatic cardiac arrest. Physician approval is not required for prehospital LTO$^+$WB transfusion.

The SAFD obtains the LTO$^+$WB from the STBTC. If the SAFD does not transfuse the unit within 14 days, they exchange it at the STBTC for a new unit of LTO$^+$WB. The STBTC then sends the LTO$^+$WB unit that was in prehospital circulation to a local trauma center for utilization. SAFD EMS transports blood products in Credo Golden Hour Mobile Series 4 2 L EMT coolers (Pelican BioThermal). SAFD deploys the QinFlow Warrior IV fluid warmers (QinFlow Inc.) and two pressure systems to administer prehospital blood products. The pressure systems currently in use are the Ventlab disposable pressure infuser (SunMed LLC) and the Braun Y-type blood set with an inline handpump (B. Braun Medical Inc.).

Whole blood for traumatic cardiac arrest rationale

Despite popular misconceptions, traumatic cardiac arrest resuscitations are not futile.[5–9] When the UT Health San Antonio, Department of Emergency Health Services, OMD designed the SAFD EMS prehospital LTO$^+$WB transfusion protocols, we envisioned the case of non-compressible torso hemorrhage causing a traumatic cardiac arrest. The team believed the judicious application of prehospital LTO$^+$WB had the potential to reduce mortality in this cohort of patients. It is unclear if this particular patient would have survived her injuries without the prehospital transfusion of LTO$^+$WB.

LIMITATIONS

This case is limited in its generalizability secondary to the logistics of our region-wide prehospital whole blood program and the regulatory framework of EMS medical direction in Texas. The state of Texas is unique in that it is a delegated medical practice state. As a result of this policy, an individual EMS medical director has the autonomy to implement new protocols and service lines. While this flexibility has its benefits, it also makes regional and state coordination challenging. As evidenced by this case, transfusion triggers differ among EMS systems in our region. This variance illustrates the discrepancy among medical directors as to which patients would benefit most from this therapy. Finally, including women of childbearing age in a prehospital LTO$^+$WB initiative remains controversial due to the

risk of alloimmunization. However, the relevant stakeholders in our region made the collective decision that the potential benefits of including all women in such a program outweighs the risks.[10]

CONCLUSION

A patient with out-of-hospital blunt traumatic cardiac arrest due to non-compressible hemorrhagic shock received two units of $LTO^{+}WB$ before arriving at the hospital. On hospital arrival, the patient was deemed stable enough to be treated by interventional radiology and was discharged neurologically intact on post-injury Day 12. The prehospital availability of $LTO^{+}WB$ may facilitate the appropriate resuscitation of critically ill trauma patients.

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CONFLICT OF INTEREST

The authors have disclosed no conflicts of interest.

AUTHOR CONTRIBUTIONS

JM drafted the original manuscript. All authors critically reviewed and edited the case report. JM takes responsibility for the paper as a whole.

DISCLAIMER

The views expressed in this article are those of the author(s) and do not reflect the official policy or position of the city of San Antonio, the U.S. Army Medical Department, Department of the Army, DoD, or the U.S. Government.

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