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Can heroic roadside care save lives?

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Prehospital emergency care is an important part of trauma systems across the USA and the world. From a once 'load and go' service, the provider's skillsets and scope of practice have evolved to include multiple procedures that can be performed in the field. It is still debated if performing some prehospital procedures contributes to improved patient outcomes after traumatic injury and saves lives. The topic was debated at the 40th Annual Point/Counterpoint Acute Care Surgery Conference.

Level of evidence: III

INTRODUCTION

Prehospital care consisting of Emergency Medical Service (EMS) and bystanders can provide lifesaving care to patients in need. In trauma, prehospital care provided by EMS has been invaluable in stabilizing injured patients en route to the hospital. Since the advent of the first EMS systems during the 19th century under Napoleon, major advances have occurred in the prehospital management of traumatically injured patients.1 Lessons learned from the military have aided in the advances of civilian EMS treatments.^{2 3} In the 1960s, traumatic injury was identified as a public health crisis, and subsequent evaluations of the health and financial cost of trauma became obvious.⁴ The increase in violent crimes and deaths from gunshot wounds (GSWs) across the USA is now also considered a public health crisis.5

The overall goal of prehospital care was to deliver patients to the hospital within the 'golden hour'. This was defined as the first hour after traumatic injury, the most critical period of patient care in which resuscitation was initiated and definitive care was rendered.⁶ In the military, the golden hour mandate in 2009 demonstrated that transfer to definitive care within 60 min had a profound decrease in mortality.7 Delays in transport and treatment can increase morbidity and mortality for patients; although, more recent research has replaced the golden rule with an emphasis on rapid transport, taking every minute of delay into consideration.89 Fortunately, 91% of USA residents have access to a trauma center within 60 min by ground and air.¹⁰ Despite this level of access, transportation to a hospital is still a major challenge, and prehospital care and education remain paramount to patient survival. Basic life support instruction, including the use of an automated external defibrillator (AED), is available to the public so that they can provide life-saving cardiopulmonary resuscitation (CPR) for individuals suffering from cardiac arrest. Similarly, programs like Stop the Bleed are designed

for bystanders to be able to provide hemorrhage control after injury until EMS arrives or until the patient can be transported to the hospital.¹¹

Research has led to several advances in field care, including protocols for prehospital tranexamic acid and whole blood transfusion, field deployment of highly trained physicians, and use of resuscitative endovascular balloon occlusion of the aorta (REBOA) in appropriate settings. There is debate regarding whether procedures in the field delay transport to the hospital, leading to worse outcomes.¹² Studies in certain major cities have evaluated transport to trauma centers by non-EMS personnel demonstrating improved survival for trauma patients with penetrating wounds transported by non-EMS personnel and private vehicle.¹³¹⁴ The question remains as to how much prehospital care should be delivered prior to transport and if this results in lives being saved. Additionally, are there major prehospital procedures that represent an extension of hospital care that can be or should be performed in traumatically injured patients?

This conference proceeding summarizes the arguments and evidence discussed at the 40 Annual Point/Counterpoint Acute Care Surgery Conference.

HEROIC CARE WILL SAVE LIVES Dr Samuel Galvagno, DO, PhD, Professor of Anesthesiology, University of Maryland Medical Center

There is a critical role of prehospital interventions in potentially saving lives, especially for patients located far from trauma centers (Online supplemental file 2). Prehospital care can represent an extension of hospital care to the community and bring critically injured patients back to the hospital expeditiously. From an epidemiologic standpoint, there has been a decrease in unintentional injuries with millions of lives saved due to advances in trauma care and preventative strategies. Looking at data from death in the population, there has been a steady downtrend, but in the last 10 years, there has been a small uptrend in deaths due to motor vehicle crashes. The question that should be asked is, have we plateaued in our care and can we push this to zero deaths? There may be instances where heroic roadside care can push this down.

Delayed transport to the trauma center is agreed on as the wrong thing to do for patients. Data suggest that the longer a patient remains in the field that there is increased risk of death, but the argument today focuses on those patients who are not near a trauma center. Being in close proximity to a trauma center has been demonstrated by Dr. Haut and colleagues to have improved outcomes. Ground transport is imperative, but air transport via helicopter has also made a significant difference in the prehospital care of trauma patients. It is not simply the transport but also the measures that can be done while in transport that contribute to the life-saving care including things like whole blood.

We talk about patients not in proximity to a trauma center and in such present this case. A patient was involved in a trauma on the Eastern Shore. The Injury Severity Score was 66. The University of Maryland, Shock Trauma Center (STC) Go-Team was activated but was canceled en route. During the prolonged extraction, the patient received 9 L of crystalloid. After extraction, the patient was noted to have severe trauma to the pelvis and extremities. Fluids were given because that was all EMS had in the field; they did not have blood. They were taken to a local facility and underwent an exploratory laparotomy, pelvic packing, and exploration of the left lower extremity. Their resuscitation consisted of 19 units of blood and 2 units of fresh frozen plasma. The patient was transferred to the STC and underwent multiple operations. Unfortunately, they developed acute respiratory distress syndrome with progressive acidosis and succumbed to the injuries. We can ask the question: what if we had not been canceled, were able to get to the patient to help with the resuscitation, give blood, and get that patient to the STC? Would their outcome be different? In another scenario in which a patient is crushed and trapped, the deployment of the Go-Team assisted with resuscitation and helped avoid dialysis in this patient. The Go-Team consists of one physician and one certified registered nurse anesthetist (CRNA). They have the capabilities for blood transfusions, ultrasounds, REBOA placements, amputations, thoracostomies, advanced analgesia, and airway management. All of which can be considered heroic roadside care. In a 9-year review of the STC Go-Team, 50% of patients required at least one unit of blood, and 32% required two units. Despite being developed for potential amputations in the fields, there have been no amputations in the 9-year review. On admission to the STC, 18% had a REBOA placed, and 27% required massive transfusion protocols.¹⁵ Other systems have evaluated the ability to perform prehospital thoracotomies for cardiac arrest in less than 10 min and saw an 18% survival in the setting of cardiac tamponade. These improvements in prehospital care are not only seen in the physician teams but also in the military. Helicopter flights with critical care flight paramedics demonstrated lower risk of mortality. These are people that can perform some advanced interventions and not simply 'load and go'.

In discussing resuscitation and patients receiving crystalloid, we know that blood products are better. EMS units carrying whole blood and plasma has also been studied as a viable resuscitative fluid in the prehospital environment. If blood is not available, is REBOA placement a viable option in the prehospital setting for temporizing hemorrhage? Other considerations are ultrasoundguided arterial lines to help guide therapy. The concept could be the placement of a femoral arterial line in the field that can be used to guide resuscitation and can later be upsized at the trauma center for a REBOA. The Hinds Protocol is an example of prehospital care following motorcycle crashes that does not involve CPR, but calls for intubation, finger thoracostomies, pelvic compression, reducing fractures, and administering fluid or blood. At a very far end of the spectrum, measures such as extracorporeal membrane oxygenation (ECMO) in the field are being investigated in Europe and the USA if these patients are unable to be transported. While this is not yet done in trauma, it begs the question if this is something that can eventually be done. While considered 'heroic,' these interventions are things

that would be done at a trauma center, seemingly extending that arm out to the community.

HEROIC CARE WILL NOT SAVE LIVES

Dr Ben Lawner, DO, EMT-P, Associate Professor of Emergency Medicine, University of Maryland Medical Center

The problem in trauma is decompensated hemorrhagic shock with dismal survival estimated for out-of-hospital traumatic cardiac arrest (Online supplemental file 1). The question becomes just because we can, does that mean we should? The challenge is an access problem. If you cannot get to the patient to assess and transport them to definitive care, it is a problem. While a majority of Americans live near a trauma center either by ground or air, there are additional logistic considerations. The weather has significant impacts on transport, particularly by air. Is the EMS rig the only unit for a service area? Who is available in the ambulance or helicopter to do the heroic care, and what resources are available? The goal is to reach and treat the patient prior to circulatory arrest. If you cannot get to the patient or do not have the personnel or equipment, a conversation about standards of life-saving care needs to be had before considering heroic care.

In Baltimore, if EMS responds to a patient with a GSW, the clock is running, and we have to be able to get to the patient. The patient may not be in the location where they were shot. The response time is at least 5 min, and transport time may be 5 min. There are 28 ambulances for a population of $653\,000$ people. If the tools are available for heroic care, how do we get these tools to the scene? What is the standard of care? Rapid transport of trauma patients to the nearest trauma center is of the utmost importance. Studies have looked at police transport of trauma patients to the nearest facility and have demonstrated the feasibility of police for rapid transport.

The deployment of REBOA is feasible but takes ultrasound and training. How do we leverage the technology in order to do the best for patients? The challenge still remains getting to the patient and getting the patient to a trauma center. REBOA is also not without complications including downstream arterial thrombosis. In reviewing the trauma literature, we know that there are critical time periods for penetrating injury. While we can do a finger thoracostomy, if it is not done at times within 10 min, it is futile. In a highly organized trauma system in Baltimore, EMS may not reach the patient prior to circulatory arrest. It is an issue of deployment, dispatch, and people calling 911 with minimal information. EMS providers have to then find the patient. When we talk about heroic care, it is exceedingly important to minimize the time to the patient as there is no space for heroic efforts if we are outside of the window for intervention.

A nuanced approach to heroic care should be undertaken such as implementing whole blood programs, incentivizing rapid transport when possible, and embracing evidence-based interventions. The binary approach to trauma is not always practical; some patients do benefit from resuscitation and others may benefit more from the 'load and go'. We know that most people experiencing cardiac arrest have a reversible injury, that is, cardiac tamponade or pelvic injuries. Why do we not incentivize providers to take care of this with ultrasound and finger thoracostomy as the literature discusses the feasibility of these interventions? The Go-Team is a complementary organization that often, on arrival to the scene, brings incident command, ketamine, and blood. Heroic care is feasible, but we have to consider the implementation of the EMS/hospital systems. Circulatory arrest following trauma is time dependent and unless patients are rapidly identified, it is difficult to affect meaningful survival-based interventions. Enhancing current care standards can have a sustainable impact and will be a mechanism by which the EMS system is maintained and evolves.

EVIDENCE SUMMARY

Prehospital care has developed over more than a century to address the needs of sick and critically injured patients. Through military conflicts, addressing the treatment of wounded soldiers has helped advance the field of emergency medical care. During the American Civil War, injured soldiers were removed from the battlefield and surgeons were responsible for treating wounds. The Army Medical Department expanded to include field hospitals, hospital trains, and hospital ships to treat soldiers.² The civilian sector has benefited from military research and advancements.

Rapid transport of injured or ill patients to the hospital was adopted in the civilian sector. This was initially done by undertakers but evolved to become the emergency medical system.¹⁶ The concept of organized civilian prehospital care dates back to 1865 when the first civilian ambulance service was created in Cincinnati followed by New York in 1869. The standard at that time was to immediately transport the patient to the hospital.¹⁶ Additional military conflicts contributed to the impetus to advance prehospital medical care. As previously mentioned, in the 1960s, increased concerns about cancer, heart disease, stroke, and injury arose as major public health crises.⁴ Rescue squads started to form and oversight began to shift to municipal hospitals and fire departments.¹⁶ In 1973, The Robert Wood Johnson Foundation funded 44 EMS projects for new technology and training.⁴ In the same year, the EMS Services Development Act was passed, which placed the nation's EMS under the jurisdiction of the Department of Health, Education, and Welfare. This subsequently established more than 300 EMS systems across the USA.4 16

The tools available to personnel working within EMS systems have advanced to include various medications and procedures to aid ill and injured patients. The quick actions of EMS personnel in the field and rapid transport to definitive care contribute to lives saved.¹⁷ The concept of prehospital care that could be considered heroic has also evolved. Technological advancements like CPR and defibrillators have improved life-saving prehospital care.17 While those technological advancements are now considered standard of care, they were likely once considered heroic. The beginning of CPR dates back to the 1700s with mouth-tomouth resuscitation and in the 1930s-1940s evolved to include chest compressions and defibrillation for cardiac arrest.¹⁸ ¹⁹ Additionally, bystanders have been able to render care using CPR and AEDs, leading to improved survival in prehospital cardiac arrest.^{20 21} Programs like Stop the Bleed and Until Help Arrives provide tools for bystanders to intervene in traumatically injured individuals.11

Trauma center accessibility is one of the key considerations of prehospital care as it has a large effect on survival. From 2013 to 2019, there was an increase in the number of American College of Surgeons-verified trauma centers. This resulted in 91% of Americans being within 60 min of a trauma center compared with 78% 6 years prior; this reflects both ground and air transport.¹⁰ Several studies have demonstrated the negative association between greater distance from a trauma center and mortality, particularly in penetrating trauma.²² In Maryland, the odds of death after penetrating injury increased by 5.7% for every 5 min increase in prehospital time and increased by 8%

for every 5 mile increase from the trauma center.²³ Since 1996, Philadelphia has widely adopted police transport of penetrating trauma victims with research demonstrating reduced mortality among severely injured patients transported by police versus EMS.¹³ While this does not negate the benefit of having a viable and strong EMS program, it does raise the question of how much care needs to be provided at the scene compared with a 'load and go' approach.

Despite the need for rapid transport and definitive hospital care, there are situations in which prehospital measures can be life-saving. In several EMS systems, physicians can be deployed with medics or CRNAs to assist in patient care at the scene, thus extending hospital care to the field.²⁴⁻²⁸ In London, physicians of the London Air Ambulance (LAA) were successful in placing 15 REBOAs in the field and getting the patients to the hospital for definitive care. None of these patients experienced a prehospital arrest.²⁴ London-based physicians on helicopter EMS services are able to perform resuscitative thoracotomies in the prehospital setting as well. Over the span of 15 years, 71 patients underwent thoracotomies, and 13 of these survived to hospital discharge.²⁶ These thoracotomies were not performed by surgeons but by physicians in emergency medicine and anesthesiology, raising the question of who should be performing the procedure. Furthermore, while not performed in trauma patients, 8 patients over 10 years underwent ECMO cannulation and initiation in the prehospital setting in Paris following cardiac arrest, demonstrating its feasibility.²⁶ While this is definitely heroic prehospital care, the applicability to traumatic cardiac arrest is questionable.

The USA healthcare system has not adopted field deployment of physicians as widely or readily as healthcare systems within Europe; this remains an area to be explored. There is a difference in paradigm for emergency medical care rendered in the field in the USA compared with Europe. Described as the Anglo-American (AA) and Franco-German (FG) EMS systems, the main difference is the triage and management of patients in the field. AA systems emphasize rapid transport to the hospital, while FG systems may spend more time with patient stabilization in the field.²⁹ In the AA system, EMS units are staffed mainly by paramedics and EMTs and are an extension of the hospital's emergency department. In the FG system, the on-scene physician extends the capabilities of an inpatient unit or intensive care unit as a physician can determine where a patient needs to go and can do more procedures than an EMT/paramedic. The physicians in Europe who respond to emergent calls can be anesthesiologists, surgeons, intensivists, or hospitalists who receive additional training in emergency medicine.²⁹⁻³¹ This contrasts with the USA, where Emergency Medicine is a separate medical subspecialty. These specialists evaluate and triage patients and determine if advanced procedures are needed. The presence of a physician makes it possible to bring some of the aforementioned heroic measures into the field.

To fully implement the ability to bring the hospital to the patient in the USA would require a change in philosophy, yet there are many challenges to making that possible. While there are similarities between the systems, in FG systems, ambulances may function as a part of the hospital system or managed by municipalities; whereas in the USA, EMS units that respond to traumatic events are operated mainly by municipal fire/EMS departments.^{4 32} EMS funding and protocols can differ between municipalities with assets like whole blood being available in some areas and not others. Additionally, the geographical size of the USA compared with European countries presents another challenge to shifting the paradigm. Municipalities in the USA may be spread across greater areas with significant distances to

Heroic intervention	Benefit of implementation	Needed for implementation	Barriers to implementation
Blood transfusion	Decreased mortality secondary to hemorrhagic shock	EMS training Storage protocols Transfusion protocols	State regulations (EMS scope of practice) Lack of reimbursement
Point of care ultrasound (POCUS)	Increased diagnostic ability for reversible causes of mortality (pneumothorax, pericardial effusion)	POCUS training and certification POCUS equipment	Need for continued practice Funding to purchase POCUS equipment
REBOA	Decreased mortality secondary to hemorrhagic shock	Teaching ultrasound skills Operative skill for venous access REBOA deployment training REBOA kits on EMS units	Training and volume needed for proficiency Skill level of EMS personnel Distance to definitive care Increased risk of visceral or lower extremity ischemia Risk of vascular injury
Thoracostomy (±tube)	Reversal of tension pneumothorax in traumatic cardiac arrest Failure of needle decompression	Strict protocols/guidelines EMS training programs Instruments on EMS units POCUS	Minimal data with EMS crews Risks of iatrogenic injury Need for ultrasound Potential need for physician—EMS
Resuscitative thoracotomy	Decreased mortality secondary to obstructive and hemorrhagic shock	Strict protocols/guidelines EMS/physician training programs	Low rate of survival Risks of iatrogenic injury Need for physician—EMS?
ECMO	E-CPR: improved out-of-hospital mortality and outcomes secondary to cardiac arrest	Mobile ECMO equipment EMS units capable of transport Comprehensive training of physicians and EMS Strict inclusion criteria and protocols	Need for physician—EMS, ECMO teams Dedicated ECMO EMS units Financial burden
ECMO, Extracoporeal membrane oxygenation; E-CPR, Extracorporeal cardiopulmonary resuscitation; EMS, Emergency Medical Service; REBOA, resuscitative endovascular balloon occlusion of the aorta.			

Table 1 Several heroic measures, as discussed, may have benefits to out-of-hospital implementation, but there are challenges and potential barriers in the USA

the next large city. There are significant differences between funding and staffing of urban and rural EMS and between the states themselves.³³ In the largest cities, fire departments operate hundreds of EMS units, making it difficult to staff each with a physician. EMS systems would need to grow to employ physicians and staff EMS units, likely challenging an already problematic EMS funding system.³⁴ There is also the question of what specialties would contribute to staffing EMS units. Will these physicians, like in Europe, be of various specialties or only Emergency Medicine physicians, adding to an already taxed medical practice? Different leadership, budgets, and resources without a centralized system of standards and protocols, combined with an overall physician shortage, make physician-staffed EMS systems in the USA less likely and thus make implementing more complex procedures in the field difficult.

While some physician-staffed helicopter EMS exist, these are dispatched to transport the most critical patients to the hospital and may often rendezvous with ground EMS crews for transport.^{15 35} In situations similar to the LAA, it may be feasible to perform these heroic measures when a helicopter EMS unit is dispatched, and the physician determines that stabilization in the field should be prioritized over immediate transport. Continued training of EMS crews in advanced procedures combined with training with physician-staffed air units can potentially lead to the introduction of more advanced prehospital interventions in the USA. Yet, it will still be dependent on EMS providers to assess the situation, call for physician-staffed flight EMS, and perform any prehospital interventions required until they arrive.

Despite the breadth of prehospital interventions that can be performed, EMS providers must determine which interventions may be of no benefit to the patients and when they should prioritize transport. This may include deferring intubation of hemodynamically unstable patients who are still protecting their airway or establishing intravenous access. If an intravenous catheter is being placed for the administration of crystalloids, this may worsen coagulopathy and hypothermia and should be avoided. Additionally, establishing access may take between 8 and 12 min, and transport to the hospital may be quicker. Taking the time to establish intravenous access is often indicated when patients

need to be intubated, and it cannot be performed en route, during extrication when analgesia is required, and when blood products are available for transfusion.¹² For trauma patients with massive hemorrhage, balanced resuscitation of blood, fresh frozen plasma, and platelets in a 1:1:1 ratio to simulate whole blood is broadly known to be superior to crystalloid.³⁶ Taking a nuanced approach to heroic care could include the widespread availability of prehospital blood transfusion in the setting of traumatic hemorrhage. Whole blood is more practical in the field compared to component therapy and has been associated with better outcomes.^{37–39} In the military, prehospital blood transfusions were associated with less mortality.⁴⁰ Furthermore, military studies have demonstrated the ability to safely collect and transfuse fresh whole blood in the prehospital setting.⁴¹ While fresh whole blood is not practical in civilian settings, stored whole blood may have a place in prehospital EMS systems. Additional studies are required to evaluate the ability to implement this on a larger scale.

CONCLUSION

Prehospital care has an important role in the management of the injured patient, and EMS personnel must carefully balance the tools at their disposal with the need to transport the patient to definitive care. Access, including the ability of EMS to reach, extract, and ultimately transport the patient, is critical to survival. If unable to reach a trauma center expeditiously, various measures can be undertaken to save a life, including the deployment of physician-led interventional teams, prehospital blood product administration, and field procedures such as thoracotomy and REBOA (table 1). Prehospital medical systems must continue to evolve to have a beneficial impact on survival and continue to be an extension of hospital care in the community.

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