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RESUSCITATION CHALLENGES IN PROLONGED FIELD CARE DURING THE WAR IN UKRAINE

Mykola SHEVCHENKO
Major, Medical Service
Senior Resident, Department of Anaesthesiology, Resuscitation and Intensive Care, Zaporizhia Military Hospital

Natalia MOMOT, PhD
Lieutenant, Medical Service
Lead Anesthesiologist, Medical Service and Sustainment Group "East"

Roman KUZIV
Lieutenant Colonel, Medical Service
Commander, Medical Service and Sustainment Group "East"

Lars VELDHUIS, MD, PhD
Resident in Anesthesiology

Inna DEMITER, PhD
Anesthesiologist, Charitable Foundation "MOAS Ukraine"
Head of Department

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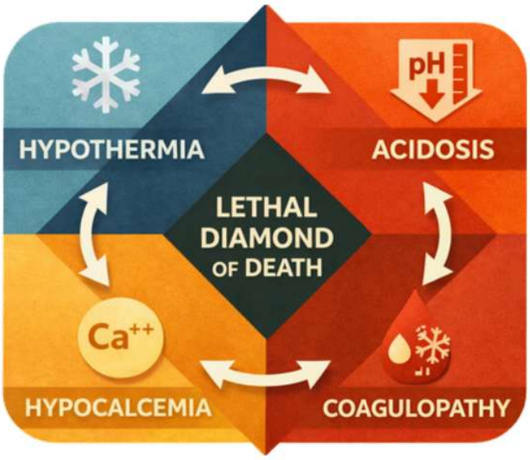


Relevance of the problem

Hemorrhagic shock remains one of the leading causes of preventable deaths following major traumatic injuries. Therefore, trauma care doctrine emphasises early haemorrhage control, rapid evacuation and prompt initiation of blood transfusion. However, the conditions of modern high-intensity warfare challenges these principles. Contested airspace and the widespread use of unmanned aerial systems have substantially altered casualty flow and medical planning.

As a result, patients with traumatic injuries frequently arrive at Role 1 medical facilities well beyond the traditionally accepted "golden hour", in a state of decompensated hemorrhagic shock. Under these circumstances, resuscitation at Role 1 must address not only haemorrhage control, but also the early correction of physiological derangements that would normally be managed later in the evacuation chain.

The concept of the "golden hour" in trauma care is crucial for preventing the development of severe hypothermia, acidosis, coagulopathy and hypocalcemia a combination commonly referred to as the "lethal diamond of death". [1] These physiological derangements significantly reduce the survival chances and require immediate and effective intervention. [2]

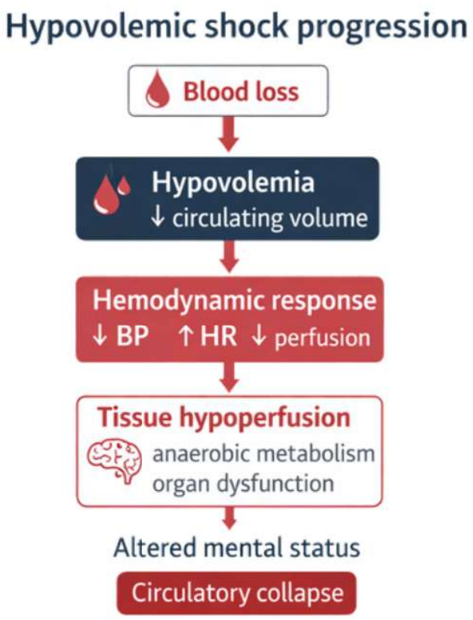
Massive blood loss leads to tissue hypoperfusion and anaerobic metabolism, resulting in metabolic acidosis. Acidosis reduces the activity of coagulation factors, further compromising hemostasis. Simultaneously, hypothermia develops as a consequence of environmental exposure and the infusion of cold fluids and blood products. Even mild hypothermia significantly disrupts platelet function and enzymatic coagulation pathways, thereby worsening coagulopathy. Progressive coagulopathy increases ongoing blood loss, thereby exacerbating acidosis, hypothermia, and hypocalcaemia — the components of the lethal diamond.

Effective resuscitation requires early and simultaneous correction of all components.

Isolated treatment of a single element is insufficient, as these processes are interdependent and self-reinforcing. [2]

Resuscitation challenges in prolonged evacuation

This paper discusses the resuscitation challenges associated with hemorrhagic shock during prolonged field care. In addition, we present two clinical cases from a Ukrainian military hospital to illustrate the practical approach for treating patients with decompensated hemorrhagic shock in a Role 1.



Hypovolemia and hemorrhagic shock Patients presenting after prolonged evacuation are frequently in a state of advanced hemorrhagic shock. This decompensated hemorrhagic shock is characterised by profound hypovolemia, hypotension, tachycardia and an altered mental status.

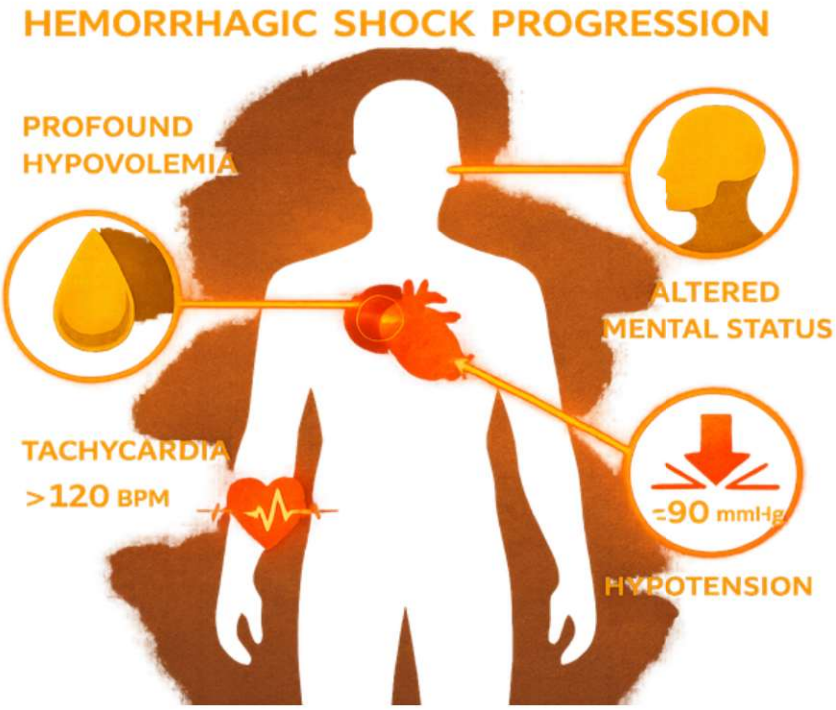
Ongoing blood loss, delayed surgical control and limited prehospital resuscitation options contribute to progressive circulatory collapse. The primary objective upon arrival is rapid restoration of circulation volume to improve vital organ perfusion.

Prehospital treatment includes direct haemorrhage control using tourniquets, pressure dressings and if available, administration of blood products. While these interventions may prevent early mortality in some traumatic injuries, it is often insufficient to prevent decompensation during prolonged transport. Upon arrival at Role 1 immediate transfusion of blood products is often necessary and must follow a massive transfusion protocol. This corrects hypovolemia and supports coagulation while reducing the need for high-dose vasopressors.

While pressure bag assisted transfusion systems improve the amount of transfused blood products per minute, this may be inadequate. Insufficient flow rates can delay effective volume replacement and thus prolong hypotension. Hypocalcaemia can contribute to deterioration of the patient's clinical condition and therefore requires timely treatment. Intravenous calcium supplementation is important in patients receiving massive transfusion, as it may improve haemostasis and cardiovascular function. Hypocalcaemia is considered a component of the "lethal diamond of death" in trauma patients, together with hypothermia, acidosis, and coagulopathy. During massive transfusion, serum calcium levels decrease primarily due to the citrate anticoagulant present in transfused blood products, which binds ionized calcium and reduces its physiological availability.

Hypothermia and temperature control

Hypothermia is a central and often underestimated contributor to deterioration in patients with hemorrhagic shock. Extended evacuation times, environmental exposure and the infusion of cold (blood) products exacerbate heat loss before arriving at Role 1. Prehospital efforts to limit heat loss include insulation, environmental protection and active warming. For passive heating, i.e. heat preservation, a thermal insulation blanket (foil) has become widely used due to its proven effectiveness, compactness, and low cost. Disposable chemical heating pads are usually used as active heating sources. In addition, they may also reduce thermal detectability by enemy forces.



At Role 1, prevention of further temperature decline becomes a priority equal to volume resuscitation. Measures include the use of dedicated heat lamps and maintaining an elevated ambient room temperature. It is also important to use conventional patient-warming systems, such as Bair Hugger and other commercial warming devices, to prevent and treat hypothermia.

In addition, intravenous fluids should be administered warmed to prevent further heat loss. The ability to deliver blood products at clinically relevant flow rates while actively increasing body temperature represents a key resuscitation capability in this setting. Crystalloid solutions were previously heated to a temperature of 38 degrees per C with a heat-machine <<Ranger>> and blood fluids also were warmed to a temperature of 37,5 degrees per C by rapid infuser system <<Belmont>> by themselves, this system does not need the heating of blood components before using, heating is made by the system.

Rapid warmed infusion as an integrated resuscitation approach

To adequately transfuse a patient and to prevent further decline of temperature or to even improve the temperature of the patient, rapid infusion systems are developed. Rapid infusion systems such as the Belmont Rapid Infuser capable of delivering high flow rates while actively warming (blood) products are frequently used to resuscitate the patient rapidly. [3,4,5] These systems combine rapid volumetric infusion, precise temperature control and pressure-regulated infusion. These characteristics address the key limitations of conventional transfusion methods such as gravity dependent infusions. The value of such systems is that they assist in early physiological stabilisation. While these systems are effective, they require large bore intravenous access such as a 14-gauge catheter, Rapid Infusion Catheter (RIC) or Cordis. Smaller catheters restrict the functionality of rapid infusions due to Poiseuille's Law; the rate of fluid flow through a catheter is directly proportional to its radius and inversely proportional to its length.

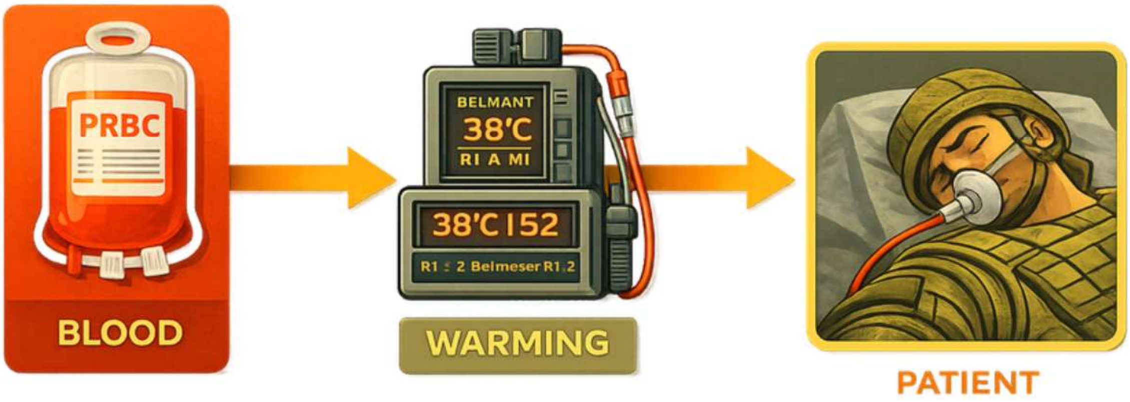
Airway management

Airway protection in patients with decompensated hemorrhagic shock is a major clinical challenge. While securing the airway is often necessary due to altered mental status, hypoxia or allowing major surgical interventions, the induction of anaesthesia itself carries a substantial risk of cardiovascular collapse leading to death. Due to the combination of severe hypovolemia, metabolic acidosis and a high endogenous catecholamine levels, the patients blood pressure highly depends on its own sympathetic tone.

Due to induction agents used by standard rapid sequence induction (RSI) there will be an abrupt loss of sympathetic drive, leading to severe hypotension or even cardiac arrest. This is known as the "physiological difficult airway", in which airway management is complicated not by anatomical factors, but by extreme physiological instability.

Securing the airway without addressing underlying shock physiology exacerbates the lethal diamond and may be fatal. The choice of induction agents should prioritise cardiovascular stability, and intubation should be viewed as a resuscitative intervention, not as a purely procedural step.

RAPID WARMED BLOOD INFUSION



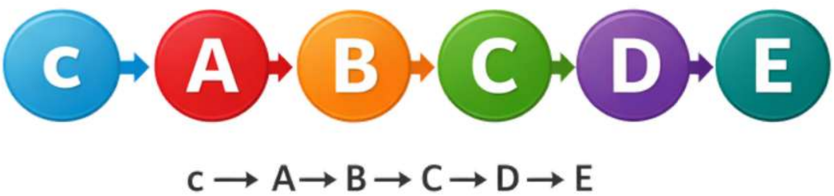
Rapid warmed infusion as an integrated resuscitation approach

Assessment and treatment

In military trauma care, the standard ABCDE approach (airway, breathing, circulation, disability, and exposure) is modified to the cABCDE sequence, in which the initial "c" is for the immediate control of catastrophic haemorrhage. This adaptation reflects the primacy of haemorrhage control in preventing early death on the battlefield. However, as outlined in the airway management section, patients subjected to prolonged field care frequently present with profound physiological instability and may not tolerate immediate endotracheal intubation.

In this context, airway management must be carefully balanced against the risk of hemodynamic collapse, and initial resuscitative efforts often need to precede definitive airway control. The following clinical cases illustrate how these principles were applied in the management of two patients who experienced prolonged field care prior to arrival at Role 1.

Assessment



Case 1

A 29-year-old male sustained multiple penetrating shrapnel wounds following a direct drone strike. Injuries included open fractures of the left lower leg, a massive soft-tissue defect of the left thigh, and traumatic amputation of the right lower limb at the distal third of the thigh. The patient arrived approximately three hours after injury. A tourniquet had been applied at the upper third of the thigh by bystanders.

On arrival, the patient was hypotensive (60/30 mmHg), tachycardic (132 beats/min), and in respiratory distress, with tachypnea (32 breaths/min) and hypoxia (SpO_2 92%). The Glasgow Coma Scale score was 12, likely due to a low-flow state. Body temperature was 35.1°C. Findings were consistent with Class III–IV hemorrhagic shock.

Direct surgical hemorrhage control of the limbs was performed. Due to the severity of shock, the patient was started on resuscitation with norepinephrine support and active warming using a heat blanket and an external warming system.

A 14-gauge central venous line was placed in the right subclavian vein, and transfusion was initiated using a balanced massive transfusion protocol (1:1 packed red blood cells to fresh frozen plasma) at a rate of 370 ml/min. In total, 1800 ml of RBC, 1500 ml of FFP, and 1500 ml of crystalloids were administered.

Intubation was performed using IV ketamine, fentanyl, and suxamethonium. Prior to evacuation to a Role 2 facility, blood pressure stabilised to 120/70 mmHg, heart rate to 97/min, with adequate oxygenation and ventilation. Body temperature increased to 36.0°C, and urine output was 0.5 ml/kg/h.

Case 2

A 45-year-old male sustained blast-related penetrating injuries to both lower extremities, resulting in traumatic amputation of the left lower limb at the distal third of the thigh. The patient arrived approximately five hours after injury with a tourniquet in place.

On presentation, the patient was in profound shock, with a blood pressure of 50/20 mmHg, heart rate of 145 beats/min, respiratory rate of 35 breaths/min, and a Glasgow Coma Scale score of 10. Body temperature was 34.5°C.

Prior to intubation, hemodynamic instability and hypothermia were managed using rapid infusion of 7 units of packed red blood cells, 7 units of plasma, and 1500 ml of crystalloid fluids at a flow rate of 500 ml/min via a subclavian line. After achieving relative hemodynamic stability, intubation was performed using ketamine, fentanyl, and suxamethonium.

Before evacuation to the next level of care, the patient's blood pressure improved to 110/60 mmHg, oxygen saturation to 99%, and body temperature to 35.8°C. Urine output was 0.5 ml/kg/h, and vasopressor support was reduced to low-dose norepinephrine.

CONCLUSION

Modern warfare, characterised by widespread use of unmanned aerial systems and contested evacuation routes, has fundamentally altered casualty care timelines. Increasingly, severely injured patients present far beyond the traditional golden hour, often arriving at Role 1 facilities with advanced physiological derangement. The presented cases illustrate the challenges of managing decompensated hemorrhagic shock under conditions of delayed evacuation.

Rapid correction of hypovolemia combined with prevention of further heat loss is essential. Using actively warmed blood in Role 1 demonstrated life saving interventions.

Therefore, the ability to rapidly administer warmed blood products should be regarded as a core resuscitation capability rather than an optional adjunct. To improve the outcome of these patients, Role 1 teams must be trained, equipped and supported to manage advanced shock physiology. Incorporating these capabilities into modern military medical training is essental to meet the evolving demands of contemporary conflict.

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