There isn’t nearly as much that we, as prehospital providers, can do for trauma patients compared to medical patients.

- BLS skills such as controlling bleeding and managing the airway.
- Trauma is a “surgical disease”, i.e. only surgeons can “cure” it.

However, there are preventable causes of death in trauma. Understanding some of the pathophysiology of trauma can help us to help our patients.

Three factors have been identified as the leading causes of death in trauma patients. These factors actually “feed” one another, and have come to be known as the “triad of death.”

- **Hypothermia** — when a patient’s core body temperature gets too low (core temperature <35°C/95°F).
  - One study showed that almost half of all trauma patients brought to the hospital by EMS were hypothermic upon arrival.
  - A study showed that every single trauma patient whose core temperature dropped to 32°C/90°F or below died.

- **Acidosis** — when a patient’s blood becomes too acidic (pH < 7.2).
  - The body has a very low tolerance for changes in pH (normal: 7.35–7.45).
  - Acidosis can cause “impaired cardiac performance, decreased responsiveness to cardiac inotropic drugs, [and] decreased renal perfusion”.
  - Prehospital providers can unknowingly contribute to acidosis by administering large amounts of normal saline.
    - Normal saline (0.9% sodium chloride)

- **Coagulopathy** — when a patient loses the ability to form clots and stop bleeding (INR [international normalized ratio] > 1.5).
  - One review found that up to a third of trauma patients are coagulopathic upon arrival to the ED.
  - In one study, patients with extreme coagulopathy had a mortality rate of 100%.
Patients who present to trauma centers with those three conditions have a mortality rate of about 50%\(^1\); another study found it was nearly 70%\(^6\); the US Army estimates that it can be as high as 90%\(^7\). In other words, if we let our patients develop these three conditions then we’ve just given them, at best, a 50/50 chance of living or dying.

The most frightening thing about the trauma triad of death is that each of the three factors contributes to another of the factors, hence what was said earlier about them “feeding” each other.

- **Bleeding initially causes coagulopathy.**
  - As the patient bleeds, they lose their clotting factors.
- **Hypothermia worsens coagulopathy.**\(^8\)
  - Clots can’t form when the temperature of the blood is too low.
- **Coagulopathy worsens acidosis.**\(^9\)
  - As a patient bleeds, they lose the ability to perfuse tissues. As tissues lose perfusion, they begin to undergo anaerobic metabolism. One of the byproducts of anaerobic metabolism is lactic acid. As lactic acid accumulates in the poorly perfused tissues, the body enters metabolic acidosis.
- **Acidosis worsens both hypothermia and coagulopathy.**\(^10\)
  - As the body becomes more and more acidic, the cardiac cells become more irritable and less effective. Since “flowing blood … is the most important heat-
exchange pathway inside the body”\textsuperscript{11}, decreased cardiac output means the
body loses its ability to warm itself (thermoregulation).

- Additionally, many patients have baseline coagulopathy. These include
patients who routinely take blood-thinning medications, such as
heparin/Coumadin.

\textbf{What can we do?} How can we prevent the trauma triad of death?

- **Hypothermia** is something we definitely can control in the prehospital setting.
  - **Exposure.** We are trained to remove a patient’s clothes in order to perform a
    full physical exam. This is good, but what happens when we’re done with the
    exam? Do we cover the patient up with a blanket, or do we leave them lying
    naked and exposed to the air?\textsuperscript{9,12} **Turn up the temperature in the back of
    the ambulance**, even if you as a provider are uncomfortable, and **cover the
    patient with a blanket** when possible.
  - **IV fluids.** Fluids are usually kept at room temperature, which is colder than
    the body’s normal temperature. When we introduce these fluids directly in to a
    patient’s bloodstream via an IV, we can significantly lower their core
    temperature.\textsuperscript{12} If you have the required equipment or supplies, **give warmed
    IV fluids** instead of colder, room temperature fluids.

- **Acidosis** is a little bit harder to address in the prehospital setting. Most agencies
carry sodium bicarbonate, which can be used to reverse acidosis. However, it
must be given in a very controlled manner in order to prevent overshooting and
causing alkalosis. Some EMS agencies are starting to carry point-of-care blood
chemistry tests (e.g. i-STAT) that can tell you the patient’s blood pH and allow
you to calculate the required dose of bicarb. If your agency has such capability,
consult with your medical director about the possibility of a protocol to treat
diagnosed acidosis.

  - Giving a crystalloid other than normal saline (e.g. lactated Ringer’s solution)
    will not reverse acidosis, but it can reduce a patient’s risk of developing
    acidosis.\textsuperscript{4} One literature review concluded that lactated Ringer’s solution “is
    suitable for resuscitation in many cases, and that the routine use of [normal
    saline] in massive fluid resuscitation should be discouraged”\textsuperscript{4} (emphasis
    added). **This can be a good strategy to “stay ahead of the curve”** and
    proactively prevent the triad of death, instead of reactively trying to fix it once
    it sets in. “An ounce of prevention is worth a pound of cure.”

- **Coagulopathy** is arguably the toughest of the three factors to treat in the
 prehospital setting.
- The most definitive treatment is the administration of blood products. If your agency has a protocol for this, consult with your medical director to learn more about it.
- Tranexamic acid, or TXA, can help improve the body’s ability to clot. TXA has gained a lot of traction with military providers, and now some civilian EMS agencies are adopting TXA into their protocols.¹³
- As with the acidosis recommendations above, an ounce of prevention is worth a pound of cure. There are several things prehospital providers can do to prevent coagulopathy from setting in.
  * **Stop the bleeding.** None of the other interventions will matter if the patient continues to bleed.
  * **Limiting fluid administration may have multiple benefits.**
    - Excessive fluid administration dilutes clotting factors, contributing to coagulopathy.⁵
    - Normal saline specifically is fairly acidic, and in large amounts, can contribute to acidosis.⁴
    - As stated earlier, most fluids carried in ambulances are not warmed, and can contribute to hypothermia.
    - The American College of Surgeons, in its Advanced Trauma Life Support (ATLS) guidelines, has reduced its initial fluid administration recommendation from 2 liters down to 1 liter.¹⁴
  - Some data also support the use of impedance threshold devices, such as the ResQPod. ITDs maintain a negative intrathoracic pressure and can improve perfusion of the vital organs during shock. One study showed that pigs in hypovolemic shock with an ITD and no fluid administration had a systolic blood pressure increase of 10–15 mmHg over pigs with no ITD.¹⁵
References


