We've **MARCHED** to a new beat...

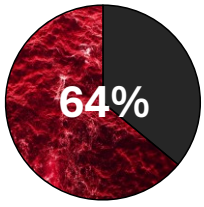
Trauma Assessment & Resuscitation

Jacob Miller, acnp, enp-c, cns, nrp, faen, faems

Preventable Deaths

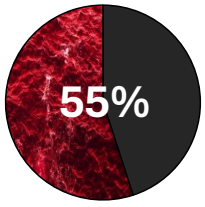
29%

Prehospital Deaths
Potentially Preventable



Hemorrhagic

11%



Hemorrhagic

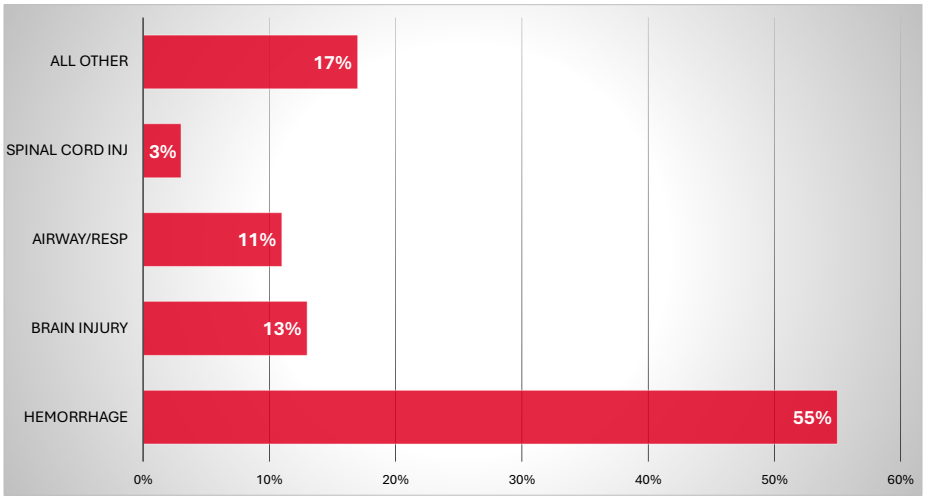
Ann Surg 2020;271:375
Curr Opin Hematol 2017;24:529
J Traum Acute Care Surg 2017;82:S1

Some patients will die before reaching the ER (or, perhaps, EMS). Our focus is not necessarily on saving *all* of them, but importantly should be on intervening in those with *preventable* causes of death.

A 2020 study in the Annals of Surgery notes that between 11% and 20% of trauma patients who die in the field do so from potentially preventable causes—accounting for approximately 30,000 deaths per year.

Over half of these are from hemorrhage.

Preventable Deaths



Ann Surg 2020;271:375

The study published in Annals of Surgery, 2020 by Drake and colleagues looked at a single county's mortality statistics for trauma.

Over half of the preventable deaths were from hemorrhage, followed by preventable sequelae of brain injury, then airway or respiratory causes, and finally spinal cord injury.

Primary Trauma Survey

J Spec Oper Med 2011;11(3):104
J Spec Oper Med 2022;21(1):11
National Model EMS Clinical Guidelines, v 3.0; 2022

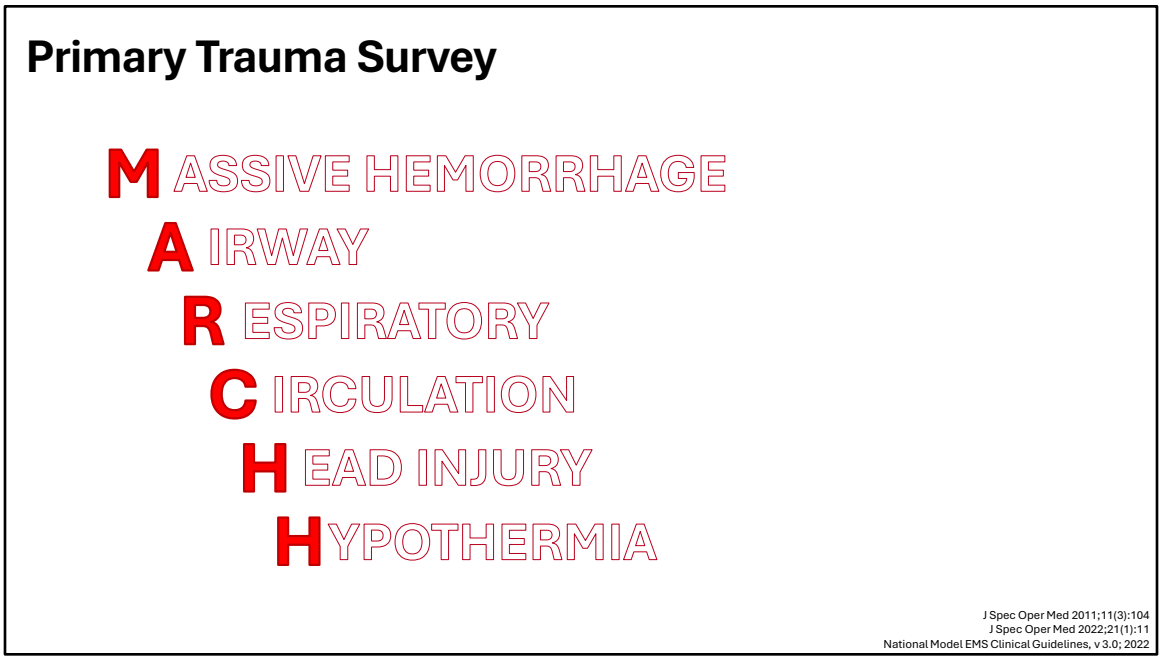
Recall that the general premise of the primary survey holds that *you are supposed to continue the primary survey start-to-finish unless you identify a life threat at the criteria you are assessing*.

Knowing that, there are two major problems with the traditional "ABC" (or "ABCD") method of conducting a primary trauma survey:

1. Massive hemorrhage, the leading cause of preventable death (by far!), is not "checked" (thus, not treated) until the "C" part of ABC – *after* airway and breathing.
   Recall that, in medical arrests, the AHA realized having circulatory support so late in their algorithm was delaying chest compressions, prompting a change to "CAB" for pulseless medical patients.
2. Although the "ABCD" approach looks at "disability," this is usually thought in context of spinal motion restriction, not head injury.

Over a decade ago, the military TCCC guidelines introduced "MARCH" to address these shortcomings with ABCD.

More recently, this has been endorsed by the 2022 version of the National Model EMS Clinical Guidelines published by the National Association of State EMS Officers.



The MARCH algorithm is shown above (note, "H" has two meanings).

Importantly, this *begins* with identifying and correcting massive hemorrhage, followed by the traditional "ABCs", then moving on to specifically address hypothermia prevention and specific care for head injury.

Two additional articles on MARCH:

- Duckworth R. (2017, Sept 1). EMS trauma care: ABCs vs. MARCH. https://www.ems1.com/trauma-assessment/articles/ems-trauma-care-abcs-vs-march-vdnYK1J4Pq5cZbnV/
- Fisher A. (2019, Sep 14). Saving Countless Lives: The MARCH Algorithm in Tactical Combat Casualty Care. https://havokjournal.com/fitness/medical/march-algorithm/

Primary Trauma Survey

M ASSIVE HEMORRHAGE
A IRWAY
R ESPIRATORY
C IRCULATION
H EAD INJURY
E NVIRONMENT
D EXTROSE

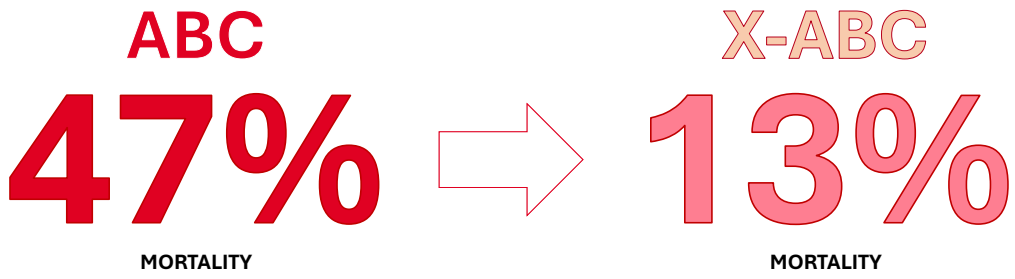
J Spec Oper Med 2011;11(3):104
J Spec Oper Med 2022;21(1):11
National Model EMS Clinical Guidelines, v 3.0; 2022

So, I really only have *one* problem with MARCH:
I *personally* dislike mnemonics where sometimes letters have one meaning, and sometimes they have two meanings.

I've also found (in personal practice) we occasionally miss hypoglycemia as a cause of a patient's trauma, attributing altered mental status to a head injury that may not be present (or may be only minor and not the cause of their AMS).

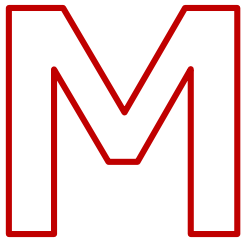
Thus, I present to you – **MARCHED**

Primary Trauma Survey



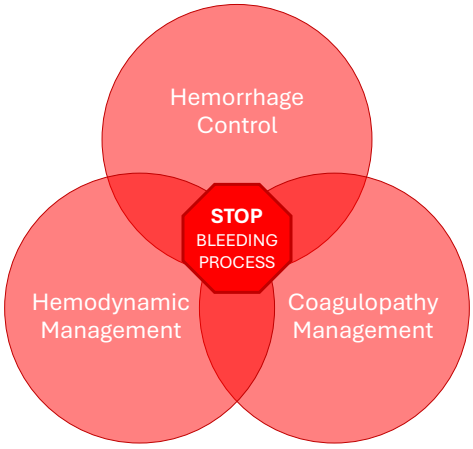
J Am Coll Surg 2024;238:367

Unsurprisingly, a 2024 study from the American College of Surgeons found that prehospital management with an up-front focus on controlling massive hemorrhage (here, “X-ABC”, where “X” stands for “e**X**sanguinating hemorrhage control”) resulted in improved vital signs on ER arrival and a significant mortality reduction compared with those managed with the traditional “ABC” approach.



Massive Hemorrhage

Hemorrhagic Shock

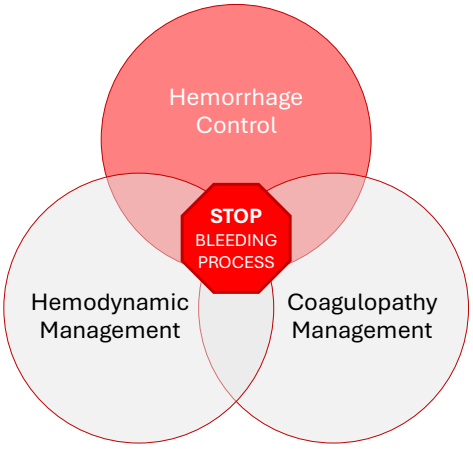


J Anaesthesiol Clin Pharmacol. 2015;31:308

At the core of hemorrhagic shock management is to STOP the bleeding process.

This is accomplished through hemorrhage control, correction of coagulopathy, and appropriate management of hemodynamics.

Hemorrhagic Shock



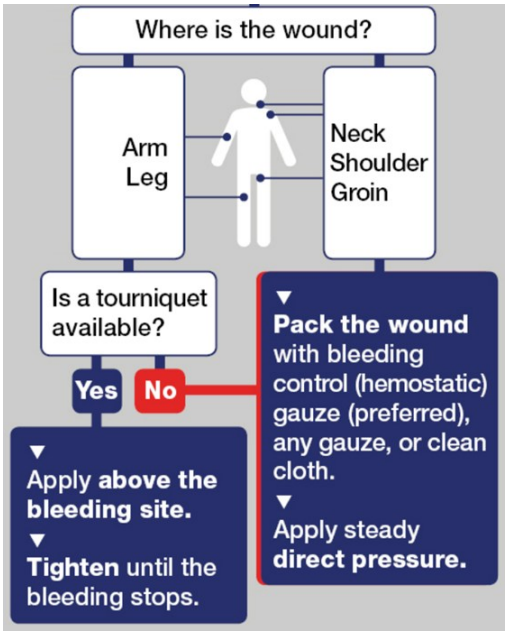
External hemorrhage:

- Tourniquet
- Hemostatic gauze
- Direct pressure

J Anaesthesiol Clin Pharmacol. 2015;31:308
Prehosp Emerg Care 2023;27:544
J Trauma Acute Care Surg 2023;94(1S Suppl 1):S2
Prehosp Emerg Care 2023; adv epub. doi:10.1080/10903127.2023.2240383

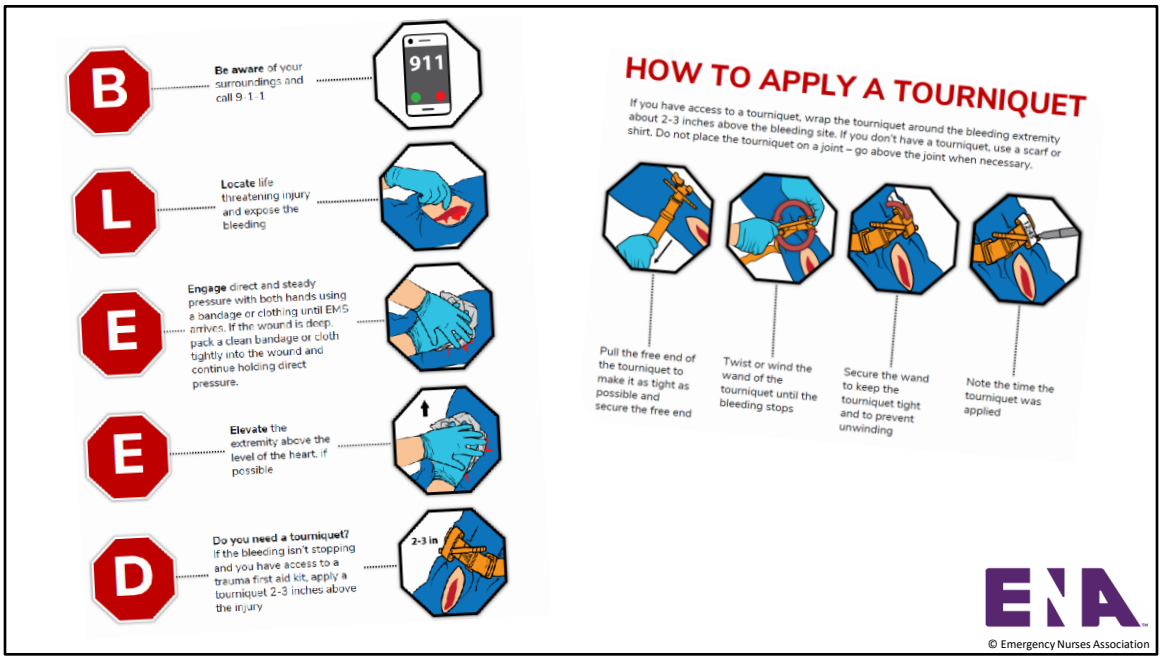
The "**M**" in MARCH is to, first and foremost, control massive hemorrhage.

We're not talking about oozing road rash, we're talking about major arterial +/- venous bleeds.



This graphic is taken directly from the ACS Stop the Bleed website (publicly available at StopTheBleed.org)

Patients with massive hemorrhage to junctional or extremity sites should have appropriate interventions taken immediately to control that bleeding.



And, I'd be remiss if I didn't point out ENA's bleeding control infographic, available free online from ENA University: https://enau.ena.org/Users/LearningActivity/LearningActivityDetail.aspx?LearningActivityID=JQ7K3tL1a/AvOCJ79SBNKw==

Reassess!

TQ:

FAIL AS EARLY AS

1 MIN

AFTER APPLICATION

PACKING:

AT LEAST

25 %

REBLEED BY 30 MIN.

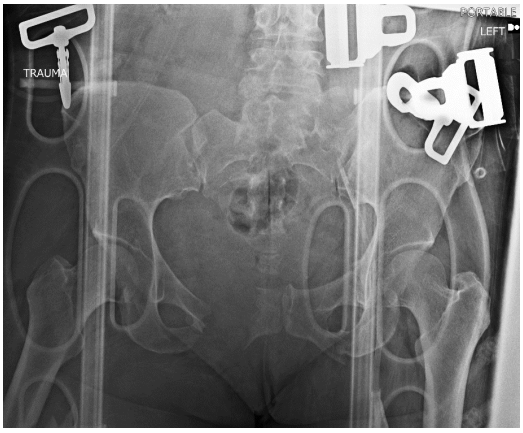
J Trauma 2008;64:S38
Mil Med 2013;178:578
BMJ Mil Health 2020;166:194
Mil Med 2021;186:384

For those of us caring for patients after a TQ was placed or a wound was packed, understand that (like most other interventions we perform), these are not “set it and forget it” interventions – we need to carefully and continuously reassess all interventions performed during our ongoing surveys.

Tourniquets have been shown to fail as early as a minute or two after application, which may require subsequent tightening or the placement of a second tourniquet.

Similarly, there is evidence that up to 25% of packed wounds experience a rebleed within the first half-hour of bleeding control.

Pelvic Injuries



Mortality

36%

JAMA Surg 2023;158:63

Some might argue this is a “C” intervention, but in my practice, I consider open-book pelvic fracture as a potentially correctable cause of massive hemorrhage (an “M” intervention).

The literature cites mortality from pelvic fractures (especially open pelvic fracture) as high as 45% - however, these numbers vary widely. Newer literature shows mortality from pelvic fractures (open or closed) generally in the 4-14% range [J Orthop Surg Res 2018;13:83], however a retrospective review of data from the American College of Surgeons database found overall mortality still averaged 36% amongst patients with pelvic fractures and associated hemorrhage.

Because a pelvic binder is relatively easy to apply and fairly inexpensive, I usually opt to apply a pelvic binder to any patient with significant mechanism and hemodynamic instability early in my resuscitative course.

Pelvic Injuries

Instability on exam:	**Sn: 26%**	Sp: 99.9%
Pain/Tenderness: ***(*GCS ≥14)***	**Sn: 74%**	Sp: 97%
Abnl Hemodynamics:	**Sn: 84%**	Sp: 32%

J Trauma 2009;66:815
Injury 2020;51:4

Our physical exam skills are poorly sensitive for instability (meaning, we can't rule out a fracture just because the pelvis "feels stable" on assessment). Even patients may not be able to reliably exclude fracture on clinical assessment—especially if they have any other painful or distracting injury (as is often the case if there was enough force to cause a pelvic fracture). However, both physical exam or subjective pain/tenderness are quite *specific* for pelvic injury—so assume there's a fracture if either of those is positive!

The most *sensitive,* but, admittedly, least specific, finding is abnormal hemodynamics.

For this reason, any patient with significant mechanism plus shocky vitals should really receive a pelvic binder in the field.

Pelvic Binders

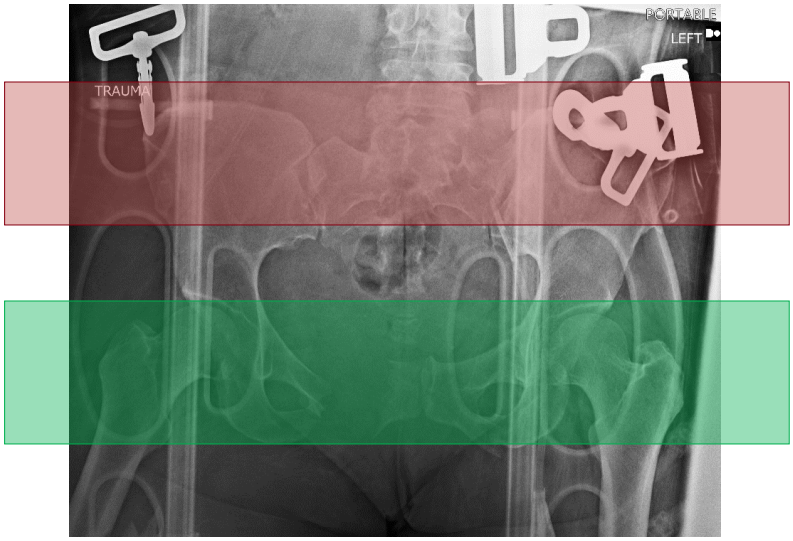
- Commercial > DIY
- Sheets:
  - Difficult to secure
  - More **lethal bleeding** vs commercial binder (**23%** vs **4-8%**)†

Curr Surg Rep. 2023;11:93

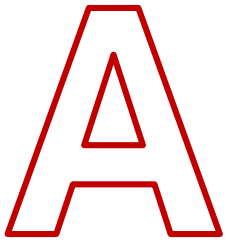
† Injury 2013;44:1760
Scand J Trauma Resusc Emerg Med 2016;24:110
Curr Surg Rep 2023;11:92
Prehosp Emerg Care 2023;27:544
Prehosp Emerg Care 2024;28:425

Commercial pelvic binders, regardless of brand, perform better than “do-it-yourself” pelvic binding with sheets or other creative devices.
If *all* you have available to you is a sheet, that’s still better than nothing, but may be ineffective.

“Location, location, location”



Also – remember – the purpose of a pelvic binder is to close an open-book (pubic symphysis) fracture! The binder should be applied **low** on the pelvis, at the level of the femoral trochanters. Applying the binder too high (i.e., at the level of the ASIS) can lead to a fulcrum-like effect and actually *worsen* an open-book pelvic fracture



Airway

Airway Management

Emerg Med Clin N Am 2018;36(1):66

RSI with VL, DL, or FOB:
0/252 neuro deterioration†

RSI + hypotension = bad!
↓ *induction dose*
↑ *NMBA dose*

† Anesth Analg 2018;127:450
Crit Care Horizons 2015;1:1
Ann Emerg Med 2016;68:181
Emerg Med Clin N Am 2018;36:61

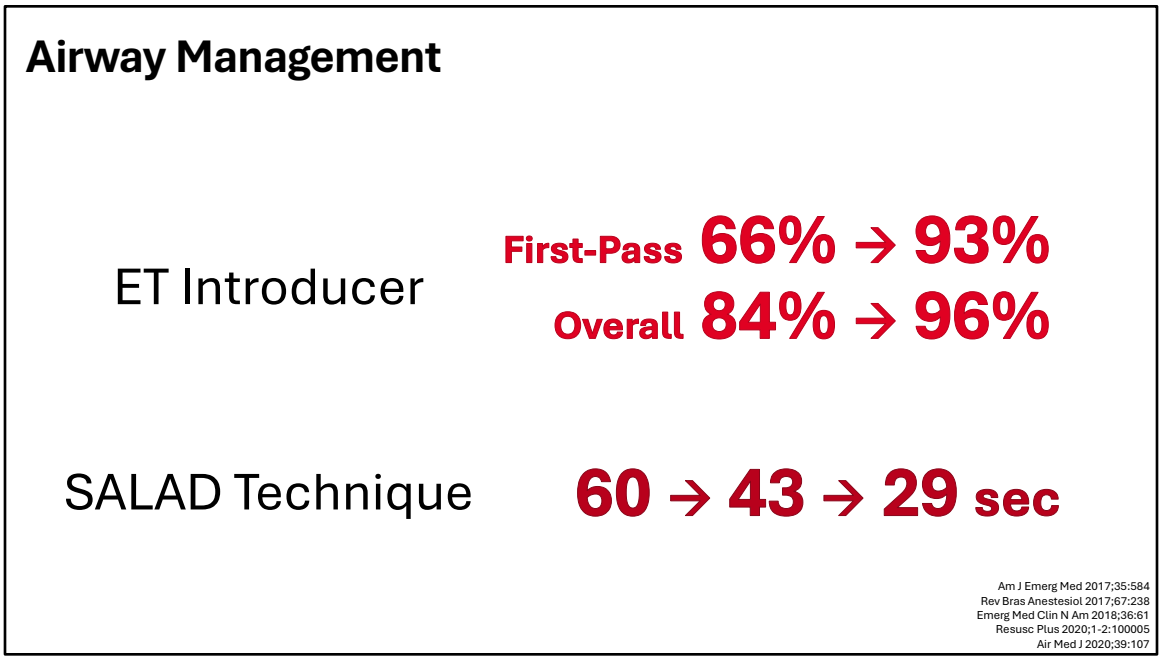
If properly performed, airway management shouldn't cause or worsen c-spine injury! Remember the purpose of a laryngoscope is to distract the mandible forward to obtain a glottic view, not to rock the c-spine.

Set yourself up for success—remove the anterior portion of the cervical collar (or open the rigid c-collar) as is shown in this photo. You can consider having another healthcare provider hold in-line stabilization, but c-spine injury is rare, and exacerbating a c-spine injury through intubation is *exceedingly* rare. The best course of action is to set yourself up for first-pass success the first time.

A quick caution about using pharmacology (RSI) for airway management:
Patients with hypotension or increased shock index (more on that later) are significantly more likely to develop profound hypotension or even arrest with "standard" induction agent doses.
Patients with hypotension or increased shock index should have:

- Resuscitation initiated with blood products before induction
- Push-dose vasopressors immediately available
- Induction doses cut *at least* in **half**

Some sources also suggest *increasing* paralytic dose in hypotensive patients (due to difficulty reaching target receptors in a low-flow state)



Some other helpful adjuncts to improve first-pass success:

ET introducer (commonly called the "bougie"): Studies show time and again that this can help improve first-pass success *when used with direct laryngoscopy or standard-geometry video laryngoscopy – there's insufficient evidence about its use with hyperangulated video laryngoscopy devices*. Importantly, the BOUGIE trial published by Driver et al. (JAMA 2021;326(24):2488) showed no reduction in success rates when intubating physicians more familiar with stylet use were assigned to use a bougie for intubation; several studies, however, have shown improved first-pass success among clinicians more accustomed to using these devices.
My take-home is that, at worst, a bougie doesn't lower your first-pass success rates, and at best, it may improve them significantly. (But you have to train with it!)

The SALAD technique (Suction Assisted Laryngoscopy for Airway Decontamination) can be useful to manage heavily soiled (blood, vomitus, other debris) airways, but also needs to be practiced! This technique essentially uses a large-bore suction catheter to clear the airway, the catheter is then left in situ in the hypopharynx during intubation to keep the view clear.

If you're not familiar with the SALAD technique, this is a great #FOAMed video by Dr. Jim DuCanto discussing it (SALAD begins around 4:50 into the video):

- https://youtu.be/uSYFamlG_N0

Respiratory Support

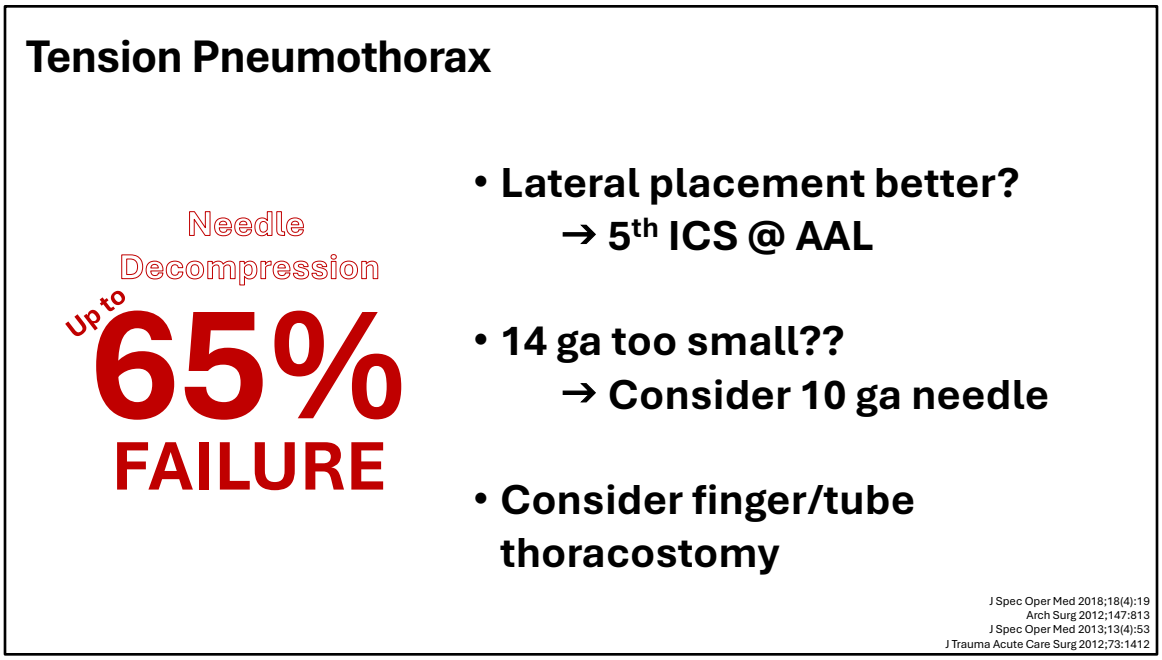
Impact Brain Apnea

Resuscitation 2016;105:52

Although rare, impact brain apnea is exactly what it sounds like: an acute episode of apnea following a significant impact to the brain.

The duration of apnea tends to correlate with the energy delivered to the brain; i.e., the higher the energy, the longer the apneic period may last.

This is critical to recognize as rapid intervention may prevent morbidity and mortality.



Needle decompression of TPTx can fail up to 65% of the time, but I suspect that number was before the increased availability of purpose-built decompression needles.

To that note, tension PTx should be decompressed with a needle *designed for decompression*. These needles are usually long (at least 8 cm) and sturdier than traditional IV catheters. Some studies suggest a 14ga might be too small for adults and recommend at least a 10ga catheter be used. Others suggest that, depending on body habitus, placement in the 5th ICS at anterior axillary line is more likely to be successfully placed into the pleural space than traditional anterior placement (2nd ICS at midclavicular line).

If there's any doubt about the success of needle decompression, a finger or tube thoracostomy should be performed as this provides tactile confirmation that you have definitely entered the pleural space.

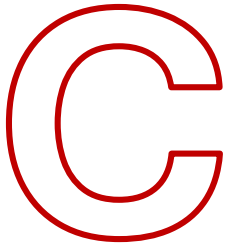
Oxygen

- Supplemental oxygen (empiric)
  - *Seems generally bad for everything*
- High incidence of hyperoxia in trauma
  - Hyperoxia might be bad in TBI
  - Restrictive oxygen strategy may be feasible
- **AVOID HYPOXIA!**

BMJ 2018;363:k4169
Lancet 2018;391:1693
Acta Anaesthesiol Scand 2019;63:531
Acta Anaesthesiol Scand 2019;63:947

Although there's a paucity of data on the effects of hyperoxia in trauma, we KNOW that **hypoxia** should be avoided at all costs!

If SpO2 is reliably normal, it's probably reasonable to forego supplemental oxygen, but if there's any doubt (especially if there's concern for TBI), it may be better to err on the side of applying oxygen empirically.



Circulatory Support

Damage Control Resuscitation

- Permissive hypotension
- Minimize crystalloid
- Balanced blood product resuscitation
- Goal-directed coagulopathy management

Crit Care Clin 2017;33:15-36

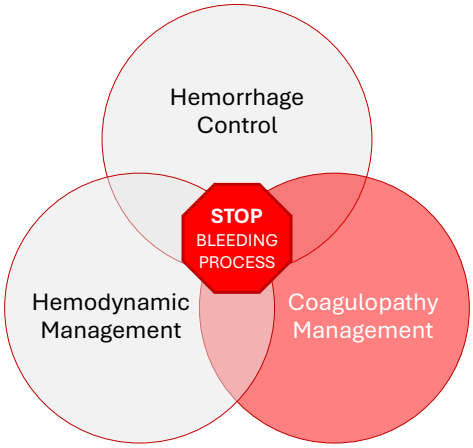
These are the principles of damage control resuscitation, intended to minimize collateral damage while awaiting definitive surgical correction of the patient's injuries.

Everyone should be able to perform the first and second bullet point:
- Permissive hypotension (usually to a systolic around 80 mmHg, or just enough to maintain a palpable radial pulse and mentation)
- Minimize the use of crystalloid (i.e., not blood) fluids.

A balanced 1:1:1 resuscitation is ideal, but in critical trauma, it's still better to use whatever blood products you have available rather than crystalloid

Goal-directed coagulopathy management (e.g., guided by clotting studies like thromboelastography [TEG] or thromboelastometry [ROTEM]) may not be available at all institutions, but should be employed when available.

Hemorrhagic Shock



J Anaesthesiol Clin Pharmacol. 2015;31:308

Although “goal-directed coagulopathy management” (e.g., TEG/ROTEM) maybe feasible at trauma centers, it’s unlikely to be available to EMS or smaller hospitals.

Coagulopathy

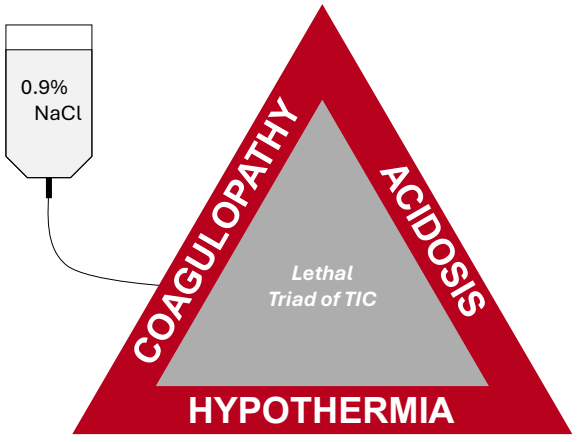
TXA

< 3 Hours

Lancet 2010;376:23
Lancet 2019;394:1713
Ann Emerg Med 2024;83:435

We've seen with CRASH-2 that empiric tranexamic acid (TXA) has a mortality benefit if given in the first 3 hours (and the sooner the better) after major injury. CRASH-3 demonstrated safety in TBI patients, with a potential for mortality benefit in some subgroups.

Iatrogenic TIC



New Engl J Med 2018;378:829-39
J Anaesthesiol Clin Pharmacol 2015;31:308-16

While the triad of coagulopathy-acidosis-hypothermia has been shown to be detrimental to patients, we can *iatrogenically* worsen this trauma-induced coagulopathy by providing cold, acidotic fluid (NS pH = 5.5, LR pH = 6.5) that contains no clotting factors. Go back a few slides to the basic tenets of "damage control resuscitation"—minimize crystalloids!

Even though ATLS still calls for "up to 2 liters" of crystalloid before switching to blood, that may not be the best strategy

Blood for Blood

PROMMTT (2013)	PROPPR (2015)	PAMPer (2018)	COMBAT (2018)
Give more plasma	*1:1:1*	*By EMS*	*Esp. if ETA >20 min*

JAMA Surg 2013;148:127-36
JAMA 2015;313:471-82
Crit Care Clin 2017;33:15-36
Lancet 2018;392:283-91
New Engl J Med 2018;379:315-26
Ann Surg 2021;273:358-64
JAMA Surg 2020;155:e195085

Studies have repeatedly shown that using a balanced blood product resuscitation strategy in the ER and in the field is feasible and associated with lower mortality.

Blood! for Blood

65% increase

IN MORTALITY

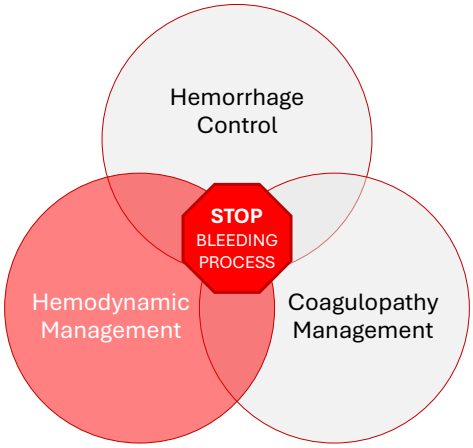
PER LITER OF CRYSTALLOID

EVEN *WITH* BLOOD PRODUCTS

New Engl J Med 2018;379:315-26
Ann Surg 2021;273:358-64

To drive home the “minimize crystalloid” point, a secondary analysis of the PAMPer study published by Guyette et al. (Ann Surg 2021) showed a 65% relative increase in odds of mortality *per liter* of crystalloid administered in the field, including among those who received prehospital blood products.

Hemorrhagic Shock



J Anaesthesiol Clin Pharmacol. 2015;31:308

Hemodynamic Goals

80 < SBP < 90 mmHg

SBP >100 / MAP >80

Uncontrollable hemorrhage:

Consider lower target for shortest possible time

J Anaesthesiol Clin Pharmacol. 2015;31:308
World J Emerg Surg 2019;14:53

Damage control resuscitation suggests that permissive hypotension should be used until definitive bleeding control (generally operative, unless isolated extremity trauma amenable to TQ, for example) can be obtained. In these cases, guidelines generally recommend maintaining an SBP of no more than 80-90, or presence of palpable radial pulse, or presence of intact mentation.

This becomes *exceedingly* difficult in patients with polytrauma and concomitant head injury. While we want to keep BP low for uncorrected hemorrhagic shock, we know that hypotension is associated with a significant increase in mortality for TBI patients. Consensus guidelines *generally* recommend keeping SBP above 90-100-120 (depending on the guideline) in TBI patients, even with hemorrhagic shock.

Beware Occult Badness

Shock Index

$$\frac{\text{HR}}{\text{SBP}}$$

(nl 0.5-0.7)

If >0.9:
↑ transfusion
↑ mortality
↑ RSI arrest

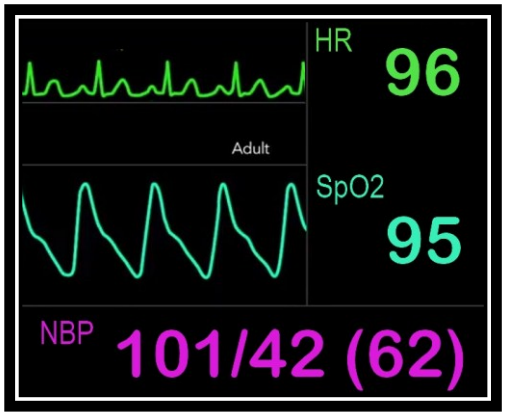
J Trauma 2009;67:1426
J Trauma 2011;70:384
World J Emerg Med 2012;3:114
Crit Care 2013;17:R172
Resuscitation 2013;84:1500

The Shock Index is also a useful tool to evaluate for the presence of occult shock, or the degree of overt shock.

Essentially, the shock index is simply HR divided by SBP. Two numbers we frequently look at in isolation, but combined to provide us an additional look at the patient's physiology. For adults, a normal range is 0.5-0.7; anything above 0.9 is considered "elevated" and is associated with increased need for transfusion, increased mortality, and increased risk of RSI arrest (especially when induction agent doses are not adjusted – refer back to the airway slide!)

*The 3 A.M. math here is that a **HR that's higher than (or pretty darn close to) the SBP is a bad thing**.*

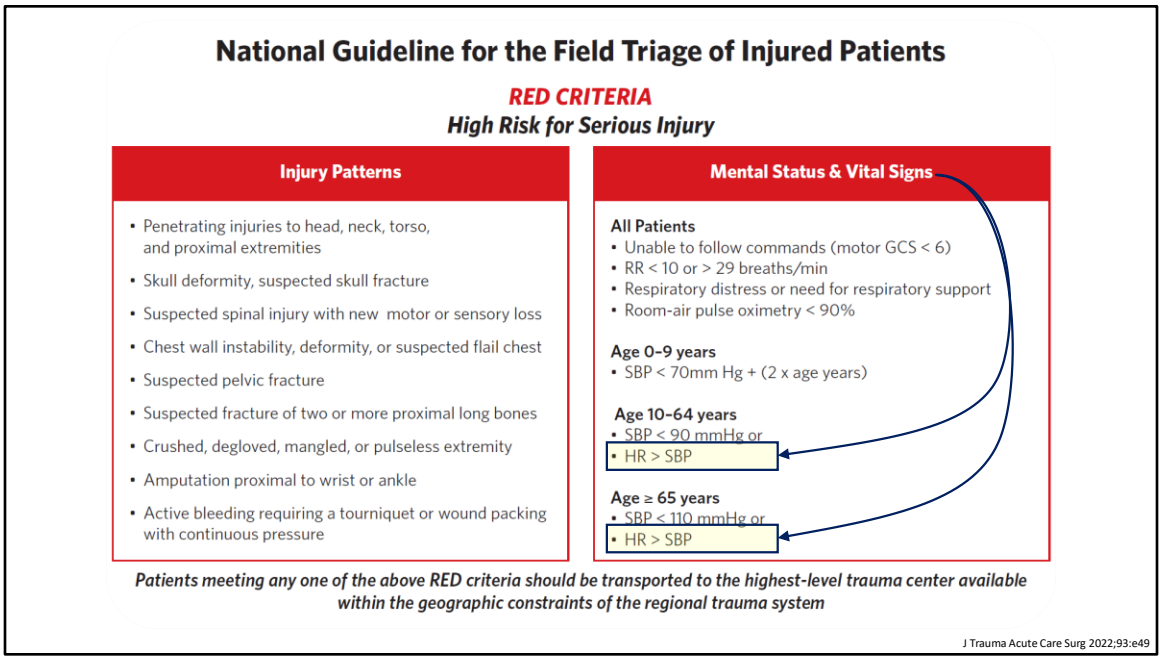
Beware Occult Badness



SI 0.95

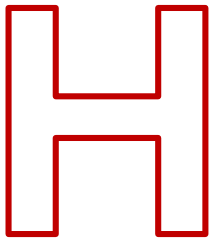
Here's a classic example of the shock index at work:

The patient arguably is neither "tachycardiac" nor "hypotensive" by standard definitions, but has an elevated shock index of 0.95, placing them at considerable risk of deterioration in the right contexts.



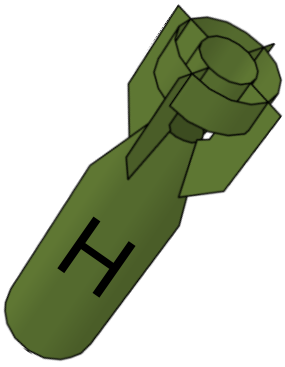
The evidence for Shock Index is so compelling that it was incorporated into the latest 2022 National Trauma Triage Guidelines.

A shock index >1 should automatically be transported to the highest level of trauma care in the local trauma system!



Head Injury

Head Injury: H-Bombs



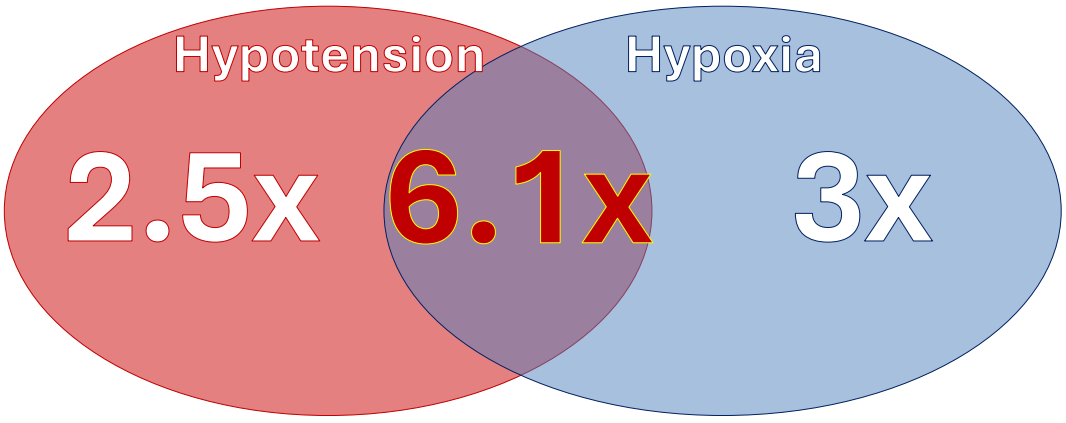
- Hypotension
- Hypoxia
- Hyperventilation

Ann Emerg Med 2017;69:62
JAMA Surg 2019;154:e191152

The 3 major “H-bombs” of head injury that lead to the highest morbidity and mortality are hypotension, hypoxia, and hyperventilation.

Although not commonly discussed, a 4th “H-bomb”, hypoglycemia, should also be ruled-out for any patient with altered mental status.

“H-Bombs”



Ann Emerg Med 2017;69:62

Data from the EPIC-TBI study:
Any single episode of prehospital hypotension (SBP <90) increased odds of death by 2.5
Any single episode of prehospital hypoxia (SpO2 <90) increased odds of death by 3
And any combination of the above (occurring at the same time or separate times) increased odds of death by 6-fold!

Note: EPIC-TBI patients were isolated TBI without hemorrhagic shock or polytrauma.

EPIC-TBI Bundle

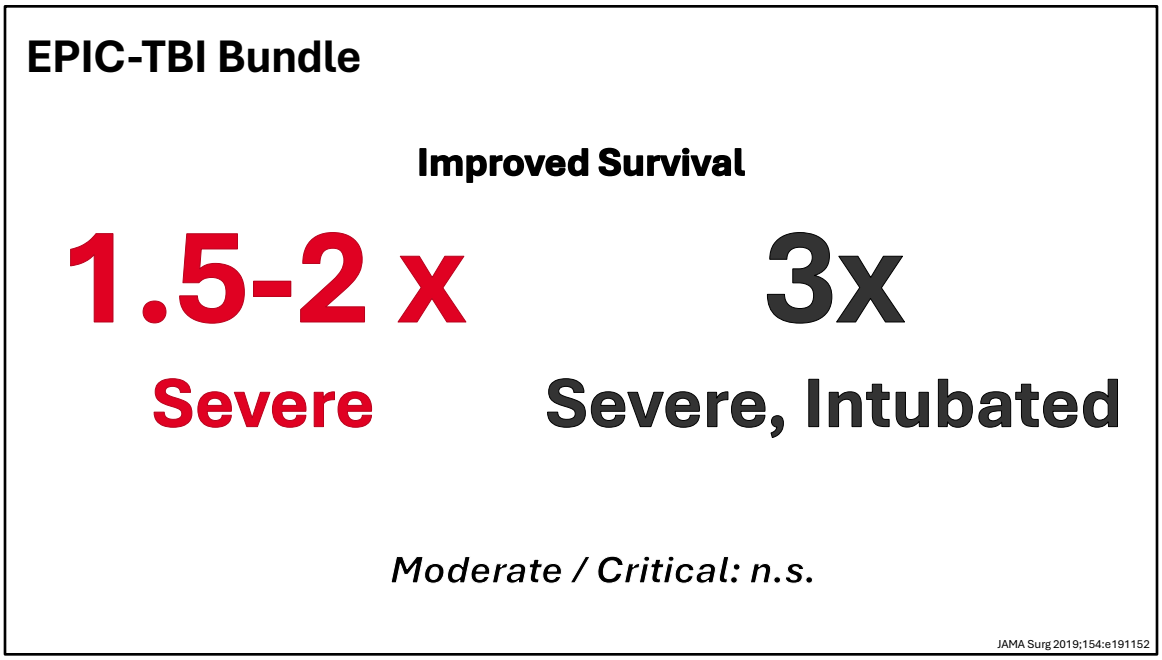
- q3-5 minute HR/BP/SpO2
- 15 LPM oxygen NRB
- *ANY* SBP <90 mmHg:
  - 1 liter crystalloid bolus, **and**
  - IVF to keep SBP ≥90
- Vent rate timer on BVM; target EtCO2 40
  - NO hyperventilation, even for "herniation"

JAMA Surg 2019;154:e191152

This was the EPIC-TBI protocol for included EMS agencies.
Importantly, this was evaluated as an "all-or-nothing" package deal, so it's not really possible to evaluate if one intervention was more impactful than another.

Note: EPIC-TBI patients were isolated TBI without hemorrhagic shock or polytrauma.

Of note – hyperventilation was highly discouraged, and interventions were targeted at maintaining a normal respiratory rate or a normal EtCO2. We know hyperventilation lowers PCO2, which, in turn, causes cerebral vasoconstriction. In theory, in "herniation," that can(?) lower ICP. However, (a) we're not always great at identifying who is truly herniating and who isn't, (b) hyperventilation as a temporizing measure is unlikely to convey a long-term benefit, so unless the patient is being hyperventilated as they're being wheeled into the OR, it's not likely to be helpful, and (c) if we overly hyperventilate patients that don't need it, we may cause more harm from limiting blood flow (i.e., oxygen/glucose delivery) than any purported good.

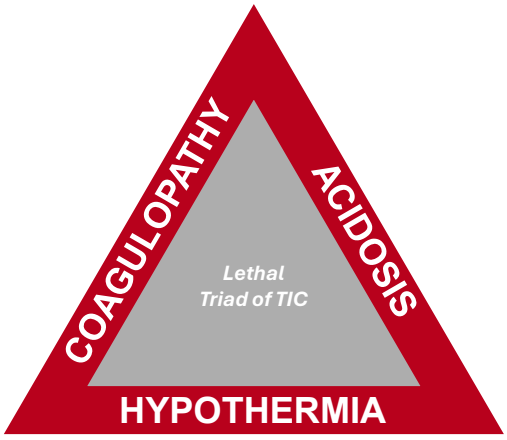


As a result of the EPIC-TBI bundle, this region saw a 1.5-to-2-fold increase in survival to hospital discharge among patients with severe TBI, and a 3-fold higher survival-to-discharge among those severe TBI patients that required intubation. A limitation of this study is that neurologic outcomes/function wasn't recorded, so it's unclear the extent of deficit that survivors faced or their disposition (e.g., to home, to rehab, or to long-term care).

Mortality was not significantly impacted in those with moderate TBI (i.e., those likely to survive anyhow) or critical TBI (i.e., those likely to die anyhow).

Environment (Temperature)

Hypothermia



Incidence:
36.8%

Higher risk:
- More severe injury / cormorbidities
- Prehosp interventions, esp RSI

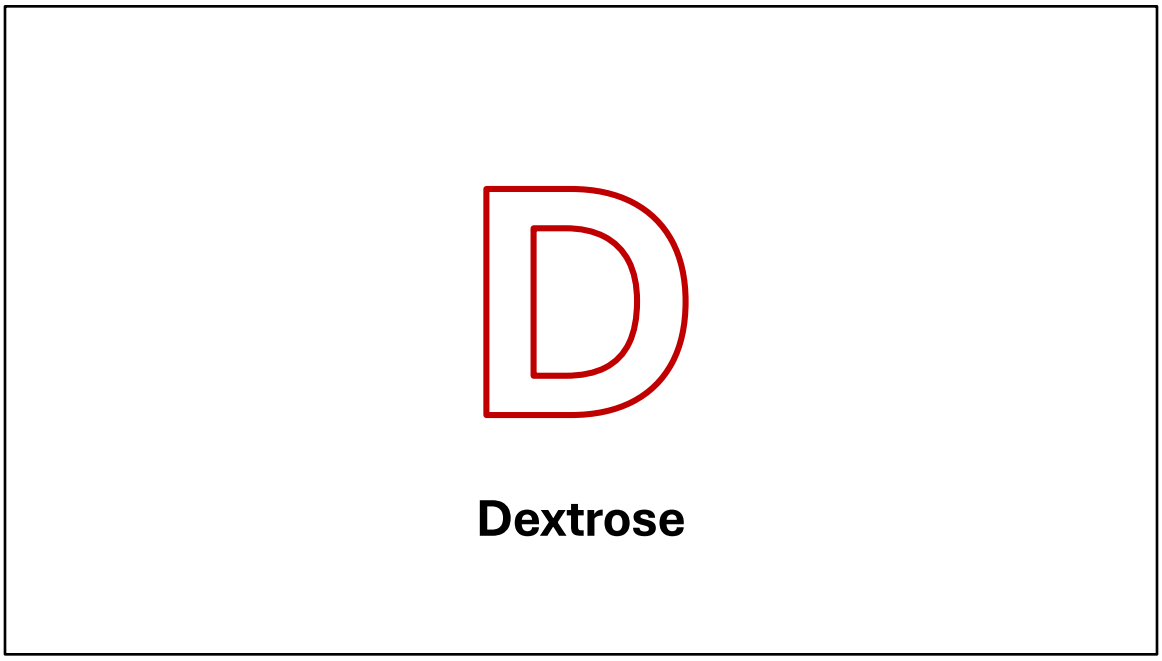
Injury 2013;44:86
Emerg Nurse 2016;24(5):19
Prehosp Emerg Care 2017;21:575
Prehosp Emerg Care 2020;24:15

Despite knowing the harmful effects of hypothermia, around 1/3 of trauma patients arrive at trauma centers relatively hypothermic.

Remember: If you're warm, the patient is freezing. If you're sweating, the patient is probably still cold. Keep them covered, and keep the heat ramped up in the ambulance/aircraft/trauma bay!

It's important to expose the patient to identify injuries and/or follow-up on interventions, but it's equally important to keep the patient warm between those evaluations.

RSI medications, especially paralytics (and especially the longer, non-depolarizing agents) can inhibit a patient's ability to generate heat, further contributing to heat loss and hypothermia.



Lastly, keep in mind that blood glucose should be evaluated early on in anyone with altered mental status. Even in the severely injured patient, AMS may not be due to head injury. It's generally considered poor form to RSI somebody for AMS in the setting of a "head injury," only to find out that they're simply hypoglycemic.

SUMMARY / RECAP

M ASSIVE HEMORRHAGE
A IRWAY
R ESPIRATORY
C IRCULATION
H EAD INJURY
E NVIRONMENT
D EXTROSE

J Spec Oper Med 2011;11(3):104
J Spec Oper Med 2022;21(1):11
National Model EMS Clinical Guidelines, v 3.0; 2022

To summarize:

- Don't think ABC, think MARCHED
- Focus on controlling hemorrhage up front
- *Then*, proceed with ABCs
- Don't forget about specific management considerations in head injury
- Keep your patients warm
- And rule-out hypoglycemia for anyone with AMS – it's fast, easy, and minimally invasive!

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