HEMOSTASIS: STOP THAT BLEED!

A LECTURE ON DAMAGE CONTROL RESUSCITATION (DCR)

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This lecture will review the current management of critical hemorrhagic shock patients. The tenets discussed are appropriate for only the most severe trauma patients (~ 1-5% of ED trauma presentations). Damage control resuscitation consists of the following goals:

- Minimize Iatrogenic Injury from Resuscitation
- Control Internal/External Bleeding as rapidly and safely as possible
- Promote Hemostasis
- Restore Tissue Perfusion

For audio, video, and podcasts to go along with this syllabus; please go to:

http://blog.emcrit.org

Today, we will discuss three facets of DCR:

- Massive Transfusion Protocols & Hemostatic Resuscitation
- Minimal Normotension (i.e. Permissive Hypotension)
- External Bleeding Control

MASSIVE TRANSFUSION PROTOCOLS & HEMOSTATIC RESUSCITATION

Best Reviews (Spinella 2010 and Munro 2010)

How it used to be…

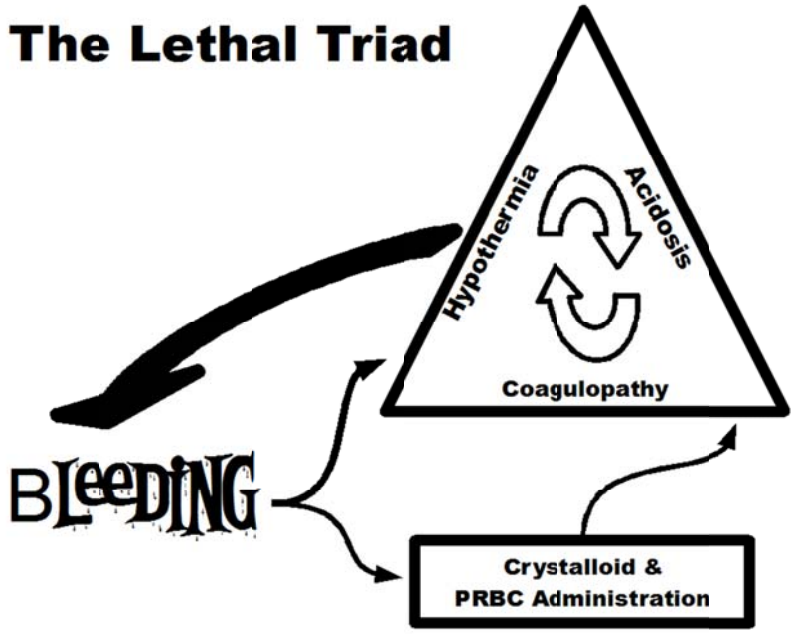
In the past, a critically bleeding trauma patient would get 2 liters of crystalloid and if still hypotensive, large volumes of PRBC to restore a *normal* blood pressure. Only if the PT/aPTT were going up would the patient get FFP. Similarly, the patient would only get platelets transfused when their PLT count dropped below 50,000-100,000. Unfortunately, conventional lab parameters of coagulopathy lag significantly in the critically ill trauma patient.

MASSIVE TRANSFUSION

Due to the military conflicts in the Middle East, a new paradigm has emerged: Hemostatic Resuscitation during massive transfusion. A massive transfusion is generally defined as the resuscitation of a patient who has received more than one blood volume of transfusion in 24 hours (≥ 10 units RBC). Massive transfusion protocols are an attempt to combat the Acute Coagulopathy of Trauma/Shock (ACoTS). They are a one-size-fits-all approach, because most trauma centers do not have access to the real-time labs,

such as TEG and ROTEM, which would allow a tailored approach (these lab tests will be discussed below).

ACoTS is caused by and perpetuates the *Lethal Triad:*



Reversal of acute coagulopathy of trauma

Prevent iatrogenic worsening by keeping the patient warm, warming all fluids, and avoiding unnecessary crystalloid. Stop any external bleeding, get the patient to definitive management of any internal bleeding with maximal speed, and use massive transfusion protocols to decide on blood products.

Predicting who will need Massive Transfusion Protocols

ABC Score

- Penetrating Mechanism
- Systolic Blood Pressure ≤ 90 mm Hg
- Heart Rate ≥ 120 bpm
- Positive FAST abdominal views

If 2 or more of the above are present, consider massive transfusion
(Score of 2 predicts 38% chance of requiring massive transfusion, 3 predicts 45%, 4 predicts 100%)

Nunez et al. Early Prediction of Massive Transfusion in Trauma: Simple as ABC (Assessment of Blood Consumption) J Trauma 2009;66:346-352

TASH Score

- Systolic blood pressure <100 mm Hg
- Heart rate >120
- Hemoglobin <7 g/dL
- Positive FAST Exam with hemodynamic instability
- Complex long bone and/or pelvic fracture
- Base excess < - 10 mmol/L
- INR > 1.5 during resuscitation period

The more of these parameters that are present, the higher the likelihood that the patient will require massive transfusion.

Yucel et al. Trauma Associated Severe Hemorrhage (TASH)-Score. J Trauma 2006;60:1228-1236.

Whole Blood and 1:1:1 Ratios

In Middle Eastern Conflicts, resuscitation is done with whole blood using a *walking blood bank.* In an attempt to duplicate this strategy in civilian trauma, many centers have moved to a 1:1:1 ratio of RBCs:Plasma:Platelets. Special consideration given to ratio transfused in first 6 hours. Most of the trials are observational and there are questions of survival bias because dying patients may not have had time to allow their ratios to catch up.

PRBCs

They do little to improve coagulopathy. They are necessary to allow carriage of oxygen to the tissues and therefore reverse acidosis and consequently hypothermia. Large volumes of RBCs may make coagulopathy worse by diluting clotting factors and platelets.

Also a question of whether older PRBCs (>14 days) are deleterious to the crashing trauma patient. Older blood may not carry oxygen as well and may perpetuate the SIRS cytokine storm.

Plasma

Historically ratios of FFP:PRBC have been 1:4 to 1:10. Multiple retrospective reviews demonstrate that mortality is significantly improved when ratio is closer to 1:1 or 1:2 FFP:PRBC, and subsequent transfusion of PRBC's is less as well when ratio is higher. Military has been large supporter of this theory.

Platelets

Observational studies indicate additional benefit when platelets are matched to RBS and Plasma. Their role may be obviated during early resuscitation by fibrinogen-containing products.

Fibrinogen

In the States, cryoprecipitate is the most widely used product. Each unit has ~250-350 mg of fibrinogen. In Europe, fibrinogen concentrates are available; each vial contains ~ 1 g of fibrinogen. One of these concentrates is US FDA approved, but has not seen much clinical use in trauma patients yet.

Some protocols add cryoprecipitate only when fibrinogen levels drop below 100 mg/dl, but increasing evidence that clot strength is augmented all the way up to 150-200 mg/dl. The clinical relevance of this in trauma patients is still uncertain.

OTHER MEDICATIONS AND PRODUCTS

Factor VIIa

Only one Level I study (Boffard 2005)
Blunt trauma patients with uncontrolled hemorrhage, after transfusion of eight units PRBC. Additional doses at 1 and 3 hours (200mcg/kg, 100mcg/kg, 100mcg/kg). Reduces requirement of other blood products (plts, cryo).Trend toward reduced mortality, MOF,ARDS.

Dose is still unclear. One study (Stein 2008) that shows similar efficacy with 1.2 mg, non-weight based dose for pts with mild to moderate coagulopathy.

Works by:
-extrinsic pathway, forming TF-VIIa complex
-intrinsic pathway by activation of Factor IX
-activates platelets by promoting Thrombin Burst
-inhibits fibrinolysis by activating thrombin-activated fibrinolysis inhibitor (strengthens clot)

Use still limited by cost ($1,000 for 1.2 mg dose up to $6,000 for 200 mcg/kg dose)
Likely most useful if utilized as part of massive transfusion protocol.

Calcium

Calcium is necessary for good inotropy. Massive transfusion dilutes out ionized calcium levels. There is also the potential for calcium to augment clot formation.

Prothrombin Complex Concentrates (PCC)

Three factor concentrate of factors 2, 9, 10 available in the US.
Four factor concentrate of factors 2, 9, 10, and 7a along with proteins C&S (Beriplex, Octaplex) is available elsewhere.

Most of the literature is on reversal of Coumadin-associated hemorrhage. Most of the current trauma literature uses the unavailable four factor concentrates.

Tranexamic Acid

Crash-2 Study (Lancet 2010)
Significant hemorrhage or predicted sig. hemorrhage (SBP < 90 or HR > 110)

1g tranexamic acid over 10 minutes followed by infusion of 1 g over 8 hours within 8 hours of injury

1.5% absolute reduction in mortality (all-cause). Surprisingly, did not affect amount of blood transfusions. No increase in thrombotic complications. This drug combats the fibrinolysis caused by hemorrhagic shock.

EXIT LABS

Draw just before patient goes to OR, Angio, or ICU; of enormous help to the team who will manage the patient. I usually just do a femoral stick and take 8-10 ml of blood.

PT/aPTT	Lactate
Fibrinogen	ICal

CBC VBG/ABG

INDIVIDUALIZED COAGULATION MANAGEMENT

Tests like thrombelastography and ROTEM allow quicker and more detailed examination of the patient's ability to make and maintain clotting.

Best Reviews: (Reikvam 2009 and Wenker 1997)

MINIMAL NORMOTENSION

Also known as permissive hypotension
RCT by (Bickell et al.)
SBP kept around 90 mm Hg, MAP kept around 65 mm Hg and avoidance of excess crystalloids

Unfortunately, blood pressure is not perfusion. Patients, especially young ones, can be profoundly vasoconstricted and demonstrate MAPs > 65 with no peripheral perfusion.

May be best to resuscitate to MAP > 65 with good radial pulse and pulse oximetry waveform. Patient may need sedation and some degree of sympatholysis. My preference is to use small aliquots of fentanyl (12.5 – 25 mcg) to achieve both of these goals.

EXTERNAL BLEEDING CONTROL

NON-COMPRESSIBLE EXTERNAL HEMORRHAGE

Quick Clot Combat Gauze- newer gauze, replaced HemCon for medics, zeolite impregnated, 4 yds x 3 inches

HemCon- chitosan, one of first bandages, moderate hemostasis with large hemorrhages

Advance clotting sponge (closed mesh bag)-zeolite; improved temperature control but poor hemostasis

WoundStat- smectite mineral and salt of cross linked polyacrylic acid Has shown 100% hemostasis in all animal experimental models Army pulled from use secondary to concerns about vessel thrombosis after use and removal.

SCALP WOUNDS

Whip stitch immediately and then get irrigation and definitive closure done later

OPEN BOOK PELVIC INJURIES

Bind pelvis closed at the level of the greater trochanters with either a bed sheet or preferably, a commercial pelvic binder

FEMUR FRACTURES

Place in traction to reduce bleeding

EXTREMITY WOUNDS

Tourniquets

Military now recommends tourniquets, stating that tourniquet use saves lives; increasing use in current conflicts. Civilian use is less supported, very low number of patients would actually benefit, but it is appropriate in certain cases and likely improves mortality (Dorlac, 2005). My practice is to use them during primary survey to allow concentration on ABCs.

Risks

- Ischemia to all structures distal to tourniquet
- Reperfusion injury (worse than hypoperfusion itself)
- Improperly placed or improvised tourniquets can cause vascular injury/injury to other structures

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