Traumatic Shock: update 2026

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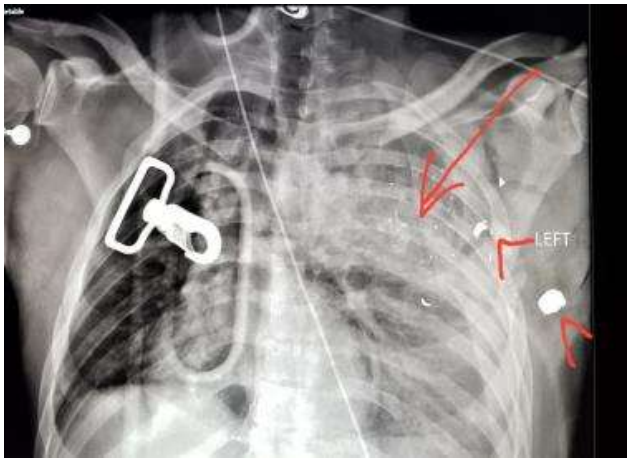
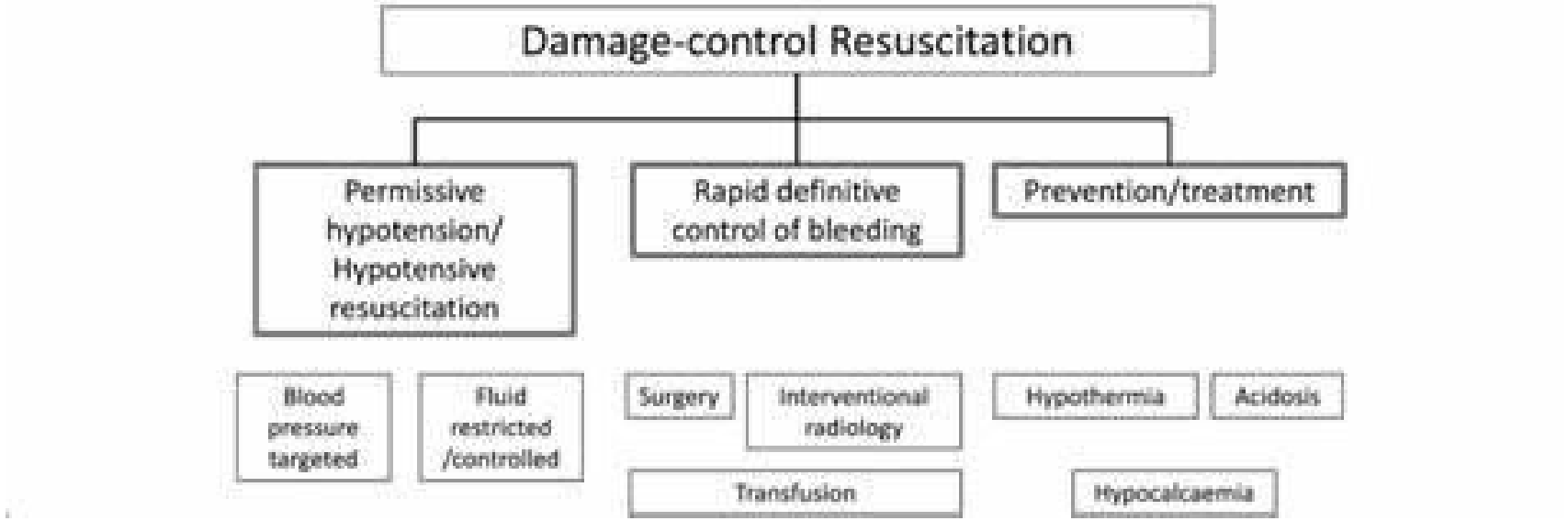
Disclosures

- Acumed
- UpToDate
- Springer, Inc

Trauma




Damage-control Resuscitation
Permissive hypotension/ Hypotensive resuscitation
Rapid definitive control of bleeding
Prevention/treatment
Blood pressure targeted
Fluid restricted /controlled
Surgery
Interventional radiology
Transfusion
Hypothermia
Acidosis
Hypocalcaemia

Permissive Hypotension

- Research presented clearly lays out that permissive hypotension is safe and has the potential to be beneficial.
- Attempting to maintain normal blood pressure while a patient is actively hemorrhaging leads to the ‘lethal triad,” which includes hypothermia, academia, and coagulopathy
  - J Trauma. 2011;70:652–663.

Bickell W. H., Wall M. J., Pepe P. E., Martin R. R., Ginger V. F., Allen M. K. & Mattox K. L. (1994). Immediate vs delayed fluid resuscitation for hypotensive patients with penetrating torso injuries.

- 289/598 pen trauma - delayed fluid resuscitation, 203 (70%) survived and were discharged from the hospital, as compared with 193 of the 309 patients (62%) immediate fluid resuscitation (P = 0.04).
- The mean estimated intraoperative blood loss was similar in the two groups.
- 238 PTS - delayed-resuscitation group survived to the postoperative period
  - 23% had one or more complications: ARDS, sepsis syndrome, ARF, coagulopathy, SSI, and PNA
  - 30% immediate-resuscitation group (P = 0.08).
- LOS -shorter in the delayed-resuscitation group.

New England Journal of Medicine, 1994.331(17), 1105–1109

Author	Date of Publication	Study Design	Level of Evidence	Study Population	Therapy or Exposure	Outcome/ Result
Bickell, W.H. [4]	1994	Prospective trial	1	598 adult patients with penetrating torso injuries (diastolic BP < 90 mmHg prehospital)	Immediate (pre-hospital) vs. delayed (once in the operating room) fluid resuscitation	70% of patients who received delayed fluid resuscitation survived vs. 62% who received immediate fluid resuscitation. P=0.04 23% of delayed vs. 30% of immediate pts had complications. Length of hospitalization was shorter in the delayed group.
Carrick, M.M. [10]	2016	Randomized controlled trial	1	168 patients in hemorrhagic shock with penetrating injuries	Experimental arm – maintained a target MAP of 50 mmHg; Control arm – standard fluid resuscitation of MAP = 65 mmHg.	Pt's were followed for 30 days. Pts in the experimental arm received less fluid. They did not have significantly different mortality rates at 24 hours or 30-days post-op.
Dutton, R. P. [11]	2002	Randomized control trial	1	110 patients in hemorrhagic shock	Target SBP > 100 mmHg (conventional) or target SBP of 70 mmHg (low). Fluid was titrated to this endpoint until hemostasis was achieved.	Titration of fluid did not affect mortality. There was an overall survival of 92.7% (4 deaths) in each group.
Morrison, C. A. [12]	2011	Randomized controlled trial	1	90 patients in hemorrhagic shock	Experimental arm – maintained a target MAP of 50 mmHg; Control arm – standard fluid resuscitation of MAP = 65 mmHg.	Pts were followed for 30 days. Pts in the experimental arm received fewer blood products and IV fluids. They had significantly lower mortality in the early postoperative period and non-significant lower mortality at 30 days.
Oyeniyi, B. T. [13]	2017	Retrospective	3	Records from a level 1 trauma center. 7080 patients (498 deaths) from 2005-2006 8767 patients (531 deaths) from 2012-2013	Analyze the temporal distribution of trauma-related deaths. Introduction of hemorrhage control interventions (a bleeding control bundle)	There was a reduction in hemorrhagic death rates, likely associated with a multimodal bleeding control bundle of care.
Schreiber, M. A. [3]	2015	Prospective randomized pilot trial	1	192 patients with a pre-hospital BP < 90 mmHg	Experimental group – 250 cc of fluid if they had no radial pulse or SBP <70 mmHg and an additional 250 cc to maintain radial pulse or SBP > 70mmHg. Control group – received 2L initially and fluid as needed to maintain SBP > 110mmHg	The control group received on average 1L less of IV fluid. Controlled resuscitation may have an early survival advantage in blunt trauma injuries, there was no difference among patients with penetrating trauma.
Stein, P. [14]	2017	Retrospective observational study	3	Compared two-time periods (2005-2007) and (2012-2014). All adult Pts with an injury severity score > 16 were included.	Changes in trauma management protocols: which included permissive hypotension, goal-directed coagulation management, etc.	Reduced incidence of massive transfusion and a reduction in transfusions of RBCs a

Permissive hypotension vs conventional resuscitation strategies in adult trauma patients with hemorrhagic shock: A systematic review and meta-analysis of randomized controlled trials.

- 5 RCT 1,158 patients were included.
- BP intervention arms SBP 50 mm Hg to 70 mm Hg – MAP 50 mm Hg or higher as vs. SBP 65 mm Hg - 100 mm Hg or MAP 65 or higher in the control arms.
- 4 trials suggested a survival benefit for 30-day or in-hospital mortality with hypotensive resuscitation
- Studies were of poor to moderate quality due to poor protocol reporting and lack of blinding.
- Odds ratio 0.70 (95% confidence interval, 0.53–0.92), suggesting a survival benefit for permissive hypotension.
- Those patients received fewer blood products and had lesser estimated blood loss.

Journal of Trauma and Acute Care Surgery 84(5):p 802-808, May **2018**.

The impact of prehospital whole blood on hemorrhaging trauma patients: A multi-center retrospective study

171 pWB and 1391 non-pWB patients- prehospital WB patients – lower ISS (17 vs. 21, $p < 0.001$) but higher prehospital SI showing greater physiologic disarray.

- Prehospital WB was associated with improvement in SI (-0.04 vs. 0.05, $p = 0.002$).
  - Mortality and (LOS) were similar.
- Prehospital WB patients received fewer RBC, FFP, and platelets units across their LOS but total units and volumes were similar.
- Prehospital WB patients had fewer MTPs (22.6% vs. 32.4%, $p = 0.01$) despite a similar requirement of CAT3+ transfusion upon arrival.

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J Trauma Acute Care Surg. 2023 Aug 1;95(2):191-196.

Prehospital blood transfusion for trauma

Shock Index

$$\frac{\text{Heart Rate}}{\text{Systolic BP}} = \text{Shock Index}$$

No Shock	Mild Shock	Moderate Shock	Severe Shock
<0.6	6≥ to <1.0	1.0≥ to <1.4	≥ 1.4

*there may be variations of this scale. Some scales may list 0.5-0.7 as normal range

- Life-threatening bleeding or severe shock
  - low-titer group O whole blood (LTOWB) over crystalloids.
  - Shock Index ≥1.1
  - Early administration—ideally within 30–35 minutes of injury—improves survival by up to 60% and reduces mortality.
  - Target SBP of permissive hypotension or for traumatic brain injury .
- Alternatives: If whole blood is unavailable, a 1:1 ratio of packed red blood cells (pRBCs) and plasma is recommended

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Trauma Surg Acute Care Open. 2025 Jul 16;

Prehospital Blood Transfusion

The landmark multicenter randomized Prehospital Air Medical Plasma Trial (PAMPer) demonstrated a significant improved 30-day mortality in patients who received two units of plasma, in addition to standard treatment, during their prehospital en-route care.

N Engl JMed. 2018;379(4):315–326.

Secondary analysis demonstrated that any prehospital blood product yielded a survival advantage compared with crystalloid therapy and those who received prehospital packed red blood cells plus plasma had the greatest survival benefit

Ann Surg. 2021;273(2):358–364.

Prehospital Blood Transfusion

- Civilian data using early transfusions of cold stored LTOWB in the prehospital setting suggests that prehospital LTOWB is safe, may be associated with hemostatic benefits, is associated with greater improvements in shock physiology, and may be associated with decreased early mortality

  - Transfusion. 2021;61(Suppl 1):S15–S21.
  - J Trauma Acute Care Surg. 2022;92(5): 839–847.


MEDICINE
MASSIVE TRANSFUSION PROTOCOL

Damage-control resuscitation

- A term coined by ***Holcomb*** et al. in 2007, represented a strategy that was introduced to work synergistically with damage control surgery (DCS) during the initial phases of Operation Iraqi Freedom and Operation Enduring Freedom.

What You Need to Know Series – Reviews

Damage control resuscitation in adult trauma patients: What you need to know

Danny T. Lammers, MD *and* John B. Holcomb, MD*, Birmingham, Alabama*

ABSTRACT: Death after injury is a worldwide epidemic. Hemorrhage as a cause of death represents the leading potentially preventable condition. Based on hard-won experience from the recent wars, and two decades of military and civilian research, damage-control resuscitation (DCR) is now widely used. This article will briefly describe the history of blood transfusion, outline "why we do DCR," and then discuss "how we do DCR." Modern DCR occurs both prehospital and in the hospital and has several main tenants. Currently, DCR focuses on the liberal use of temporary hemorrhage-control adjuncts, early use of whole blood or balanced blood product-based transfusions, mitigation of crystalloid use, hypotensive resuscitation to promote hemostasis and decrease coagulopathy, and correction of ongoing metabolic derangements, followed by rapid definitive hemorrhage control. These concepts have evolved from a series of lessons learned over time from both civilian and military trauma casualties, and DCR is now the standard of care in trauma resuscitation. (*J Trauma Acute Care Surg.* 2023;95: 464–471.

KEY WORDS: Damage Control Resuscitation; Transfusion; Whole Blood; Hemorrhagic Shock; Traumatic Coagulopathy.

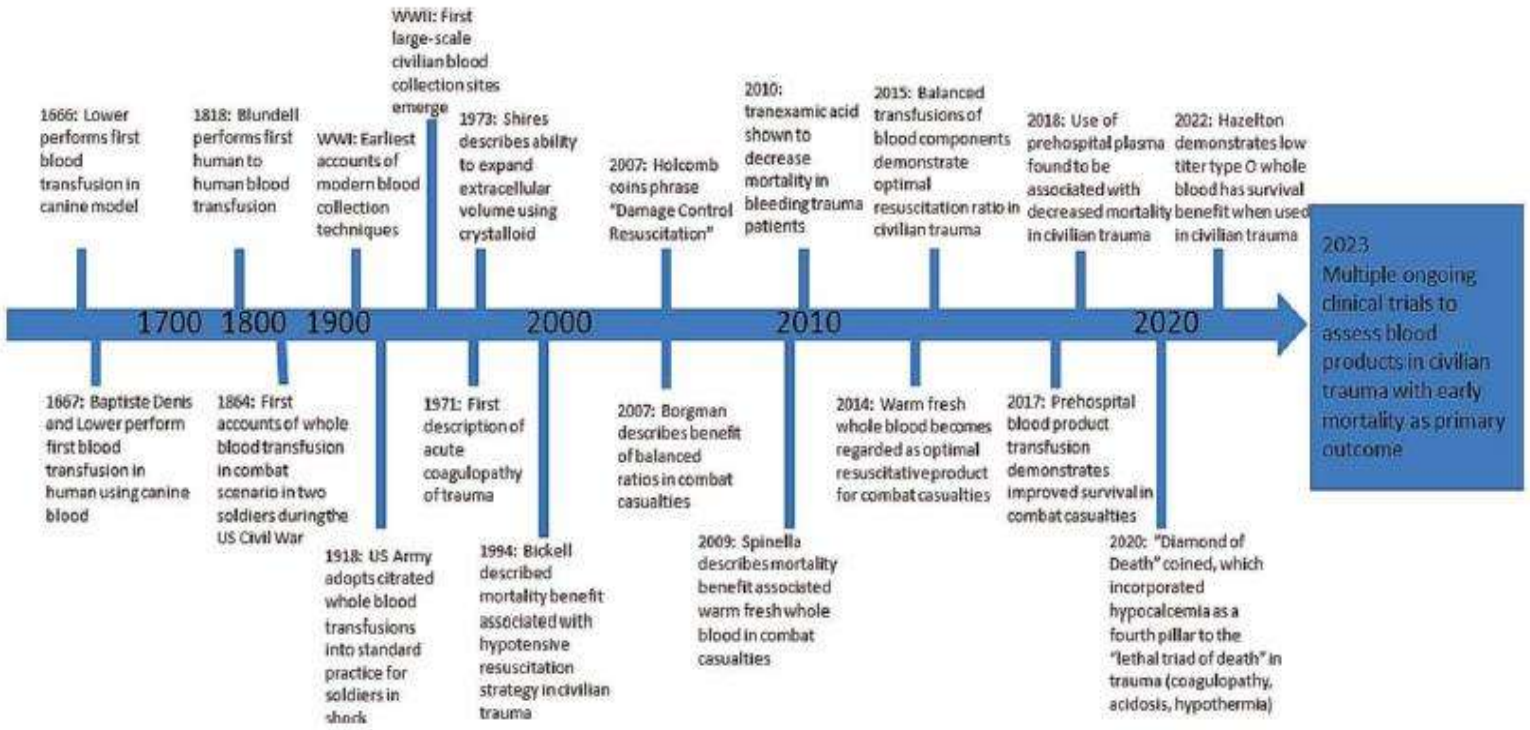
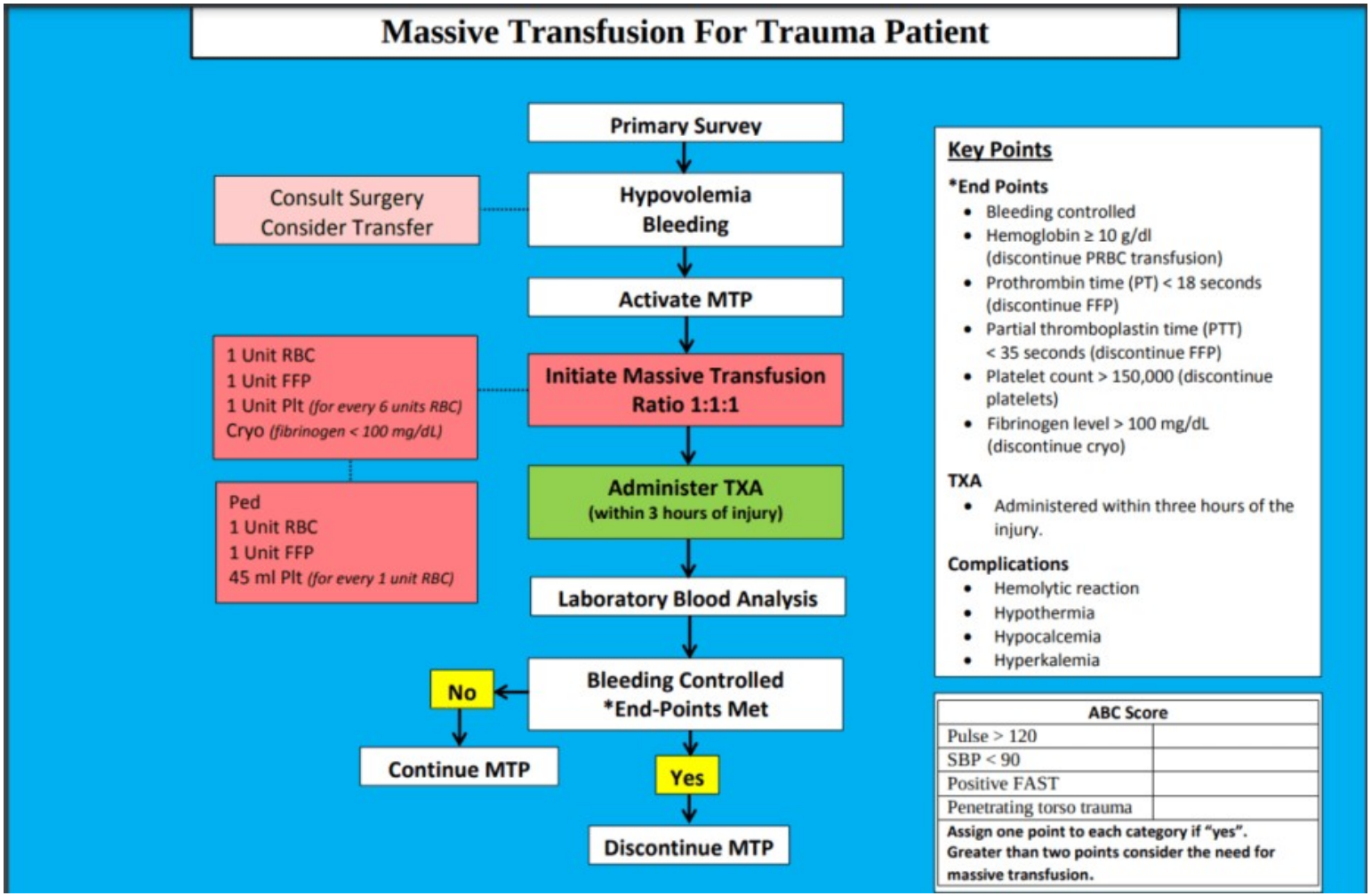


Figure 1. Evolution of resuscitation from 1666 to 2023.

Massive Transfusion For Trauma Patient



Key Points

***End Points**

- Bleeding controlled
- Hemoglobin ≥ 10 g/dl (discontinue PRBC transfusion)
- Prothrombin time (PT) < 18 seconds (discontinue FFP)
- Partial thromboplastin time (PTT) < 35 seconds (discontinue FFP)
- Platelet count > 150,000 (discontinue platelets)
- Fibrinogen level > 100 mg/dL (discontinue cryo)

TXA

- Administered within three hours of the injury.

Complications

- Hemolytic reaction
- Hypothermia
- Hypocalcemia
- Hyperkalemia

ABC Score	
Pulse > 120	
SBP < 90	
Positive FAST	
Penetrating torso trauma	

Assign one point to each category if "yes". Greater than two points consider the need for massive transfusion.

Massive Transfusion Protocol (MTP) - Findings from the PROPPR study.

- 12 Level I North American trauma centers
- 680 patients, 613 underwent a surgical procedure, 397 underwent a laparotomy, and 346 underwent an emergency laparotomy.
- Patients - emergency laparotomy were 51.5% & 50.3% for 1:1:1 and 1:1:2, respectively (p = 0.20)
  - Median time to laparotomy - 28 minutes in both treatment groups
  - Surviving to 24 hours and 30 days were similar between treatment arms;
- 24-hour survival - 86.8% for 1:1:1 and 83.1% for 1:1:2 (p = 0.29)
- 30-day survival - 79.3% for 1:1:1 and 75.0% for 1:1:2 (p = 0.30)

J Trauma Acute Care Surg. 2016 Apr;80(4):568-74.

Damage Control Resuscitation

- Permissive Hypotension
  - Target MAP = 50-60 mmHg
  - Minimize dilution effect and hypothermia secondary to overzealous fluid replacement
- Early use of Blood products over isotonic fluids for volume replacement
- Early correction of coagulopathy
  - Massive transfusion protocol: RBC:FFP:Platelets = 1:1:1

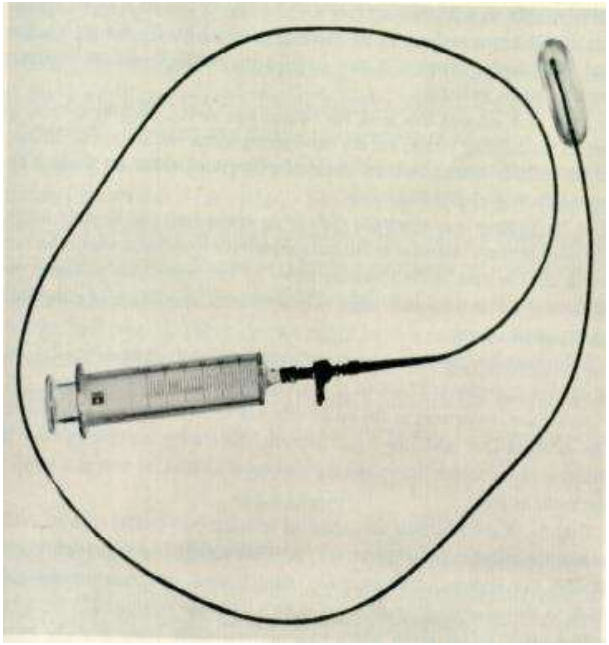
Cureus. 2021 Jul 19;13(7):e16487.

Prehospital	Hospital	Hospital
• Physical exam • Vital signs • IV or IO Access • Minimal crystalloid • Compressible hemorrhage control with appropriate Devices • Start Blood (WB or balanced components) • Hypotensive resuscitation • C-Collar for blunt patients • Pelvic binder	• Physical exam • Vital signs • FAST exam • Start Blood (WB or balanced components) • Hypotensive Resuscitation • Central Access • External hemorrhage control with appropriate devices • CXR/Pelvis X-ray / Other Imagining • Decompress chest as indicated • Pelvic binder	• Send labs • Rapidly To OR and/or IR • Intubation (low TV) • CFA arterial line • Minimal crystaloid • Other hemostatic adjuncts as indicated (REBOA, etc) • After hemostasis acheived, component tranfusion based on lab values

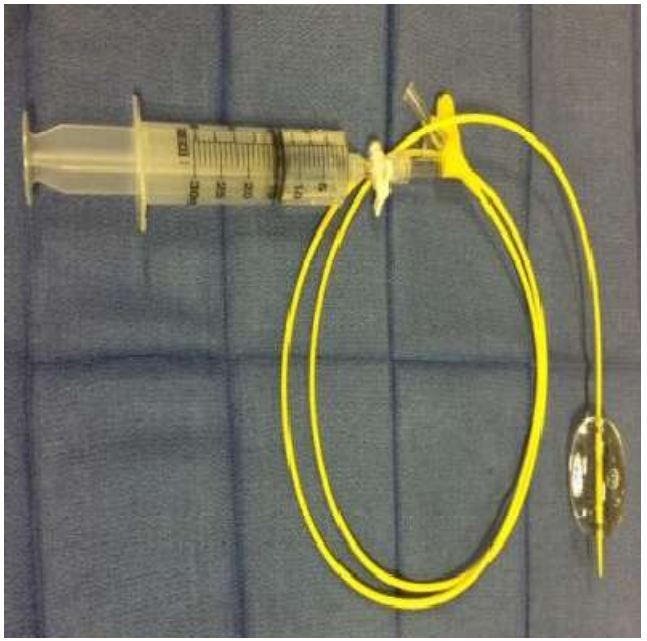
Emergency Field Tourniquet

- Early use of tourniquets and hemostatic dressings has been widely implemented and associated with improved outcomes.

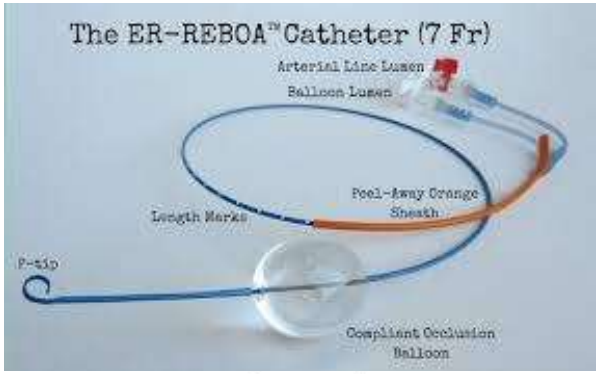
Aortic Resuscitative Balloon

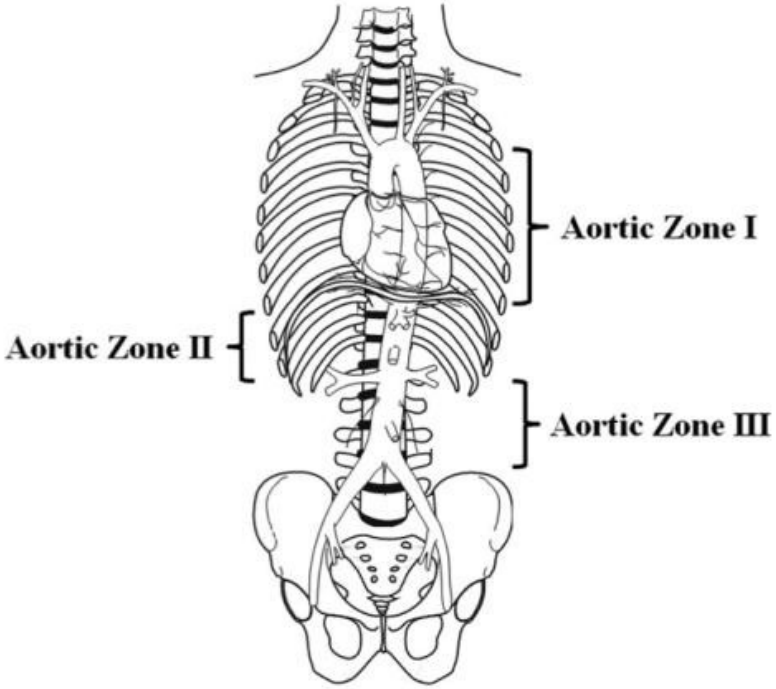


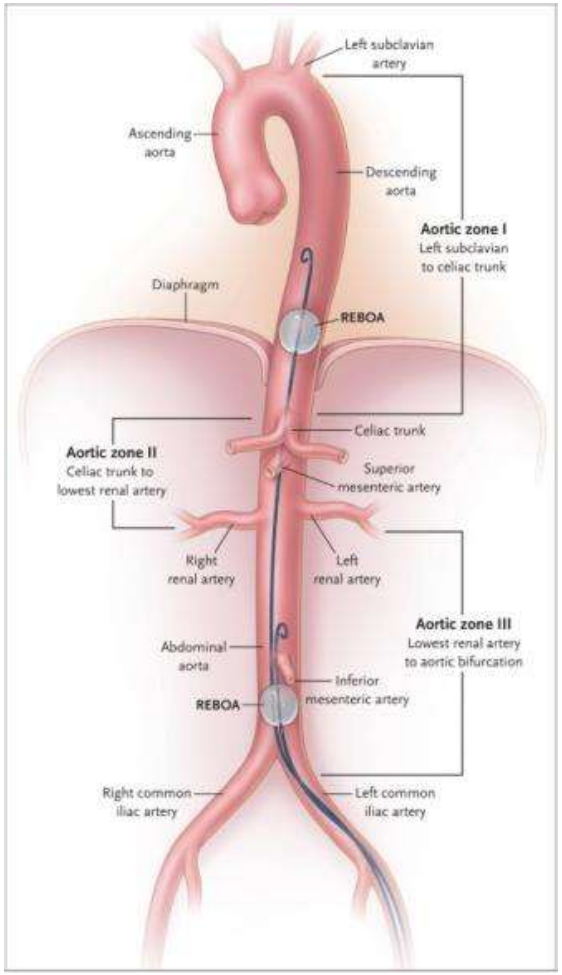
Historical



CODA 32 mm balloon mounted on 100 cm flexible 10 Fr catheter (Cook Inc.)
Introduced via 14 Fr sheath







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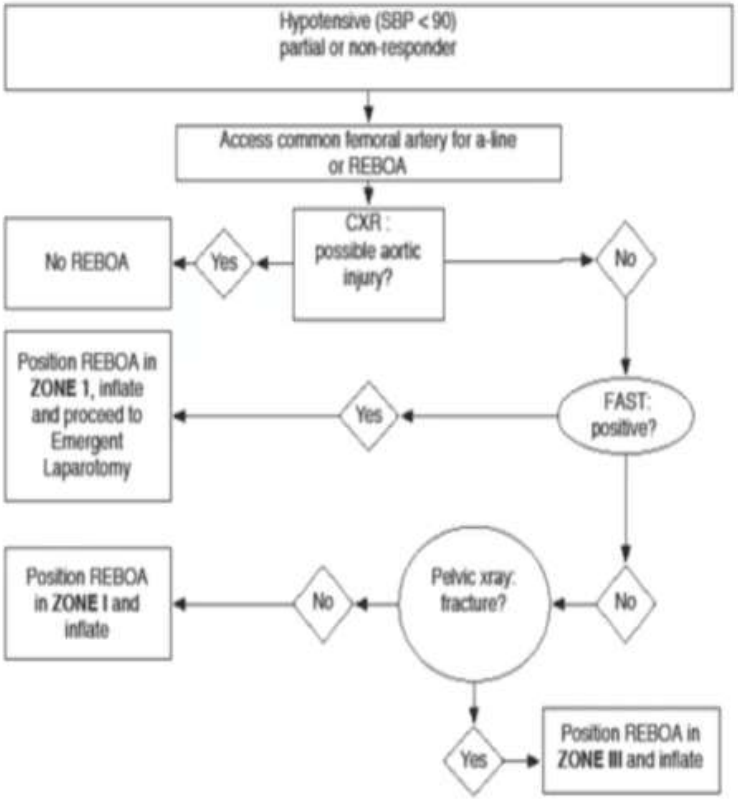
Basic endovascular skills for trauma course: Bridging the gap between endovascular techniques and the acute care surgeon

- Catheter-based skills is increasing in the field of vascular trauma



J Trauma Acute Care Surg. 2014 Aug;77(2):286-91.

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Implementation of REBOA as an alternative to resuscitative thoracotomy (RT) for noncompressible truncal hemorrhage

- 72 RT patients, 45 (62.5%) died in the ED, 6 (8.3%) died in the operating room, and 14 (19.4%) died in the ICU
- 24 REBOA patients, 4 (16.6%) died in the ED, 3 (12.5%) died in the operating room, and 8 (33.3%) died in the ICU
- Location of death between the RT and REBOA groups, there were a significantly higher number of deaths in the ED among the RT patients as compared with the REBOA patients (62.5% vs. 16.7%, $p < 0.001$).
- REBOA had fewer early deaths and improved overall survival as compared with RT (37.5% vs. 9.7%, $p = 0.003$).

J Trauma Acute Care Surg. 2015 Oct;79(4):523-30;

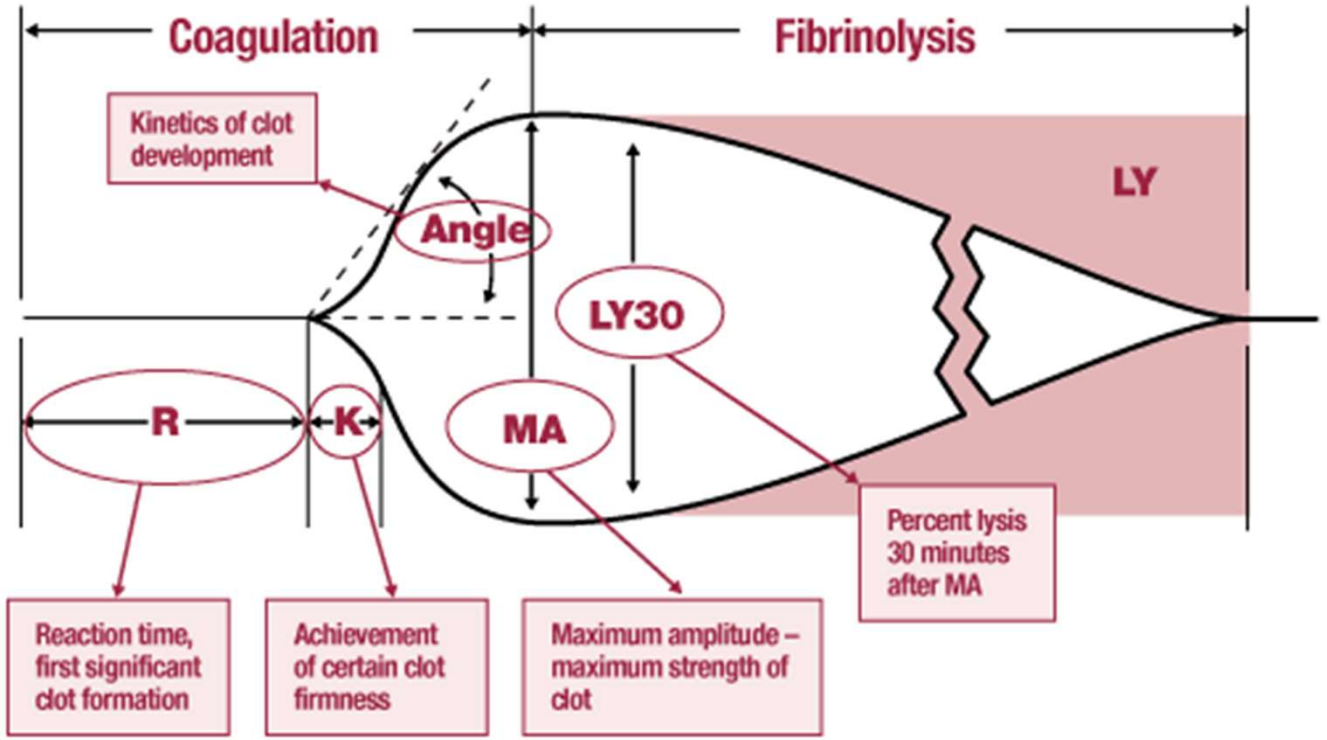
Adjuncts for DCR

- Hyperfibrinolysis represents a unique coagulopathy phenotype displayed by a subset of patients that has been associated with poor outcomes
- Tranexamic acid (TXA), an antifibrinolytic agent that acts as a lysine receptor antagonist on plasminogen to block fibrinolysis, has demonstrated a significant decrease in mortality for civilian traumas when administered within 3 hours of injury
- Data from military trauma patients have been congruent with civilian data and indicate increased survival rates with early administration of TXA for patients at risk for hemorrhagic shock.
- Civilian guidelines recommend the administration:
  - 1-g TXA bolus within 3 hrs from injury followed by another 1-g infusion of TXA over 8 hours
- Civilian systems & DoD have deployed a simpler dosing regimen
- 2 gm patients with TBI and/or hemorrhagic shock)
  - Rowell et al

(TEG) / (ROTEM) to monitor hemotherapy vs usual care (MTP)

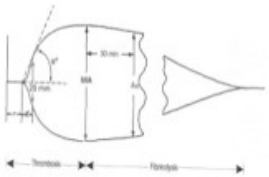
- CRASH-2 Trial: TXA safely reduced the risk of death in bleeding trauma patients in this study.
- TXA should be considered for use in bleeding trauma patients
  - *Lancet. 2010 Jul 3;376(9734):23-32.*
- Absence of evidence that TEG or ROTEM improves M&M in patients with severe bleeding.
- Application of a TEG or ROTEM guided transfusion strategy seems to reduce the amount of bleeding but whether this has implications for the clinical condition of patients is still uncertain.
  - *Cochrane Database Syst Rev. 2011 Mar 16;(3):CD007871.*

TEG


Coagulation
Fibrinolysis
Kinetics of clot development
Angle
LY
LY30
R
K
MA
Percent lysis 30 minutes after MA
Reaction time, first significant clot formation
Achievement of certain clot firmness
Maximum amplitude – maximum strength of clot

TEG

TEG Parameters



Maximum amplitude

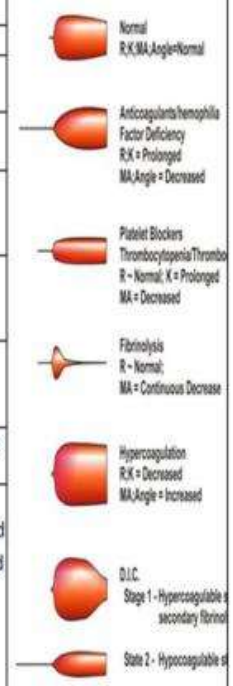
- is a direct function of the maximum dynamic properties of fibrin and platelet bonding
- represents the maximum strength of the fibrin clot
- Correlates more to platelet function and to lesser extent to fibrinogen

MA ↓ by

- Thrombocytopenia
- Thrombocytopathy
- Fibrinolysis
- Hypofibrinogenemia

Laboratory Value	Interpretation	Blood Product Transfusion
R less than 4 min	Enzymatic Hypercoagulability	No treatment if bleeding
R between 11-14 min	Low clotting factors	Plasma and RBC's
R greater than 14 min	Very low clotting factors	Plasma and RBC's
a-angle<45 degrees	Low fibrinogen level	Cryoprecipitate/ Fibrinogen /Platelets
MA between 46-54 mm	Low platelet function	Platelets / Cryoprecipitate/ Fibrinogen
MA between 41-45 mm	Very low platelet function	Platelets / Cryoprecipitate/ Fibrinogen
MA at 40 mm or less	Extremely very low platelet function	Platelets / Cryoprecipitate/ Fibrinogen
MA greater than 73 mm	Platelet Hypercoagulability	No treatment if bleeding
LY30 greater than 3%, CI less than 1.0	Primary fibrinolysis	**Tranexamic acid** 1g IV over 10 minutes followed by 1g in 250cc NS infused over 8 hours

QUALITATIVE INTERPRETATION -- PATTERN RECOGNITION



- Refer to TEG analysis tree for values outside these ranges

Primary fibrinolysis

- Fibrinogen deficiency can occur early during the resuscitative period and has been intimately linked to the degree of shock and tissue injury a patient experiences

TXA: Tranexamic Acid

Primary fibrinolysis – acute coagulopathy of trauma (ACOT)

Presence of hyperfibrinolysis (HF) in severe traumatic injuries associated with high mortality rate (70-100%)

Acts binding to plasminogen and blocking the interaction of plasminogen with fibrin, pre-venting dissolution of the fibrin clot

Indications:

- Adult trauma patients with severe hemorrhagic shock(SBP≤75 mm Hg), with known predictors of fibrinolysis, or with known fibrinolysis by TEG (LY30>3%)
- Administer only if less than 3 hours from time of injury
- 1 g IV over10 minutes, then 1 g IV over 8 hours

Adjuncts for DCR

- Hypocalcemia - remains an integral component during early trauma resuscitation.
  - incorporated into the lethal triad of death
  - “the diamond of death”
  - hypocalcemic state found to be associated with the need for ongoing transfusions, increased risk for massive transfusion, and higher mortality rates

Vasopressors in Trauma

- Traditional teaching - no role for vasoactive medications in hemorrhagic shock
- Understanding that hemorrhagic shock can alter neurohormonal function resulting in a vasopressin-depleted state despite ongoing blood product replacement
- Sims et al. assessed the addition of low dose vasopressin into their resuscitation strategy.
  - Incorporation of vasopressin during the acute resuscitative period
  - Decreases overall blood product requirements
  - Decreased rates of deep venous thrombosis despite vasopressin use being associated with enhanced platelet function.
- Despite the fact that the addition of vasopressors may help augment a physiologically depleted state and overcome refractory vasoplegia, data surrounding these concepts are limited and vasopressor administration during hemorrhagic shock is only currently recommended by European guidelines

Delayed interventions and mortality in trauma damage control laparotomy

- Mortality increased in patients undergoing
  - Delayed vascular interventions
  - Unplanned re-exploration
  - Re-exploration for hemorrhage control

Surgery. 2016 Aug 4.

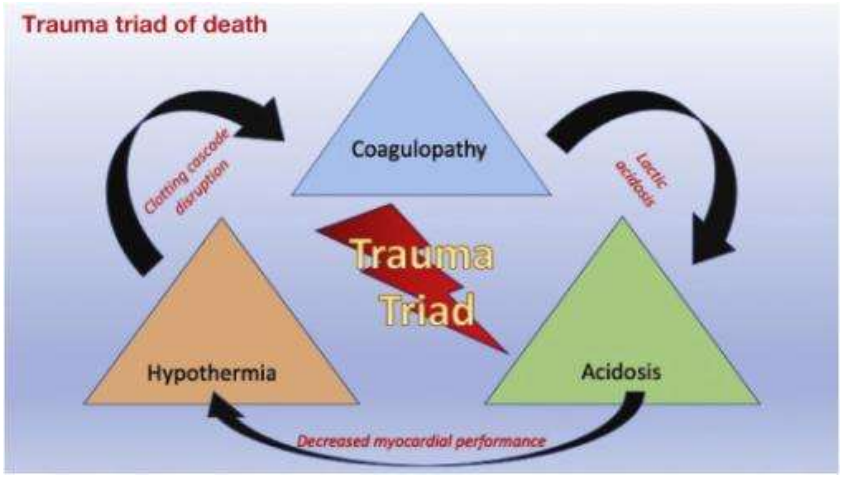
The Trauma Laparotomy

Direct Exploration (Definitive Management)

- Stable patient
- Primary repair or management of traumatic injuries

Trauma Laparotomy Packing (Damage Control)

- Trauma Shock
  - Stop Bleeding
  - Stop Contamination
- Look out for the Lethal Triad



Conclusion

Damage Control Resuscitation

- Permissive hypotension
- Prehospital blood
- Massive transfusion
- TXA / TEG / Ca correction
- DCS
- ICU

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