Damage Control In Trauma

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I have nothing to disclose....except
Damage Control
Objectives

• Historical Perspective
• Definitions
• Coagulopathy of Trauma
• Damage Control Resuscitation
• Abdominal Trauma and Open Abdomen
• Thoracic Trauma
• Vascular Trauma
• Military Experience
• Conclusions
Damage Control
Historical Perspective

• Definition from US Navy
• “The Principle of performing the minimum amount of repairs necessary to maintain Ship Worthiness”
• 1.- Take all practicable preliminary measures to prevent damage
• 2.- Minimize and localize damage as it occurs
• 3.- Accomplish emergency repairs as quickly as possible, restore equipment to operation and care for the injured personnel.

Damage Control
Historical Perspective

• Pringle in 1908 ushered damage control by creating the maneuver that bears its name in hepatic injuries (Temporary Hilar Clamping)
• Kashuk in 1982 described the concept of vicious cycle of hypothermia, coagulopathy and acidosis
• Stone in 1983 was the first to describe the procedure
• Jurkovich in 1987 demonstrated 100% mortality in severely injured patients whose temperature fell below 32 C
• RotondSo in 1993 landmark paper describing the concept of Damage Control in Trauma. He demonstrated an improvement of survival on [DCL from 11% to 77%] in a subset of patients with major vascular and visceral injuries

Hsu et al Int J of Crit Ill and Inj Sci 2011
Rotonde et al J of Trauma 1993
Cirocchi et al Cochrane Review 2010
Stages of Damage Control (DC) Definitions

Stage 1: DC1
- Control hemorrhage
- Limit peritoneal contamination
- Temporary abdominal closure

Stage 2: DC2
- Hypothermia prevention/treatment
- Correction of coagulopathy
- Correction of acidosis

Stage 3: DC3
- Definitive surgery
- May require multiple surgeries
- Creation of ostomies, feeding access, fascial closure
- No longer than 72 hours from Stage 1
Damage Control Resuscitation

• Up to a third of trauma patients arrive to the hospital already coagulopathic with increased mortality
• ATLS states about damage control procedures before the secondary survey
• ATLS still goes by 3:1 rule in crystalloid/blood replacement

Coagulopathy of Trauma

[Diagram showing the process of hyperfibrinolysis involving PAI-1, T-PA, and plasmin]
Damage Control Resuscitation

- Study to compare Damage Control Resuscitation (DCR) with a historical cohort on patients treated from the ER to OR done by Dr McSwain Jr in New Orleans.

  Criteria to activate the MTP were: HR>100, initial SBP <100, Hb<9, ph<7.25, INR>1.5, initial temp <35oC.
- The DCR had more use of PRBC and FFP but much less crystalloid use and this was associated with a survival advantage and shorter hospital stay.
- When compared the use of MTP in trauma and nontrauma populations, 24 hour mortality, overactivation of the protocol and less efficient use was found as well.
- Study in the Houston area applying the concept of DCR, permissive hypotension and less crystalloid use also replicated better outcomes and less blood product usage.

Duchesne et al The Am Surg 2011
Mprse et al American Surgeon 2012
Cotton et al Annals of Surgery 2011

Damage Control Resuscitation

- This study was done by Dr Mattox in Houston and through a community informed consent he randomized prospectively patients with severe trauma to permissive hypotension in the OR comparing MAPs of 65 (standard) to 50.
- Interim analysis concluded that it is a safe technique with decrease in the use of blood products and decrease in postoperative coagulopathy.

Morrison et al Journal of Trauma 2011
The importance of early treatment with tranexamic acid in bleeding trauma patients: an exploratory analysis of the CRASH-2 randomised controlled trial

The CRASH-2 collaborators

Summary
Background: The aim of the CRASH-2 trial was to assess the effects of early administration of tranexamic acid on death, vascular exclusive events, and blood transfusion in trauma patients with significant haemorrhage. Tranexamic acid significantly reduced all-cause mortality. Because tranexamic acid is thought to exert its effect through inhibition of fibrinolysis, we undertook exploratory analysis of its effect on death due to bleeding.

Methods: The CRASH-2 trial was undertaken in 274 hospitals in 40 countries. 20,311 adult trauma patients with, or at risk of, significant bleeding were randomly assigned within 6 h of injury to either tranexamic acid (facing dose of 1 g over 30 min followed by infusion of 1 g over 8 h) or placebo. Patients were randomly assigned by selection of the lowest numbered treatment pack from a box containing eight numbered packs that were identical apart from the pack number. Both participating and study staff (i.e. investigators and trial coordinating centre staff) were masked to treatment allocation. We examined the effect of tranexamic acid on death due to bleeding according to time to treatment, severity of haemorrhage as assessed by systolic blood pressure, Glasgow coma score (GCS), and type of injury. All analyses were by intention to treat. The trial is registered at ISRCTN67367103, ClinicalTrials.gov NCT00753779, and South African Clinical Trial Register/Department of Health D008.20070711.00055.2.

Findings: 10,094 patients were allocated to tranexamic acid and 10,217 to placebo, of whom 10,040 and 10,047, respectively, were analysed. 1053 deaths (35%) were due to bleeding. We recorded strong evidence that the effect of tranexamic acid on death due to bleeding varied according to the time from injury to treatment (for interaction p<0.0001). Early treatment (≤1 h from injury) significantly reduced the risk of death due to bleeding (IRR=0.74 [95% CI 0.62–0.88]; p<0.0001). Treatment given between 1 and 3 h also reduced the risk of death due to bleeding (IRR=0.87 [95% CI 0.76–0.98]; p=0.01), but treatment given after 3 h seemed to increase the risk of death due to bleeding (IRR=1.33 [95% CI 1.15–1.56]; p=0.002). Treatment given after 3 h seemed to increase the risk of death due to bleeding (IRR=1.37 [95% CI 1.15–1.62]; p=0.004). We recorded no evidence that the effect of tranexamic acid on death due to bleeding varied by systolic blood pressure, Glasgow coma score, or type of injury.

Interpretation: Tranexamic acid should be given as early as possible to bleeding trauma patients. For trauma patients admitted late after injury, tranexamic acid is less effective and could be harmful.

Funding: UK NIHR Health Technology Assessment programme, Pfizer, BUPA Foundation, and J.P. Moulton Charitable Foundation.
Damage Control Resuscitation

• 1. Limited Fluid Resuscitation
• 2. Permissive Hypotension unless there is a TBI
• 3. Avoid large volumes of crystalloids (edema, compartment syndromes and acidosis)
• 4. Avoid synthetic colloids (cause coagulopathy and kidney failure)
• 5. Issues with patients on Coumadin or platelet inhibitors (Use of platelets assays: PFA100 and multiplate)
• 6. Use of REG/ROTEM
• 7. Ratio of PRBC, FFP, platelets Ideal Hb (7-10gr)
• 8. Recombinant Factor VII, Fibrinogen concentrate and Prothrombin Complex Concentrate (Teragnostic Approach)

Bickel et al: NEJM 1994

RR > 10 min Decrease Coag Factors FFP or Cryo
Angle < 52o Hypofibrinogenemia Funct Fibrinogen Analysis
MA< 49 mm or Maff <14 mm Decrease Fibrinogen FFP
MA <49 mm Maff>14 mm Decreased Platelets Platelets
Lysis at 30 min > 8% Primary fibrinolysis Tranexamic Acid
Damage Control Resuscitation

• Study of Prehospital plasma resuscitation in patients with severe hemorrhagic shock
• Possibility of starting with plasma transfusion on the prehospital period with use of thawed plasma and point of care measurement of INR, lactic acid and hemoglobin
• Effective early treatment of trauma induced coagulopathy with plasma to PRBC ratio to close to 1
• In this study there was proof of damage control resuscitation for trauma coagulopathy extending to 24 hours post trauma but no survival benefit

Kim et al J Trauma Acute Care Surg 2012

Guess who doesn't belong?
Damage Control Laparotomy

- Open and pack four quadrants
- Spleen injury: Do Splenectomy
- Severe Kidney injury: Be sure that patient has two kidneys and possibly remove the badly injured one
- Severe vascular injuries: attempt repair or shunt
- Pancreas: Proximal, Place drain, distal without ductal injury: drain, with ductal injury, distal pancreatectomy and splenectomy
- Dudoenal, attempt repair, if not drain
- Colonic Reapir Issues and diversion in DCL is Controversial
- Never attempt to do a Whipple in the first (index) operation, HAS TO BE STAGED
- Options for closure: Sutures, towel clips, Bogota Bag, Vacuum Pac, Meshes (absorbable, biologic), Skin graft, Component Separation
- Complications like enteroatmospheric fistulas, loss of domain, etc.

Chovanes et al SCNA 2012
Georgoff et al Journal of Surgical Research 2012
Open Abdomen

- Multiple techniques have developed
- To this date, no RCT have been written comparing traditional vs DCS to compare outcomes between these two techniques
- Bogota Bag
- Negative Pressure Therapy
- Concept of Primary, Secondary and Tertiary Abdominal Compartment Syndrome
- Use of Absorbable or Biologic Mesh and Component Separation for Abdominal Wall Reconstruction

Demetriades D Int World J 2012
Cirocchi et al The Cochrane collaboration 2010
Photo Essay: Cure Worse Than the Disease? Toxic Epidermal Necrolysis August 1, 2006

Enteroatmospheric fistula

August 13, 2006
Damage Control Thoracotomy

- Can be a Posterolateral, lateral, anterior, median sternotomy or a Clam shell incision
- Ligation or shunting of great vessels, covered vascular stent
- Closure of heart injuries with sutures or staples
- Lung tractotomy or quick non anatomic wedge resection or hilar clamp or 180 degree hilar twist
- Esophagus: closure and/or drainage
- Tracheal injuries: bypass the segment with ETT or place the ETT through the injury
- Chest tubes and VAC PAC chest

Chovanes et al SCNA 2012
Damage Control Vascular

- Direct Pressure, packing, repair or ligation
- 86% of proximal stents remain patent vs 12% of distal stents
- Extremity salvage rate of 93%
- Use of Intravascular stents in challenging areas like aorta or subclavian vessels
- ALWAYS DO FASCIOTOMY
  
  Chovanes et al SCNA 2012
Damage Control Orthopedics

- Prolonged definitive orthopedic procedures on an unstable patient have higher mortality
- Proposed first do life saving procedures followed by:
  - Salvage surgery for control of hemorrhage and stabilization of long bones and pelvic fractures
  - External Fixators (avoid vascular injuries)
  - ICU management
  - Definitive Surgery which is still controversial (<2 weeks)

Staeheli et al Patient Safety in Surgery 2012

Damage Control
Military Experience

- Interesting paper about the French experience in Afghanistan
- French Hospital in Kabul with 3 OR, ICU and ER
- Over 18 months did 483 procedures of which 31% were war related injuries, 26% non war trauma, 24% non trauma emergencies and 18% elective procedures
- Great variety of cases including vascular and damage control procedures
- Propose for surgeons a: Course of Advanced Surgery on an Exterior Mission (Cachirmex) with extensive training in thoracic and vascular techniques in five modules over a two year period
- Have trained successfully over 85 surgeons
- (In the US we have short courses like ASSETT and ATOM

Bonnet et al Injury 2012
38th Donald F Egan Scientific Memorial Lecture

Lessons From the Tip of the Spear: Medical Advancements From Iraq and Afghanistan

LCDR Jason J Schrager MD (USNR), Richard D Broom MD-BRT FAARCE, and Col Jay A Johnstungrus MD (USAF Reserve)

- Tremendous amount of experience gained from the conflicts in Iran and Afghanistan
- Revival and improvement in the concept and use of Tourniquets and local hemostatic agents for non compressible areas like groin and axila
- Transfusion of fresh blood from “walking” blood banks
- More blood and FFP and less crystalloids
- Five factors of lethal triad; acidosis (base deficit >6), coagulopathy INR >1.5, hypothermia T<96F, hypotension SBP <90 and anemia Hb <11
- Physicians on transport making transport into and airborne trauma bay
- Quick transition to the next level of care with damage control techniques (more aggressive techniques based on more edema caused by blast injuries in healthy warriors

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Damage Control Military Experience

Continuous En Route Care
Current Route from Injury to Definitive Care

- CASEVAC 1 Hour
- TACTICAL EVAC 1-24 Hours
- STRATEGIC EVAC 24-72 Hours
- Forward Surgical teams, MFST, FAST, FAB, SSTP Level 2
- Combat Support Hospital, EMEDS, Fleet Hospital Level 3
- Definitive Care Level 4

Surgical Capability
Damage Control
Conclusions

• 1.- Over two decades the concept of Damage Control in Trauma and Surgery has improved outcomes
• 2.- The added effect of Damage Control Resuscitation with better RBC:FFP:platelet ratio, Permissive Hypotension and less use of crystalloids has decrease the number of DCL, Abdominal Compartment Syndrome, incidence of Open Abdomen and outcomes as well

“Judging by the barbed-wire and signs, your mom had a long shift and doesn’t want to be disturbed.”