Optimizing the Outcomes of Poly Trauma Patients

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Benefits of a Trauma System

- Only 50% of US have statewide trauma system. Survival better in states with inclusive system
  - Utter et al. J Trauma 2006

- The implementation of trauma systems decrease hospital mortality of the severely injured by 15 to 20%
  - Jurcovich et al, Mullins et al. J Trauma 1999; 47 (class III evidence)

- Reduction of 8 to 10% in vehicular crash mortality
  - Nathens Jurcovich Cummings JAMA 2000 (class II evidence)

- 25% reduction in mortality (pts <55yrs) at trauma center
  - MacKenzie et al. NEJM 2006 (class I evidence)
Trauma System
Quality Improvement (QI)

- System wide Trauma Registry essential
  - Injury severity indices
  - Measurable outcomes indicators
- Verification of centers
- Measure compliance with defined standards
- Monitors performance and standards of care
- Track complications, deaths and errors
- Develops guidelines, policies and protocols
- Trauma Coordinators essential

ACS WEBSITE
http://www.facs.org/dept/trauma/handbook.html
Preventable Death

- Def: Calculated probability of survival of >50%

- Causes
  - Non trauma hospitals: under-estimation of injuries
  - Trauma hospitals: errors in judgment or technique

- Preventable death rate of <2% is ideal
  - Def. preventable event: ACS COT Resources for the optimal care of the trauma patient 2006

- What about preventable suboptimal outcomes?
  - Function (outcomes scoring)
  - Cost
  - Utilization of resources
For optimal outcomes, the polytrauma patient needs ideal management at every phase.

This involves all the health professionals: EMS, Emergency Care, Trauma Surgery, Anaesthesia and Critical Care teams.

Communication, cooperation and continuity of care is essential.
Airway management: Pre-hospital controversies

- Pre-hospital RSI in TBI patients: studies have shown both improved and worsened mortality. Better oxygenation vs. inadvertent hyperventilation and hypocapnia
  
  Davis et al. J of Trauma 2005

- Intubated TBI patients do better, provided end-tidal CO$_2$ is used continuously to prevent hyper- or hypocapnea

  Poste et al. Air Med J 2004
  Bulger, Surg Cl. N.A. 2007

- Value of end-tidal CO$_2$ in a shocked patient?
Ventilation Induced Lung Injury

- Increasing evidence that mechanical ventilation contributes to the pathogenesis of MODS

- VILI pathogenesis
  - High airway pressures cause over distention of alveoli
  - Repetitive alveolar recruitment and collapse: shear forces
  - Inflammatory mediators released → cell damage
  - Bacteria and endotoxin translocation from lung to blood
  - Systemic inflammatory response

- Low $V_T$ ventilation (6ml/kg), with limited airway pressures and PEEP, attenuates VILI, decreases ALI / ARDS mortality and decreases non-pulmonary organ dysfunction
  - ARDS Network NEJM 342:1301 2000
Airway & Ventilation

ARDS
- Surfactant, inhaled nitric oxide, or pharmacologic agents
  - have not consistently reduced mortality
- Steroid therapy: equivocal results.
- Prone positioning
  - may improve gas exchange
  - not shown to improve outcome in patients with respiratory failure.
  - Vincent et al, Chest. 2006;129:1061-1067

- Early percutaneous tracheostomy <48 hrs
  - facilitates weaning
  - less nosocomial pneumonia
  - shorter ICU stay
    - Rumbak et al, Crit Care Med. 32: 1689 2004
    - Griffiths et al BMJ 330: 1243 2005
Fluid resuscitation

- Adverse effects determined by fluid composition, tonicity, duration of exposure, timing, presence of inflammation / infection / second hit

- Avoid aggressive crystalloid resuscitation
  - Shown to be harmful
  - Immune mediated organ injury ALI / ARDS / MODS
  - Abdominal compartment syndrome
  - Bleeding: Clot disruption, hemodilution, coagulopathy

- Limited or no fluid pre-hospital
  - Appropriate for penetrating trauma, short distance transport.
  - Inappropriate for traumatic brain injury (TBI)

  Bickell et al NEJM 1994
  Chestnut et al J Trauma 1993
Effects of Resuscitation Fluids

- Racemic Ringer’s Lactate (D-and L-isomer of lactate)
  - widespread inflammation, cell migration and apoptosis
- Ringer’s L-isomer lactate
  - attenuates neutrophil activation
- Ketone Ringer’s and bicarbonate Ringer’s (modified RL)
  - significantly less apoptosis
- NaCl 0.9%: hyperchloremic acidosis

- Dextran: neutrophil activation

- Albumin remains controversial:
  - results in higher mortality rates
  - Albumin and normal saline solution result in equivalent outcomes
Hypertonic Saline (HTS)

- Rapid expander of plasma volume
- 250ml of 7.5% saline = 2-3 L of NaCl 0.9%
- Attenuation of immune mediated cellular injury and ARDS
  - Angle, Hoyt et al, Shock 9:1641998
- Almost no side effects in 8 double blind randomized studies
- Mixed reports from various studies, many supportive
- Definitive study requires large numbers, multicenter trials
- not yet FDA approved as routine trauma treatment
Trauma as a disease

- Trauma remains a serious global health issue and a leading cause of death in first four decades of life

- 70% of immediate or early trauma deaths are caused by blood loss and/or head injury
  - Chiara et al. Injury 33:553 2002

- Late deaths are caused by sepsis and Multi Organ Failure
  - Sepsis rates increasing
  - 30-40% fatality rate: unchanged 3 decades
US Military Combat Fluid Resuscitation Recommendations

- Low volume resuscitation with HTS, colloid or combinations, such as 7.5% NaCl - 6% Dextran
- Aggressive fluid resuscitation is deleterious
- Permissive hypotension (excluding TBI)
  sBP > 80 mmHg, palpable pulse
- Ideal fluid not yet available (except fresh whole blood)

  Champion HR. J Trauma 2003
Bleeding and Coagulopathy

- Uncontrolled bleeding
  - Usually surgical bleeding with coagulopathy
  - Rarely due to DIC
  - Etiology of 40% of early in-hospital deaths
    - Hoyt DB 2004 Semin Hematology 41

- Causes of coagulopathy
  - 25 – 36% of trauma pts are already coagulopathic on admission
  - Hemodilution, anemia, massive transfusion
  - Hypothermia: ↓ platelet and enzyme function
  - Acidosis: ↓ prothrombin activation
  - Inflammatory cascade, Sepsis and MOF
  - HES colloids, pre injury medications
  - Hyperfibrinolysis (20% trauma pts) → early rebleeding
Treatment of bleeding

Stop surgical bleeding early

Prevent coagulopathy
- Prevent hypothermia, acidosis
- Appropriate fluid resuscitation
- Auto transfusion for thoracic injuries
- Monitor s-Lactate
- Blood, platelets and FFP
  - 1:1:1 ratio
  - give before onset of coagulopathy
- Surgery +/- damage control procedures

Angio-embolization: early decision
rFVIIa: order early
Blood substitutes

- Polymerized hemoglobin
  - Human: Polyheme, Hemolink
  - Bovine: Hemopure
- Good oxygen carrying, delivery x 24 hrs
- Useful in acute blood loss
- Causes ↑ BP (volume expansion effect)
- Immune modulatory effect
- Improves oxygenation of ischemic limbs / flaps
  - L Levien, ISBT Science Series 2006: 1 167 - 173
Secondary Brain Injury

- Cascade of destructive processes, continues for hours – days
- Hypotension (sBP < 90mmHg):
  - 1 episode pre-resuscitation is associated with a 2x ↑mortality and morbidity
    - Chesnut et al, J Trauma 34:216 1993
- Hypoxia <60 mmHg predicts poor outcomes
- Pyrexia >38.5C predicts poor outcomes
- Hypocapnia causes cerebral vasoconstriction and ↓cerebral perfusion

- Evaluation and treatment:
  - Guidelines for the Management of Severe Traumatic Brain Injury
    - www.braintrauma.org Brain Trauma Foundation.
Induced Hypothermia as Neuroprotection

- Almost all destructive inflammatory processes are favorably influenced by hypothermia
- Promising results for improved neurological outcomes in ischemic brain injury
- Remains controversial and high risk in trauma practice

Clinical studies: mixed results for TBI
- Induce soon or apply later for longer
- Prevent hyperglycemia and electrolyte disorders
- Adequate sedation and analgesia
- Re-warm slowly
- Control ICP

- McIntyre et al, JAMA 289:2992 2003
Damage Control Surgery: Coming of age

- The physiological basis now well established
- Prevention and early recognition of ACS
- Prevention of reperfusion injury
- Value of early wound closure
- Vacuum wound dressings

“...the judicious surgeon who chooses this method should in no way fear the whispered loss of his surgical manhood”
(Walt, 1977)
Steroids and Relative Adrenal Insufficiency

Remains controversial

- High doses of steroids are harmful
- Lower doses of glucocorticoids may be beneficial for septic shock, in abnormal adrenal function.
  - Annane et al JAMA 2002;288,862-871
- Not enough evidence that this is a disease entity
  - De Jong et al, Yearbook of Intensive Care and Emergency Med, 2006
- Hydrocortisone can be safely used to increase vascular wall sensitivity to vasopressors in septic shock, even without ACTH testing
  - Bollaert et al, Crit Care Med 26:645 1998
Pain Management

- Shortens or obviates the need for mechanical ventilation in blunt chest trauma
- Regional anaesthesia
  - Thoracic epidural
  - Paravertebral blocks
  - Regional nerve blocks
Nutrition

- Early enteral nutrition using evidence based algorithms is associated with improved outcomes
  - Martin et al, CMAJ 170:197 2004

- Small bowel feeding may have a lower incidence of VAP. New naso–jejunal feeding tubes being developed

- First 5 days: use high calorie enteral nutrition to improve nutrient delivery, TPN to bridge gap

- Maintain tight glucose control: 4.4 – 6.1 mmol/l.
Treating the Polytrauma Patient:
Adding Insult to Injury

“First Hit”
- Injury:
  - cellular, metabolic and inflammatory responses ➔ cellular damage

“Second hit”
- Resuscitation injury:
  - Cristalloids, ventilation, surgery, drugs, blood, hypothermia
- Investigational:
  - IV contrast, risks to airway and spine
- Critical Care:
  - bacterial, ventilation, lines, catheters, hypotension, hypoxia, infection etc.
Lessons from the Military

- Liberalized use of tourniquets in extremity injuries
- Intraosseous vascular access, especially via sternum
- Shunting vascular injuries before transfer or to allow surgical management other urgent injuries, heparinize stable patients
- Survival benefit for pt receiving fresh whole blood compared to component therapy
  - US Army Institute of Surgical Research

Hemostatic dressings
- QuikClot
  - Granular mineral product
  - Exothermic reaction when wet
- HemCon
  - Complex carbohydrate
  - 97% success in obtaining hemostasis in combat casualties
Sepsis & Infection Control

- Activated protein C has produced a statistically significant mortality reduction in patients with severe sepsis and septic shock
  - Concerns are: bleeding, high costs, and the lack of benefit in patients with less severe sepsis, head injury.

- Aggressive early fluid and vaso-active drug resuscitation improves outcomes in severe sepsis / septic shock

- Escalating antibiotic resistance rates require
  - Reducing length of ventilation, ICU stay, hospital stay
  - Minimal use of CVP catheters, strict aseptic technique
  - Controlled antibiotic use / antibiotic cycling
Conclusions

- Poly trauma patients are subject to series of post injury insults, many preventable
- New insights in inflammatory responses related to injury and resuscitation should guide investigation and treatment decisions
- Survival rates as well as rapid return to functionality should be end points for clinical outcomes audit
Brain Injury
Cellular and metabolic consequences

- Reperfusion injury
- Free radical production
- Harmful immunologic and inflammatory processes
- Calpain–mediated proteolysis
- DNA injury
- Mitochondrial injury and dysfunction
- Intra-cellular acidosis
- ↓energy production, ↑metabolic demands
- Membrane leakage, edema
- Calcium influx, excitotoxic cascade
- Apoptosis
- Coagulation activation, micro-thrombi
- Vascular permeability, ↑blood-brain barrier disruption
- Local brain hyperthermia
Etiology of post-trauma organ failure.

Hietbrink et al; World J Emerg Surg 2006 1:15
Published online May 2006
Cellular response to tissue injury
Biphasic model of organ failure

First phase: injury by trauma & systemic inflammatory response
Second phase: host defense failure (immune paralysis) → sepsis.

- SIRS systemic inflammatory response
- CARS compensatory anti-inflammatory response
- MARS mixed antagonist response
- MOF multi organ failure

Trauma: Immune Response

Immune dysfunction can provoke (multiple) organ failure.

- **Etiological factors**
  - Intrinsic: genetic predisposition, physiological status
  - Extrinsic:
    - type of injury or "trauma load" and
    - treatment or "intervention load".

- Intervention load is the only one which can be altered
- Appropriate treatment can minimize the damage caused by the immune response and prevent the development of immunological paralysis
Advances in Trauma Care

- Understanding the physiology
  - Fluid resuscitation
  - Coagulopathy
  - Damage control surgery
  - Glycemic control
  - Prevention of sepsis
  - Protective ventilation

- Diagnostic radiology
- Non operative intervention
- Training: ATLS, DSTC etc.
Trauma System: Definition

Integrated approach to provide optimal trauma care in a region, including:

- Prevention strategy
- Disaster plan
- Registry
- Quality improvement system
- Optimal resources for all stages: