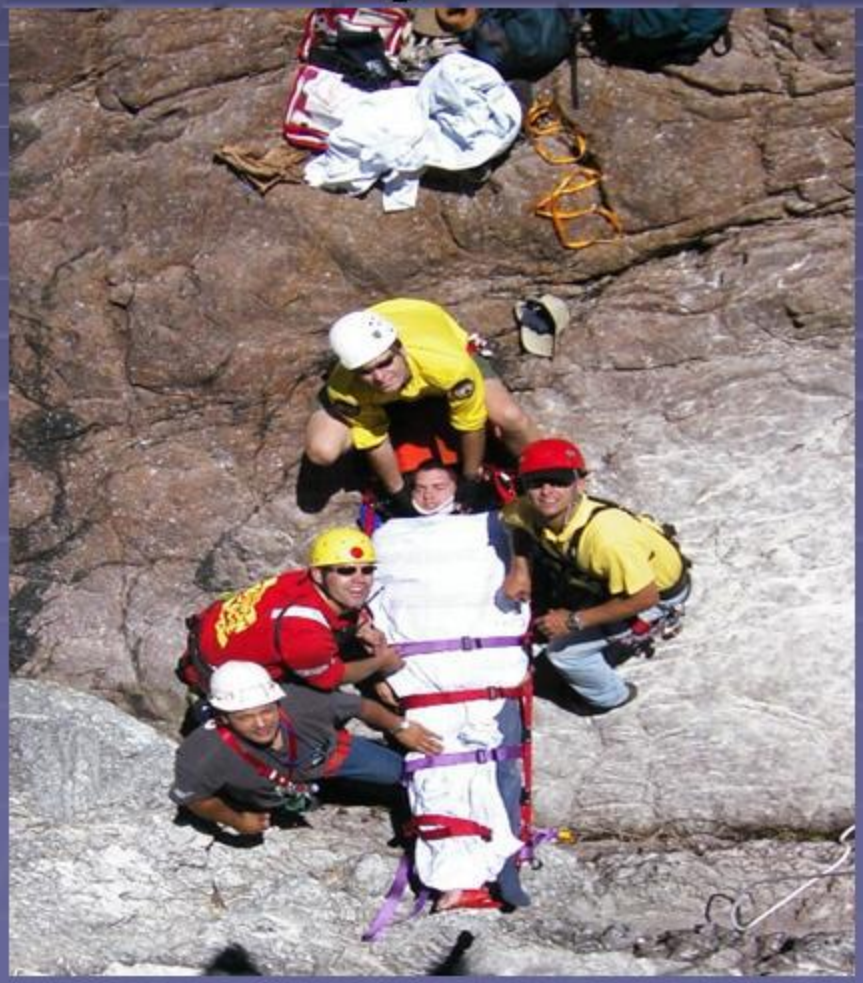
Optimizing the Outcomes of Poly Trauma Patients



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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 Trauma1999; 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 Trauma1993

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
    - Cochrane Injuries Group. *BMJ* **1998;317**,235-240
  - Albumin and normal saline solution result in equivalent outcomes
    - Finfer et al *N Engl J Med* **2004;350**,2247-2256

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
    - Angus et al. Critical Care Med 29:1303 2001

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

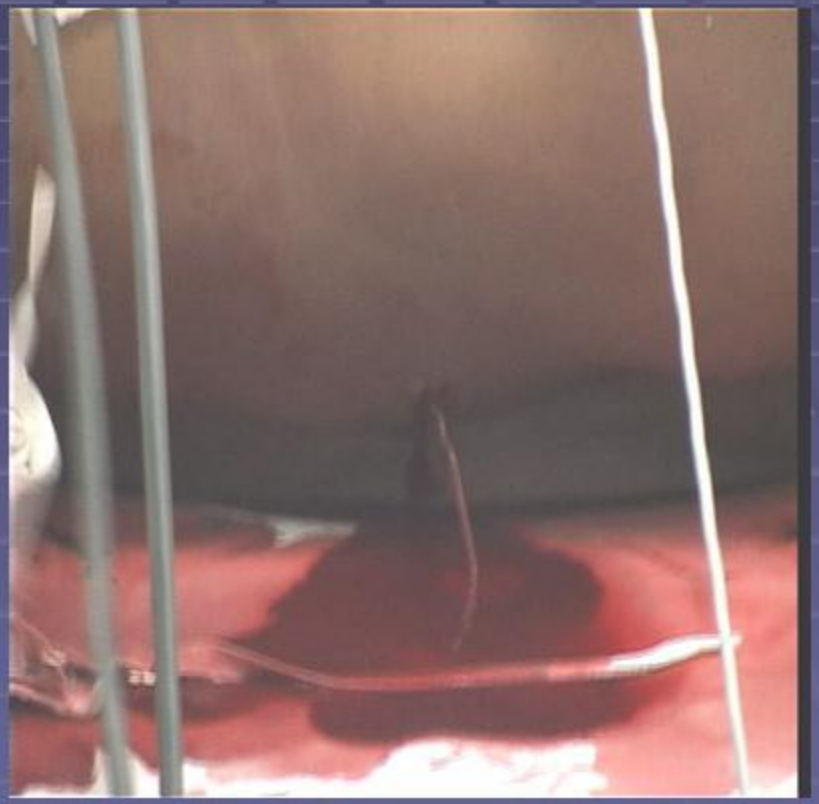
- Causes of coagulopathy
  - 25 – 36% of trauma pts are already coagulopathic on admission
  - Hemodilution, anemia, massive transfusion
  - Hypothermia: ↓ platelet and enzyme function
  - Acidosis: ↓ prothrombin activation
  - Inflammatory cascade, Sepsis and MOF
  - HES colloids, pre injury medications
  - 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 Trama 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
    - Polderman et al, Intensive Care Med 30:1860 2004
    - 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

- Hydrocortizone can be safely used to increase vascular wall sensitivity to vasopressors in septic shock, even without ACTH testing
  - Bollaert et el, Crit Care Med 26:645 1998

Pain Mangement

- 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.
  - Van den Berghe et al, N E J M 345:1359 2001

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
  - Beekley et al, Sur Clin NA 87:157 2007

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
  - Bernard et al *N Engl J Med* **2001;344**,699-709
  - 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
  - Rivers et al *N Engl J Med* **2001;345**,1368-1377
- 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

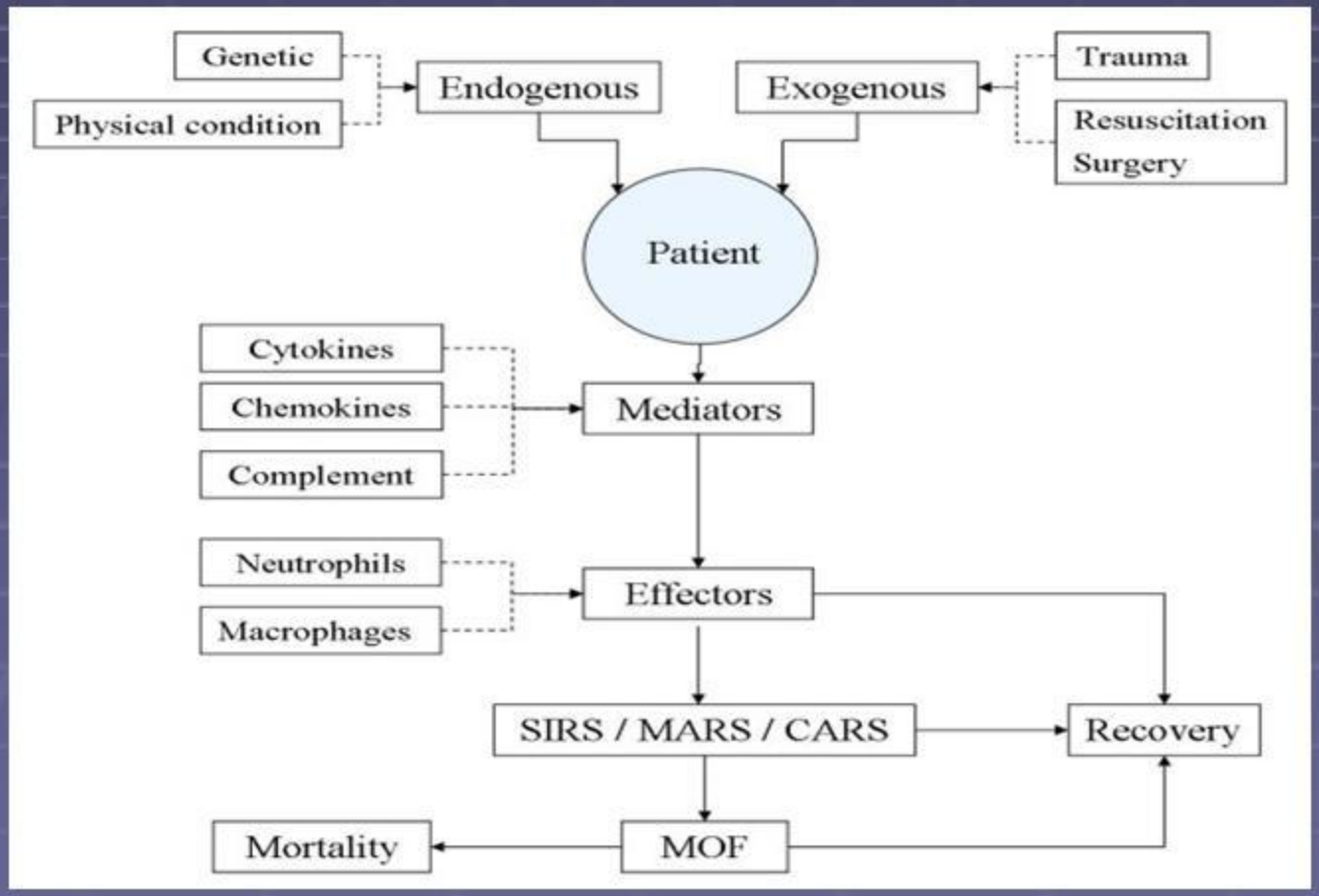
Conclusions

- 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

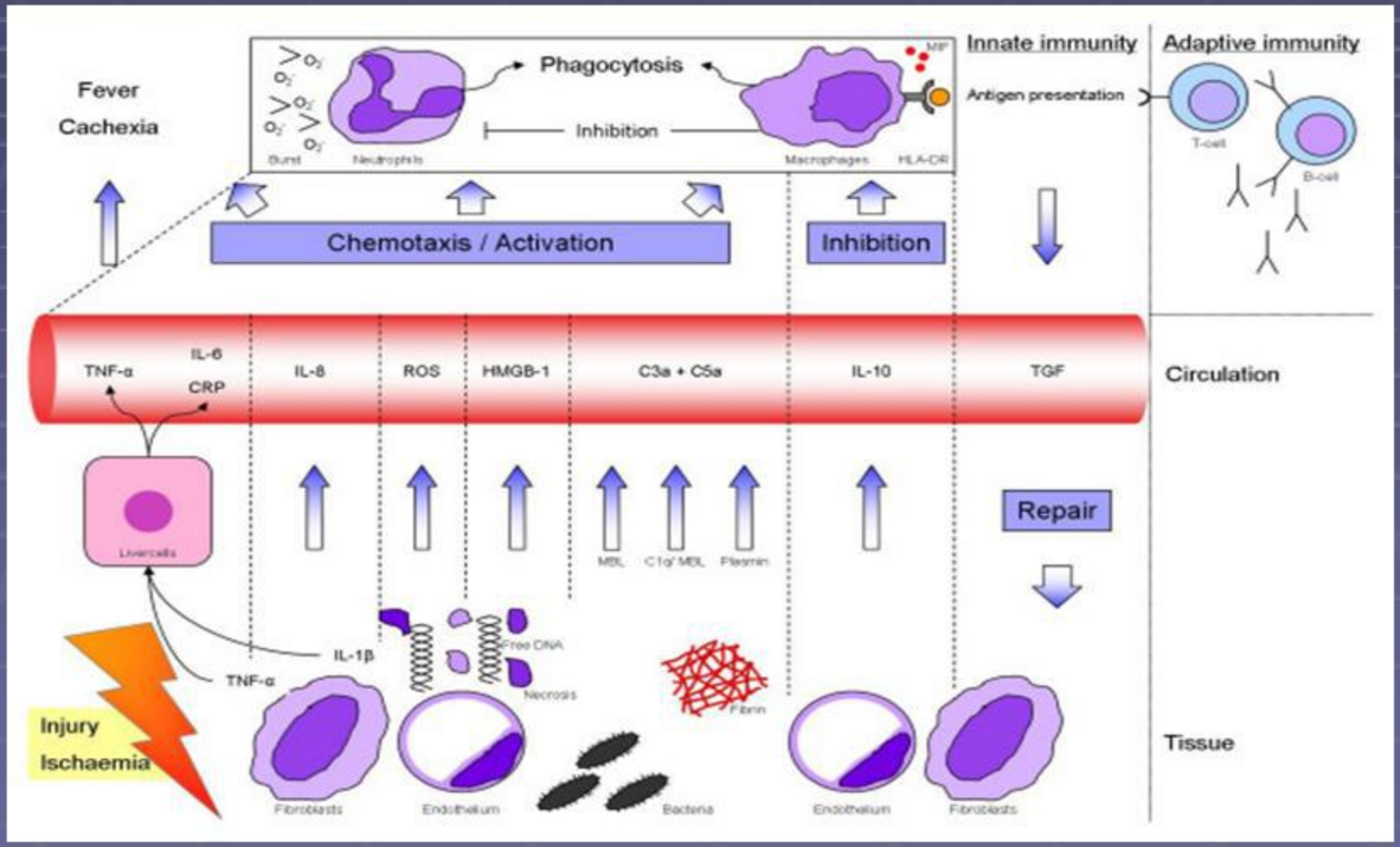
- Reperfusion injury
- Free radical production
- Harmful immunologic and inflammatory processes
- Calpain–mediated proteolysis
- DNA injury
- Mitochondrial injury and dysfunction
- Intra-cellular acidosis
- ↓energy production, ↑metabolic demands
- Membrane leakage, edema
- Calcium influx, exitotoxic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

Etiology of post-trauma organ failure.

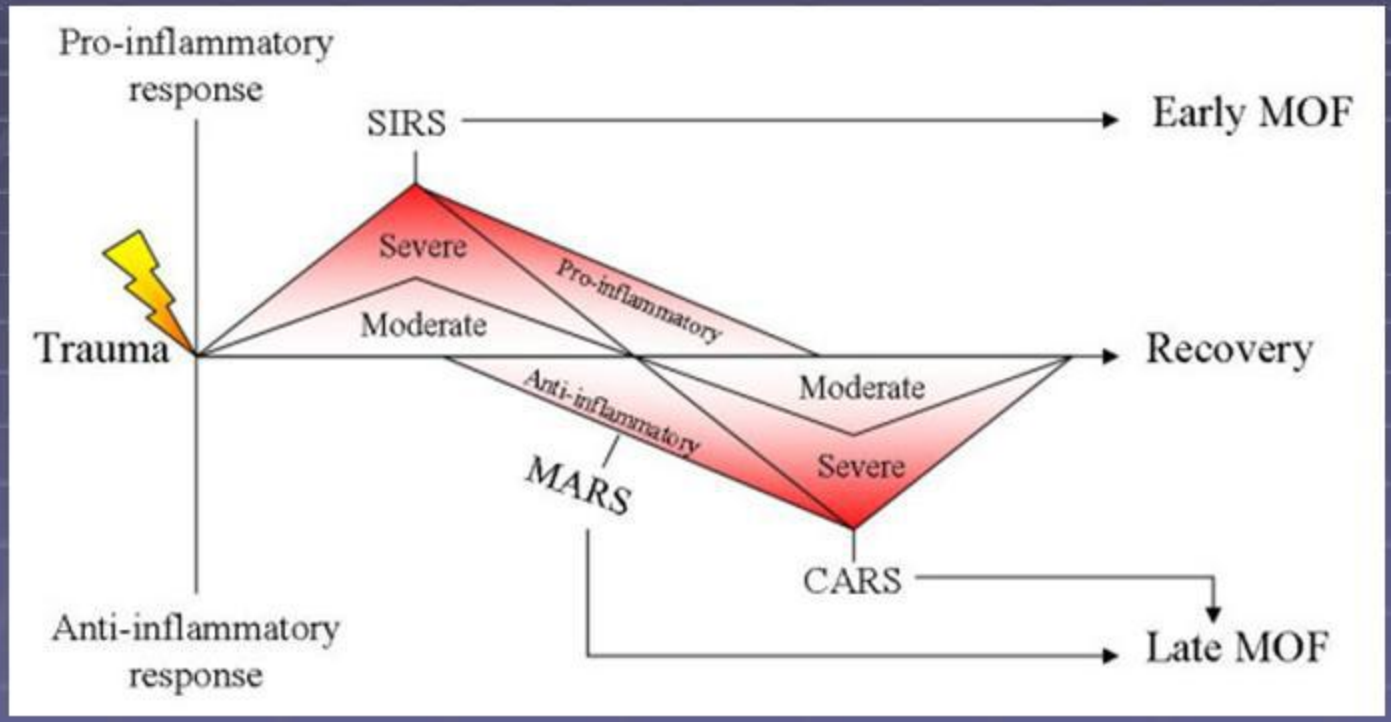


Hietbrink et al; World J Em Surg 2006 1:15
http://www.pubmedcentral.nih.gov/articlerender.fcgi?art
Published online May 2006

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

Moore FA et al, Postinjury multiple organ failure: a bimodal phenomenon. *J Trauma*. 1996;**40**:501–510.

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**
  - Trauma: the role of the innate immune system. Hietbrink et al, World J Emerg Surg. 2006; 1: 15.

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: