Radiology and the trauma patient in the ICU

Kristina Hambrœus Jonzon

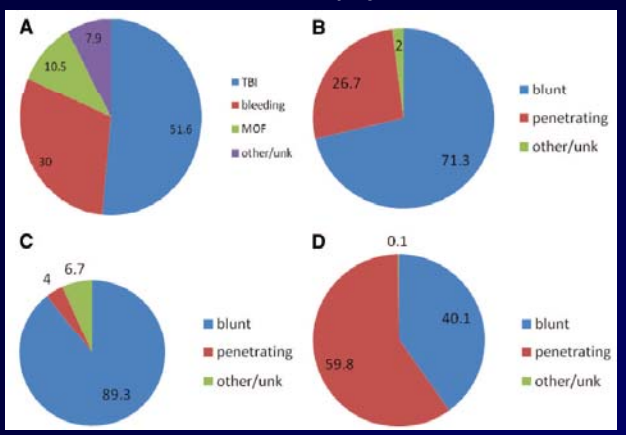
SIGNIFICANT ADVANCES IN TRAUMA CARE 1990–2009

Therapies	Monitors and Diagnostics	Medications
Damage control surgery	Focused Assessment by Sonography in Trauma (FAST)	Topical fibrin sealants
Deliberate hypotensive resuscitation	Multidetector CT	Factor VIIa
Low tidal volume ventilation	End-tidal capnography	Activated protein C
Early transfusion	Cardiac output and tissue perfusion monitors	Dexmedetomidine
Balanced (1 to 1) resuscitation	Thromboelastography	
Prehospital rapid sequence intubation		
Tight glycemic control		
Protocol driven intracranial pressure management		

Dutton et al *J Trauma* 2010 E-pub ahead of print.

TRAUMA MORTALITY

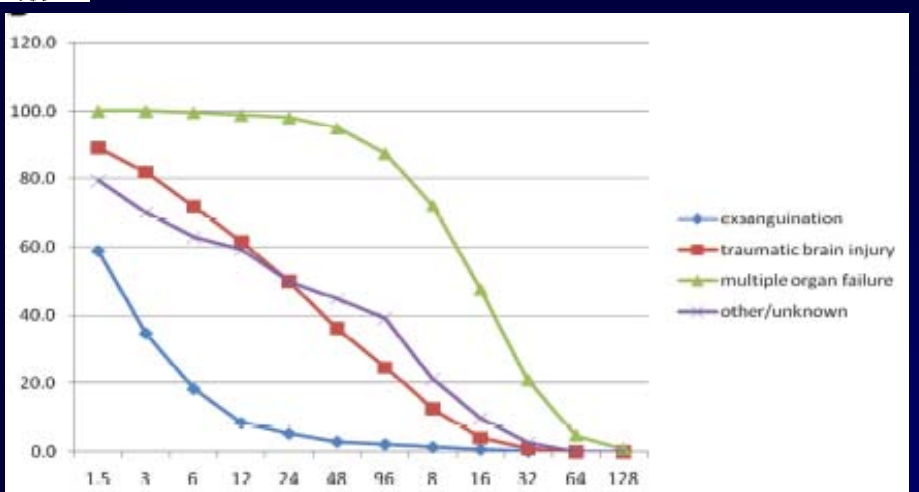
3.4 %



(A) Overall causes of death. (B) Types of injury associated with mortality due to TBI. (C) Types of injury associated with mortality due to MOF. (D) Types of injury associated with mortality due to bleeding.

Dutton et al *J Trauma* 2010. Single-center study 1997 – 2008 Baltimore 68454 admitted trauma patients.

TRAUMA MORTALITY



Percent survival over time (1.5–96 hours and 8–128 days) for the four major causes of death.

Dutton et al *J Trauma* 2010.

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THORACIC TRAUMA

- Sternal and scapular fractures
- Aortic rupture
- Heart contusion
- Traumatic diaphragmatic injury
- Blunt oesophageal rupture

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PULMONARY CONTUSION

ETIOLOGY

Blunt chest trauma → pulmonary contusion:

- fractured ribs + compression of the chest wall → direct laceration of the lung
- "spalling effect" → shearing or bursting at gas/liquid interface
- "inertial effect" → low/high density tissues accelerate at different rates
- "implosion effect" → pressure wave → rebound or overexpansion of gas bubbles

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Pulmonary Contusion Diagnosis

- **Clinical findings**
  - hypoxemia, palpation pain
  - flail chest, s.c. emphysema
  - hemoptysis, open thorax

  100% "significant acute intrathoracic injury"[1]
- **CXR** — 33% initially[2], 79% after 6 h[2]
- **CT scan** — 100% initially[2]; clinical significance?[3]

1. Rodriguez RM *et al*. Ann Emerg Med 2006 May;47 (5):415-8.
2. Schild HH *et al*. J Comput Assisted Tomogr 1989.
3. Kwon A *et al*. J Pediatr Surg 2006 Jan;41(1):78-82.

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Pathophysiology

- alveolar hemorrhage
- parenchymal destruction
- bleeding into uninvolved lung segments
- ↑ lung water
- ↑ mucus production and ↓ clearance
- ↓ surfactant
- atelectasis

Ventilation/perfusion mismatch
→ ↑intrapulmonary shunt

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PROGRESSIVE LESION

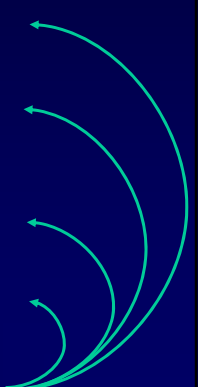
- 0 h — interstitial hemorrhage
- 1-2 h — interstitial edema, monocytes, neutrophils
- 24 h — protein, erytrocytes, massive edema, massive accumulation of inflammatory cells, fibrin, loss of architecture
- 48 h — more fibrin, cell debris, dilated and protein filled lymphatics
- 7-10 days healing

1. Fulton RL, Peter ET. The progressive nature of pulmonary contusion. Surgery. 1970;67:499.
2. Casley-Smith JR, Eckert P, Fäldi-Börcsök. The fine structure of pulmonary..Br J Exp Pathol. 1976;57:487.
3. Moseley RV, Vernick JJ, Doty DB. Response to blunt chest injury: a new expe... J Trauma. 1970;10:673.

PATHOGENESIS SIRS

Systemic Inflammatory Response Syndrome

- Activation of cyclooxygenase, phospholipase, granulocytes
- Activation of cascade systems
- Activated cells
- Release of mediators
- **CELL DAMAGE**



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PATHOPHYSIOLOGY

Secondary injury

Release of mediators

- Eicosanoids (prostanoids, arachidonic acid metabolites)
- Free oxygen radicals
- Proteases

➡ **CELL DAMAGE**

→ **Generalised progressive lung damage**

Hellinger *et al*. Does lung contusion affect both the traumatized and the noninjured lung parenchyma? A morphological and morphometric study in the pig. J Trauma 1995.
Davis *et al*. Prostanoids: early mediators in the secondary injury that develops after unilateral pulmonary contusion. J Trauma 1999.

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SYMPTOMS

- Hypoxemia — cyanosis
- Chest pain
- ↑ work of breathing — tachypnoea, dyspnoea

MAXIMUM AFTER 72 HOURS!!!

- ↑ PVR (hypoxia, ET-1, tromboxane, leucotriens)
- ↓ compliance

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ALI / ARDS

”a syndrome of inflammation and increased permeability that is associated with a constellation of clinical, radiologic and physiologic abnormalities that cannot be explained by, but may coexist with, left atrial or pulmonary capillary hypertension”

ALI
Acute respiratory failure
PaO_2/FiO_2 < 40 kPa
Bilateral infiltrates
(PcwP < 18)

ARDS
Acute respiratory failure
PaO_2/FiO_2 < 27 kPa
Bilateral infiltrates
PcwP < 18

Bernard, Artigas, Brigham, et al. *Intensive Care Med* 1994;20:225-32. *Kristina Hambræus Jonzon*

Rubenfeld et al.

N Eng J Med 2005

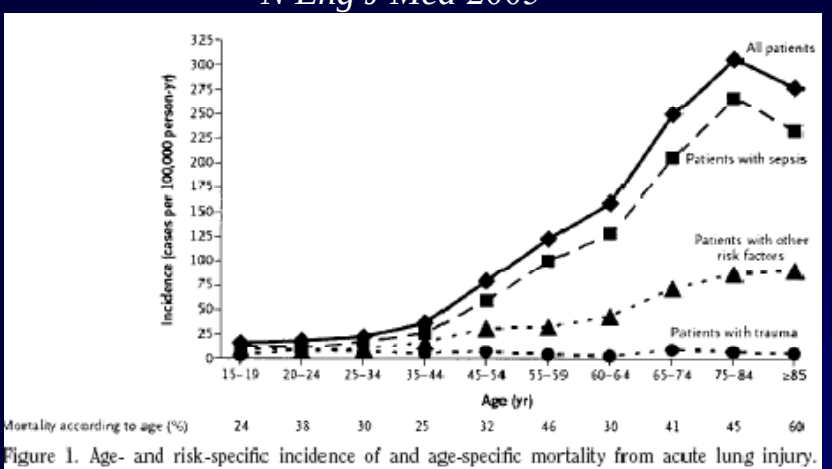

Figure 1. Age- and risk-specific incidence of and age-specific mortality from acute lung injury.

Prospective, population-based, multi-center study Washington, April 1999 - July 2000.

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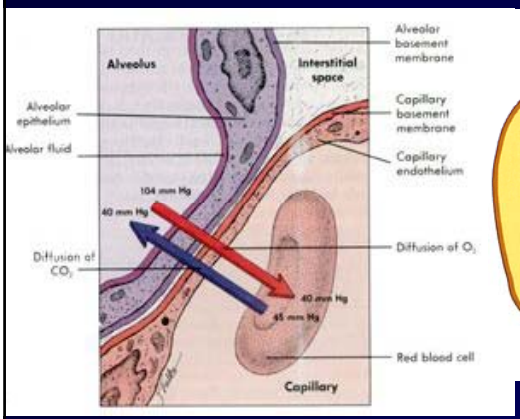
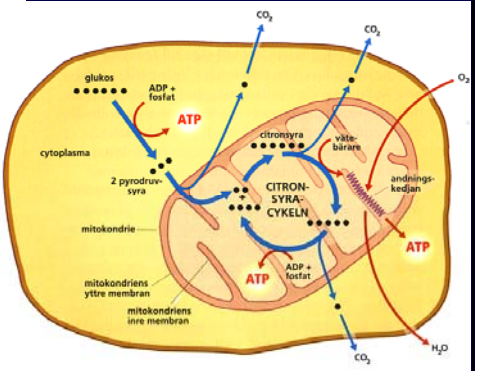
RESPIRATION

The transport of oxygen from the air to the cells, and the transport of carbon dioxide from the cell to the air.





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RESPIRATION

Passive diffusion of O_2 and CO_2 from higher to lower concentrationes.

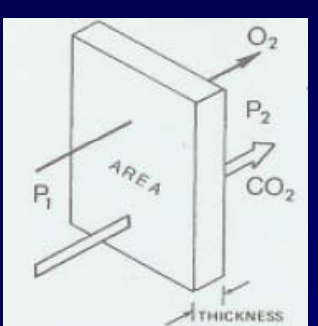
The diffusion of a gas through a membrane

is **directly** proportional to:

- the area
- the diffusion constant of the gas (Sol/√MW)
- the difference in partial pressure

is **inversely** proportional to:

- the thickness of the membrane



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MANAGEMENT

SPECIFIC

- Spontaneous breathing (O_2, CPAP, bronchodilators)
- Pain relief (Opioids, thoracic epidural block)
- Chest drainages (frontal and dorsal)
- Low pressure-low volume ventilation, PEEP
- Bronchoscopy - aggressive pulmonary toilet
- Selective differential pulmonary ventilation
- Meticulous fluid management (urinary output, BW)
- Thoracotomy, ECMO

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MANAGEMENT

GENERAL

- Active treatment of associated injuries
- Aggressive war against infections
- Prophylactic anticoagulants

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OUTCOME

Usually resolves within 7 days
Mortality 6.5[1] - 13[2] - 18[3] - 25[4] %

- 28% contusion size[5] → mechanical ventilation
- Independent risk factor for ARDS[6]
- ARDS 6%[3], low QUALY in survivors[7]
- 20% contusion size[6] → ARDS in > 78% of patients
  → > 20%[6] - 45%[7] mortality

1. Richardson *et al*. Ann Surg 1982. 2. Johnson *et al*. J Trauma 1986. 3. Svennevig *et al*. Injury 1987.
4. Clark *et al*. J Trauma 1988. 5. Wagner RB *et al*. Surg Clin North Am 1989.
6. Miller PR. Intensive Care 2002. 7. Angus D Am J Respir Crit Care Med 2001.

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