Introduction / Overview

Shock, Trauma and Resuscitation

- ATLS
- Primary survey
- Shock
- Resuscitative thoracotomy
- Abdominal trauma: FAST vs CT scan
- Pathophysiology of multiple trauma
- Damage control surgery
- Timing and tactics
Advanced Trauma Life Support (ATLS)

- Assess a patient’s condition rapidly and accurately
- Resuscitate and stabilize patients according to priority
- Determine whether a patient’s needs exceed a facility’s resources / doctor’s capabilities
- Arrange appropriately for a patient’s interhospital or intrahospital transfer
- Ensure that optimal care is provided and that the level of care does not deteriorate at any point during the processes
The course is designed to assist doctors in providing emergency care for trauma patients.

The concept of the "golden hour" represents the window of opportunity during which doctors can have a positive impact on the morbidity and mortality associated with injury.
ATLS: Primary survey

Shock, Trauma and Resuscitation

- Assessment and treatment priorities are established according to:
  - Injuries
  - Vital signs
  - Injury mechanism (high index of suspicion)
ATLS: Adjuncts

Shock, Trauma and Resuscitation

- ECG
- Urinary and gastric catheters
- Arterial blood gas analysis / pulse oxymetry
- Blood pressure and ventilatory rate
- Radiologic studies (AP-chest, AP-pelvis)
- FAST, (diagnostic peritoneal lavage)
ATLS: ABCDEs

Shock, Trauma and Resuscitation

- **Primary survey**
  - A irway with c-spine protection
  - B reathing and ventilation
  - C irculation with hemorrhage control
  - D isability: Neurologic status
  - E xposure, environmental contro

- **Secondary survey**
  - Head to toe / finger in every orifice
ATLS: Multitasking and sequences

- Different steps accomplished simultaneously ...
- Life-threatening conditions are identified and managed simultaneously

... but with sequential steps in order of importance
- Severe trauma to the limb with critical ischemia
Severe trauma to the limb with critical ischemia

High velocity trauma (train-pedestrian)

Potential severe trauma to vital body regions/organs

Limb: «just» a C-problem ...
Assume a cervical spine injury in any patient with multisystem trauma (head trauma or blunt injury above the clavicle).

The stabilisation equipment for the C-spine should be left in place until cervical spine injury has been excluded.
ATLS-A: Signs of airway obstruction

Shock, Trauma and Resuscitation

- Agitation: hypoxia
- Obtundation: Hypercarbia
- Noisy breathing, gurgling, stridor
- Hoarseness
- Location of the trachea
ATLS-A: Airway and C-spine protection

- Assess patency
- C-spine protection if required
- Signs of (potential) airway obstruction
- Chin-lift, jaw-thrust maneuver, O2
- Repeated assessment of airway
- Evaluate the need for a definitive airway management
ATLS-A: Airway management

- Airway maintenance techniques
- Definitive airway measures
- Methods of providing supplemental ventilation
- High-flow oxygen is required
- Rigid suction device
- Maintain cervical spine protection in all patients / helmet removal
ATLS-A: Airway maintenance techniques

- Chin-lift, jaw-thrust maneuver
- Oro-, nasopharyngeal airway
- Laryngeal mask airway
- Multilumen esophageal airway
- Laryngeal tube airway
- Gum elastic bougie
ATLS-A: Definitive airway

- Need for airway protection
- Severe maxillofascial fractures
- GCS<8
- Risk for aspiration (blood, vomiting)
- Risk for obstruction (neck hematoma, laryngeal injury, stridor)
ATLS-BCD: Definitive airway

Shock, Trauma and Resuscitation

- Need for ventilation/oxygenation
- Apnea
- Inadequate respiratory efforts
- Massive blood loss and need for volume resuscitation
- Severe, closed head injury with need for brief hyperventilation
ATLS-A: Definitive airway

- A tube placed in the trachea with the cuff inflated, connected to oxygen-enriched assisted ventilation, and the airway secured in place with tape

- Orotracheal tube
- Nasotracheal tube
- Surgical airway (cricothyroidotomy)
ATLS-A: Surgical airway

- The **inability to intubate the trachea** is a clear indication for a surgical airway

- Needle cricothroidotomy (15L/min, 1:4, 30-max. 45min)

- Surgical cricothroidotomy
ATLS-B: Breathing and ventilation

Shock, Trauma and Resuscitation

- Adequate gas exchange is required to maximize oxygenation and carbon dioxide elimination
- Assess function of
  - lungs
  - thoracic wall
  - diaphragm
ATLS-B: Signs of inadequate ventilation

- Asymmetrical rise and fall of the chest and adequate chest excursion
- Labored breathing
- Decreased/absent breath sounds
- Tachypnea
- Pulse oxymetry (oxygen saturation, peripheral perfusion, but no measure of adequacy of ventilation)
Shock, Trauma and Resuscitation

- Tension pneumothorax
- Flail chest with pulmonary contusion
- Open pneumothorax
- (Massive hemothorax)
ATLS-B: Tension pneumothorax

- Respiratory distress
- Neck vein distension
- Tachycardia
- Hypotension
- Hypersonoric percussion
- Unilateral absent breath sounds
- Needle thoracocentesis
- Chest tube
ATLS-B: Flail chest

Shock, Trauma and Resuscitation

- Underlying **pulmonary contusion**
- Paradoxal movement of the chest wall
- Adequate ventilation, oxygenation
- Fluid resuscitation
- Analgesia
ATLS-B: Open pneumothorax

Shock, Trauma and Resuscitation

- Sucking wound
- 2/3 of trachea: Air passes preferentially through the chest wall defect
- Hypoxia, hypercarbia

- Sterile occlusive dressing/valve
- Chest tube
- Definitive surgical closure
The initial diagnosis of shock is based on clinical appreciation of the presence of inadequate tissue perfusion and oxygenation.

- Hypovolemic shock
- Cardiogenic shock
- Neurogenic shock
- (Septic shock)
Shock, Trauma and Resuscitation

- **Neurogenic shock**

- Impairment of the descending sympathetic pathways in the cervical/upper thoracic spinal cord results in loss of vasomotor tone and sympathetic innervation to the heart

- Vasodilatation (visceral and lower extremities, blood pooling, hypotension)

- Failure of tachycardia in response to hypovolemia
ATLS-C: Shock

Shock, Trauma and Resuscitation

- **Spinal shock**

- **Flaccidity and loss of reflexes after spinal cord injury (no effect on hemodynamics)**

<table>
<thead>
<tr>
<th>Phase</th>
<th>Time</th>
<th>Physical exam findings</th>
<th>Underlying physiological event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0-1 days</td>
<td>Areflexia</td>
<td>Loss of descending facilitation</td>
</tr>
<tr>
<td>2</td>
<td>1-3 days</td>
<td>Initial reflex return</td>
<td>Denervation supersensitivity</td>
</tr>
<tr>
<td>3</td>
<td>1-4 weeks</td>
<td>Hyperreflexia</td>
<td>Axon-supported synapse growth</td>
</tr>
<tr>
<td>4</td>
<td>1-12 months</td>
<td>Hyperreflexia, Spasticity</td>
<td>Soma-supported synapse growth</td>
</tr>
</tbody>
</table>
ATLS-C: Hypovolemic shock

- Hemorrhage is the most common cause of shock
ATLS-C: Hypovolemic shock

- Compensatory mechanisms to blood loss
  - Vasoconstriction (skin, viscera, muscles)
  - Heart rate $\uparrow$, diastolic pressure $\uparrow$, pulse pressure $\downarrow$
  - Release of endogenous catecholamines
  - Release of histamine, bradykinin, β-endorphins, prostanoids and other cytokines with effects on microcirculation and permeability
ATLS-C: Circulation / hemorrhage control

Shock, Trauma and Resuscitation

- Assess blood volume, cardiac output and bleeding
- Hemodynamic status
- Level of consciousness
- Skin color
- Pulse (quality, rate, regularity)
- Urinary output
# ATLS-C: Estimation of blood loss

**Shock, Trauma and Resuscitation**

<table>
<thead>
<tr>
<th></th>
<th>CLASS I</th>
<th>CLASS II</th>
<th>CLASS III</th>
<th>CLASS IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood loss (mL)</td>
<td>up to 750</td>
<td>750-1500</td>
<td>1500-2000</td>
<td>&gt;2000</td>
</tr>
<tr>
<td>Blood loss (%)</td>
<td>up to 15%</td>
<td>15-30%</td>
<td>30-40%</td>
<td>&gt;40%</td>
</tr>
<tr>
<td>Pulse rate</td>
<td>&lt;100</td>
<td>100-120</td>
<td>120-140</td>
<td>&gt;140</td>
</tr>
<tr>
<td>Blood pressure</td>
<td>normal</td>
<td>normal</td>
<td>decreased</td>
<td>decreased</td>
</tr>
<tr>
<td>Pulse pressure</td>
<td>(increased)</td>
<td>decreased</td>
<td>decreased</td>
<td>decreased</td>
</tr>
<tr>
<td>Respiratory rate</td>
<td>14-20</td>
<td>20-30</td>
<td>30-40</td>
<td>&gt;40</td>
</tr>
<tr>
<td>Urine output (mL)</td>
<td>14-20</td>
<td>20-30</td>
<td>5-15</td>
<td>negligible</td>
</tr>
<tr>
<td>Mental status</td>
<td>+anxious</td>
<td>++anxious</td>
<td>confused</td>
<td>lethargic</td>
</tr>
<tr>
<td>Fluid replacement</td>
<td>crystalloid</td>
<td>crystalloid</td>
<td>+blood</td>
<td>+blood</td>
</tr>
</tbody>
</table>
ATLS-C: Circulation / hemorrhage control

Shock, Trauma and Resuscitation

- External hemorrhage is identified and controlled during the primary survey

- Manual pressure on the wound

![Image of hand with bandage and bleeding wound]
ATLS-C: Hypovolemic shock

Shock, Trauma and Resuscitation

- The best method of restoring adequate cardiac output and end-organ perfusion is to restore venous return to normal by *volume repletion*.

- Control of hemorrhage and restoration of adequate circulating volume are the goals of treatment of hemorrhagic shock.
# ATLS-C: Responses to initial fluid resuscitation

<table>
<thead>
<tr>
<th></th>
<th>rapid</th>
<th>transient</th>
<th>no response</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vital signs</strong></td>
<td>return to normal</td>
<td>transient recurrent shock signs</td>
<td>remain abnormal</td>
</tr>
<tr>
<td><strong>Estimated blood loss</strong></td>
<td>minimal 10-20%</td>
<td>moderate+ongoing 20-40%</td>
<td>severe &gt;40%</td>
</tr>
<tr>
<td><strong>Need for more crystalloid</strong></td>
<td>low</td>
<td>high</td>
<td>high</td>
</tr>
<tr>
<td><strong>Need for blood</strong></td>
<td>low</td>
<td>moderate/high</td>
<td>immediate</td>
</tr>
<tr>
<td><strong>Blood preparation</strong></td>
<td>crossmatch</td>
<td>type specific</td>
<td>0-</td>
</tr>
<tr>
<td><strong>Need for operation</strong></td>
<td>possibly</td>
<td>likely</td>
<td>very likely</td>
</tr>
<tr>
<td><strong>Early presence of surgeon</strong></td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
</tbody>
</table>
ATLS-C: Massive hemothorax

- Rapid accumulation of blood >1500mL (200ml/h)
- Tachypnea, shock
- Absent breath sounds, dull percussion
- Fractured ribs/flail chest

- Restoration of blood volume
- Decompression of the chest cavity
- Consider thoracotomy
Hemorrhagic shock

- Hemorrhage control by closed reduction (Pelvic trauma: open book)
ATLS-C: Hemorrhagic shock

- Hemorrhage control by closed reduction (Pelvic trauma: vertical shear)

- Pelvic clamp and pelvic packing

- Pelvic binder
ATLS: Nonhemorrhagic shock

Shock, Trauma and Resuscitation

- Tension pneumothorax
- Blunt cardiac injury
- Cardiac tamponade
- Vena caval obstruction
- Neurogenic shock
- Septic shock
ATLS-C: Cardiac tamponade

Shock, Trauma and Resuscitation

- Penetrating trauma
- Venous pressure elevation
- Tachycardia
- Hypotension
- Muffled heart tones
- Surgical exploration
- Pericardiocentesis
- Patients with penetrating thoracic trauma who arrive pulseless, but with myocardial electric activity (PEA), may be candidates for immediate resuscitative thoracotomy.

- Patients who sustain blunt injuries and arrive with PEA are not candidates for emergency department resuscitative thoracotomy.
- Evacuation of pericardial blood
- Direct control of intrathoracic hemorrhage
- Open cardiac massage
- Cross-clamping of descending aorta
Resuscitative thoracotomy

Shock, Trauma and Resuscitation

- Direct hemorrhage control
- Cross-clamping of the aorta
<table>
<thead>
<tr>
<th>FAST</th>
<th>CT scan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early diagnosis</td>
<td>Most specific for injuries</td>
</tr>
<tr>
<td>Non invasive</td>
<td>Sensitivity: 92-98%</td>
</tr>
<tr>
<td>Performed rapidly</td>
<td>Cost and time</td>
</tr>
<tr>
<td>Repeatable</td>
<td>Misses diaphragm, bowel and some pancreatic injuries</td>
</tr>
<tr>
<td>Operator-dependent</td>
<td>Transport required</td>
</tr>
<tr>
<td>Bowel gas and subcutaneous air distortion</td>
<td>Misses diaphragm, bowel, pancreatic and solid organ injuries</td>
</tr>
</tbody>
</table>
ATLS-D: Head trauma

Shock, Trauma and Resuscitation

- Primary survey
- Glasgow Coma Scale
- Pupillary size and response
- Lateralizing signs
- Spinal cord injury level

### Glasgow Coma Scale

<table>
<thead>
<tr>
<th>Response</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eye opening</td>
<td></td>
</tr>
<tr>
<td>Opens eyes spontaneously</td>
<td>4</td>
</tr>
<tr>
<td>Opens eyes in response to speech</td>
<td>3</td>
</tr>
<tr>
<td>Open eyes in response to painful stimulation (e.g., endotracheal suctioning)</td>
<td>2</td>
</tr>
<tr>
<td>Does not open eyes in response to any stimulation</td>
<td>1</td>
</tr>
<tr>
<td>Motor response</td>
<td></td>
</tr>
<tr>
<td>Follows commands</td>
<td>6</td>
</tr>
<tr>
<td>Makes localized movement in response to painful stimulation</td>
<td>5</td>
</tr>
<tr>
<td>Makes nonpurposeful movement in response to noxious stimulation</td>
<td>4</td>
</tr>
<tr>
<td>Flexes upper extremities/extends lower extremities in response to pain</td>
<td>3</td>
</tr>
<tr>
<td>Extends all extremities in response to pain</td>
<td>2</td>
</tr>
<tr>
<td>Makes no response to noxious stimuli</td>
<td>1</td>
</tr>
<tr>
<td>Verbal response</td>
<td></td>
</tr>
<tr>
<td>Is oriented to person, place, and time</td>
<td>5</td>
</tr>
<tr>
<td>Converses, may be confused</td>
<td>4</td>
</tr>
<tr>
<td>Replies with inappropriate words</td>
<td>3</td>
</tr>
<tr>
<td>Makes incomprehensible sounds</td>
<td>2</td>
</tr>
<tr>
<td>Makes no response</td>
<td>1</td>
</tr>
</tbody>
</table>
ATLS-D: Head trauma

Shock, Trauma and Resuscitation

- Dilatation of the pupil
- Deviation conjugée
- Lateralisation
- Pathologic GCS

- Neurologic examination of patients with hypotension is unreliable
ATLS-D: Head trauma management

- Rapid cardiopulmonary stabilisation in patients with severe head injury
- Early endotracheal intubation in comatose patients
- Fluid resuscitation / hemorrhage control
- Emergency head CT scan as soon as possible (secondary survey) / do not delay transfer if required
ATLS-E: Exposure, environmental control

Shock, Trauma and Resuscitation

- Patient should be completely undressed
- Avoid hypothermia
- Inspection of hidden body areas (log rolling)
Consider need for patient transfer to another facility

Communication between referring and receiving doctor is essential
Trauma management beyond ATLS

Pathophysiology of multiple trauma

Two Hit-Model

Priorities of surgical treatment

Damage control surgery

Operative phases: Timing and tactics
Pathophysiology of multiple trauma

Shock, Trauma and Resuscitation

- Correlation of proinflammatory cytokines (IL-6, IL-8) and clinical outcome after severe trauma (mean ISS=40)

Nast-Kolb D et al. *Unfallchirurg* 2005
Pathophysiology of multiple trauma

Shock, Trauma and Resuscitation

Multiple trauma (ISS 26)
Delayed nailing of femur and tibia

Nast-Kolb D et al. *Unfallchirurg* 2005
Two hit-Model

Shock, Trauma and Resuscitation

- **First hits**
  - Hypoxia
  - Hypotension
  - Organ injuries
  - Soft tissue injuries
  - Fractures

- **Second hits**
  - **Endogen (antigenic):**
    - Hypoxia
    - Hypotension, acidosis
    - Ischemia/reperfusion
    - Cellular detritus
    - Contamination/infection
  - **Exogen (intervent.):**
    - Surgery with blood loss
    - Tissue damage, hypothermia
    - Neglected trauma
    - Missed injuries
    - Massive transfusions

- **SIRS**
  - Temperature <36°C, >38°C
  - Pulse >90/min
  - Breathing >20/min or pCO₂<32mHg
  - Leukocytes >12000, <4000 or >10% immature

- **Multiple Organ Dysfunction Syndrome (MODS)**

- **Multiple Organ Failure (MOF)**

Primary surgical intervention in multiple trauma

Shock, Trauma and Resuscitation

<table>
<thead>
<tr>
<th>Duration of initial surgical intervention (h)</th>
<th>1-3</th>
<th>3-6</th>
<th>&gt;6</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>103</td>
<td>189</td>
<td>66</td>
</tr>
<tr>
<td>ISS</td>
<td>26.3</td>
<td>26.9</td>
<td>25.4</td>
</tr>
<tr>
<td>GCS</td>
<td>9.8</td>
<td>10.3</td>
<td>9.7</td>
</tr>
<tr>
<td>Duration of mechanical ventilation (d)</td>
<td>9.5</td>
<td>11</td>
<td>15.7 *</td>
</tr>
<tr>
<td>Mortality</td>
<td>11%</td>
<td>12%</td>
<td>22.7 *</td>
</tr>
</tbody>
</table>

Primary survey
Basic imaging

Resuscitation:
Preservation of perfusion and oxygenation

Vital functions? Response?

Life saving surgery

Damage control:
Preemptive intervention „Bail-out“ procedure

Early total care

Secondary survey
Extended imaging

Physiologic balance? Scoring? Resources?

Day-1-surgery

Intensive care unit

Priorities of surgical treatment

Shock, Trauma and Resuscitation

- Airway / breathing control
- Shock treatment
- Control of hemorrhage
- Prevention of septic complications
- Organ / limb saving
Endpoints of resuscitation

- Stable hemodynamics (no need for vasoactive / inotropic stimulation)
- No hypoxemia / hypercapnia
- Lactate < 2mmol/L
- Normal coagulation
- Normothermia
- Urinary output >1mL/kg/h
Damage control

Shock, Trauma and Resuscitation

- „...keeping afloat a badly damaged ship by procedures to limit flooding, stabilize the vessel, isolate fires and explosions and avoid their spreading...“

Keel M, Trentz O. AO Dialogue 2005
Anesthesiological damage control

Shock, Trauma and Resuscitation

- Airway control
- Breathing control
- Shock treatment
- Prevention of coagulopathy
- Prevention of hypothermia
- Prevention of transfusion-related acute lung injury
Damage control surgery

Shock, Trauma and Resuscitation

- Hemorrhage control
- Reduction of contamination
- Decompression of compartment syndromes
- Resection of dead tissue (debridement)
- Temporary / definitive fixation of skeletal instability
Damage control surgery

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# Damage control surgery

Shock, Trauma and Resuscitation

<table>
<thead>
<tr>
<th>Physiologic status</th>
<th>Operative interventions</th>
<th>Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Balance:</strong></td>
<td>Life saving surgery</td>
<td></td>
</tr>
<tr>
<td><strong>Vital functions?</strong></td>
<td>Damage Control</td>
<td>Day 1</td>
</tr>
<tr>
<td><strong>Response?</strong></td>
<td>Early total care</td>
<td></td>
</tr>
<tr>
<td><strong>Hyperinflammation</strong></td>
<td>2nd looks only after DCS</td>
<td>Day 2-3</td>
</tr>
<tr>
<td><strong>Window of opportunity</strong></td>
<td>Scheduled def. surgery, flaps</td>
<td>Day 4-10</td>
</tr>
<tr>
<td><strong>Immunosuppression</strong></td>
<td>No elective surgery</td>
<td>Day 11-21</td>
</tr>
<tr>
<td><strong>Recovery</strong></td>
<td>Sec. reconstructive surgery</td>
<td>≥ 4 Wo</td>
</tr>
</tbody>
</table>

Summary I

Shock, Trauma and Resuscitation

- Respect the golden hour
- Time is crucial
- Apply established concepts (ATLS)
- Respect the priorities
- Treat life-threatening injuries first
- Early assess need for transfer, do not delay
Summary II

Shock, Trauma and Resuscitation

- Overtreatment may kill the patient
- Apply the concept of damage control in critical patients
- Stable patients benefit from early total care
Thanks for your attention