Joint Trauma System

Field Critical Care – Anesthesia, Infections, and Critical Care

Joint Trauma System Battlefield Trauma Educational Program
A 25 year old active duty member is severely injured after a dismounted Improvised Explosive Device (IED) blast. He has bilateral lower extremity traumatic amputations controlled with tourniquets and has had a massive blood transfusion. Evacuation is delayed to the next level of care.

1. How would this patient be managed at Role 1, 2, and 3 facilities?

2. What critical care issues could arise in the subsequent hospital days?
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Objectives

- Airway and anesthesia in the trauma patient
- Principles of critical care on battlefield
- Management of battlefield infections

Photo courtesy of Defense Visual Information Distribution Service
Pre-induction considerations

- Hypothermia
- Warmed room, warm fluids, minimize exposure
- Need for ongoing resuscitation or massive transfusion protocol
  - Contact blood bank early.
  - Establish walking blood bank if needed.
- Proper communication: Early establishment of roles between anesthesia and other care providers is essential to success.
Patients must be evaluated for:

- Concurrent Illness and current state of resuscitation
  - Induction of anesthesia in the bleeding patient can be disastrous.
  - Medications such as propofol can cause hypotension and alternative such as ketamine may be available.

- Secure vascular access and monitoring equipment
  - Do not delay operation for placement of central venous access or invasive monitoring equipment. Consider placement of intraosseous device.

- Status of airway
  - Pre-oxygenation can be achieved effectively with 4 vital capacity breaths.

- Cervical spine mobility

Stethoscope may be only tool available in an austere environment for assessment.
6 Steps of Rapid Sequence Intubation (RSI)

1. Preoxygenate with 100% oxygen by mask
2. Cricoid pressure (maintain until ETT placement is confirmed)
3. Induction agent: etomidate
   - 0.2-0.4 mg/kg IV push (or equivalent)
4. Muscle relaxant: succinylcholine
   - 1.0-1.5mg/kg IV push (or equivalent)
5. Laryngoscopy and orotracheal intubation
   (after 1 minute or seeing fasciculations)

*Verify tube placement. Consider nasogastric or orogastric tube placement after securing airway.*
Verification of tube placement is **vital**

- Any difficulty with oxygenation/ventilation following RSI should prompt evaluation for immediate reintubation.
- Start considering a difficult airway.

*Difficult airway*
Difficult airway

- Resume oxygenation. Place a temporary oral or nasal airway if available.
- Reposition patient.
- Call for help.
- Consider alternatives to RSI.
  - Awake intubation
  - Laryngeal mask airway
  - Regional anesthesia
  - Surgical airway
Indications for a definitive airway

- Apnea/airway obstruction/hypercarbia
- Impending airway obstruction
- Excessive work of breathing
- Shock (blood pressure ≤ 80 mm Hg)
- GCS ≤ 8
- Persistent hypoxia

If continuing anesthesia, consider:

- Low lung volume ventilation (6 mL/kg)
- Communication with the next role of care
Recent conflicts: Majority of casualties have superficial wounds or extremity wounds which make regional anesthetics useful.

Advantages include:

- Excellent operating conditions
- Profound perioperative analgesia
- Stable hemodynamics
- Limb-specific anesthesia
- Reduced need for other anesthetics
- Improved postoperative alertness
- Minimal side effects
- Rapid recovery from anesthesia
- Simple, easily transported equipment needed
Shock is defined as inadequate organ perfusion and tissue oxygenation.

Classes of Shock

■ **Hypovolemic**: Absolute deficiency of intravascular blood volume (*hemorrhage*)
  - *Most common cause of shock* in the combat casualty care setting
  - Bleeding control first and foremost – damage control surgery

■ **Distributive**: Maldistribution of blood volume
  - Septic and anaphylactic shock may be seen in combat setting
Classes of Shock *(continued)*

- **Neurogenic:** Disruption of cervical chain ganglia; decreased sympathetic output
  - Seen in low cervical and high thoracic spine injuries

- **Cardiogenic:** Primary defect in the generation of cardiac output. Obstructive shock is a related disorder
  - Pulmonary embolism, tension pneumothorax are two likely clinical presentations, but myocardial infarction may occur

- **Adrenal Insufficiency:** Reduced corticosteroid output from adrenals
  - Possible with etomidate induction; may be seen in Role 3 in patient’s with prolonged critical illness
Shock can be considered uncompensated or compensated.

- **Uncompensated:** Easy to identify
  - Low urine output
  - Altered mental status
  - Hypotension
  - Poor capillary refill
  - Tachycardia

- **Compensated**
  - More difficult to discern, but hypoperfusion present

*Joint shock trauma demonstration*
*Photo courtesy of Defense Visual Information Distribution Service*
First define type and eliminate cause of the shock.

- Resuscitation in uncompensated shock
  - Goals:
    - Mean arterial pressure > 60 mm Hg
    - Urine output > 0.5 mL/kg/h
    - Lactate < 2 mmol/L
    - Adequate oxygen delivery (DO2)
  - Vigorously replete Intravascular Volume (IVV) if MAP or urine output inadequate
    - In most patients – **Blood**
    - Goal central venous pressure: 8-10 mm Hg and Pulse pressure variation < 13%
Resuscitation in uncompensated shock *(continued)*

- Only use vasopressors to support the MAP after adequate volume restoration
  - Vasopressin first-line in burn resuscitation
  - Norepinephrine in most other non-hemorrhagic situations
  - Consider epinephrine in anaphylaxis and dopamine in cardiogenic
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Compensated Shock

- Can go unrecognized, but increased anaerobic metabolism will lead to increased lactate production.
- Development of an anion gap metabolic acidosis and increased base deficit suggest inadequate resuscitation.
- A central venous saturation (ScvO2) < 65% also suggests inadequate resuscitation.

Interventions:
- Optimize SaO2 and IVV
- Consider transfusion > 10 mg/dL
- Consider inotropic therapy

Shock trauma resuscitation drill
Photo courtesy of Defense Visual Information Distribution Service
Core rewarming: Warmed resuscitative fluids, blanks, ventilator air, Bair Hugger, etc.

Reversal of acidosis: Appropriate resuscitation with blood products, colloids, and/or crystalloid

Reversal of coagulopathy: Factor replacement

Ventilatory support: Use ARDSNet low tidal volume support

Injury identification: Perform tertiary survey, obtain CT scans, and angiography as indicated.

Monitor for abdominal compartment syndrome: Anyone undergoing massive transfusion, large body surface area burn, or prolonged trauma laparotomy is at risk. A high index of suspicion must be maintained.
Some degree of Adult Respiratory Distress Syndrome (ARDS) affects 26% and 33% of combat casualties.

Risk factors include:
- Female gender, shock or tachycardia on presentation, and severe injury (Military Injury Severity Score (mISS) ≥25)
- Increased transfusion of crystalloid and FFP

Significantly increased risk of mortality

Patients with PEEP > 14 cm H2O or who appear clinically unstable should be considered candidates for activation of specialized lung teams when available.
ARDS

- ARDS occurs within one week of an insult and represents the same disease process as acute lung injury.
  - Acute presentation of hypoxemic respiratory failure
  - Bilateral infiltrates on chest radiography
  - No clinical evidence of left heart volume overload

- Peep > 5 cm
  - Mild P:F ratio 200-300
  - Moderate P:F ratio 100-200
  - Severe P:F ratio < 100

- Correct for altitude: barometric pressure (bp)/760
  *at BAF bp=641 mmHg; 641/760=.84; severe ARDS < 84
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ARDS Algorithm

**Inclusion Criteria: Acute onset of:****
1. R/E (R/t corrected for altitude)
2. Bilateral (gestic, diffuse, or homogeneous) infiltrates consistent with pulmonary edema
3. New onset evidence of left atrial hypertension

**PART II: VENTILATOR SETUP & ADJUSTMENT:****
1. Calculate predicted body weight (PBW)
   a) Males = 22.5 x height (inches) - 72
   b) Females = 45.5 + 2.3 x height (inches) - 72
2. Select one ventilation mode
3. Set ventilator settings to achieve: 
   a) V̇<sub>p</sub> = 8 ml/kg PBW
   b) RR = 1 min (at intervals) - 2 hours until 
   c) V̇<sub>p</sub> = 0.5 ml/kg PBW
   d) Set initial rate to approximate baseline minute ventilation (set >35 bpm)
4. Adjust VO<sub>2</sub> and RR to achieve p<sub>P</sub> and plateau pressure goals below.

**Oxygenation goals: PaO<sub>2</sub> = 35-60 mmHg or SpO<sub>2</sub> = 88-95%**
Use a minimum PEEP of 5 cm H<sub>2</sub>O. Consider use of noninvasive FiO<sub>2</sub>/PEEP combination as shown below (not required) to achieve goal:

**Lower PEEP/higher FiO<sub>2</sub>**
- P<sub>F</sub>O<sub>2</sub> = 0.3
- PEEP = 15 cm H<sub>2</sub>O
- FiO<sub>2</sub> = 0.8
- P<sub>F</sub>O<sub>2</sub> = 0.6
- PEEP = 10 cm H<sub>2</sub>O
- FiO<sub>2</sub> = 0.6
- PEEP = 5 cm H<sub>2</sub>O

**Higher PEEP/lower FiO<sub>2</sub>**
- P<sub>F</sub>O<sub>2</sub> = 0.3
- PEEP = 24 cm H<sub>2</sub>O
- FiO<sub>2</sub> = 0.8
- P<sub>F</sub>O<sub>2</sub> = 0.6
- PEEP = 18 cm H<sub>2</sub>O
- FiO<sub>2</sub> = 0.6
- PEEP = 12 cm H<sub>2</sub>O
- FiO<sub>2</sub> = 0.4

**Plateau Pressure Goal:** 30 cm H<sub>2</sub>O

**B. Spontaneous Breathing Trial (SBT)**:
If all above criteria are met and subject has been in the study for at least 12 hours, initiate a trial of up to 120 minutes of spontaneous breathing with P<sub>F</sub>O<sub>2</sub> = 0.3 and PEEP ≤ 5.

**Definition of Unassisted Breathing (Different from spontaneous breathing criteria as PS is not allowed):**
1. Euthetized with face mask, nasal prong oxygen, or non-rebreather
2. Non-invasive positive pressure support
3. No neuromuscular blocking agents or midazolam
Advanced therapies may be limited in austere environment, but maneuvers such as inhaled nitric oxide and extracorporeal life support may exist.

### Indications for Lung Team

- P:F < 100 after correction for elevation
- P:F < 200 + inhalational injury
- FiO2 > 0.7 & pH < 7.25 while on lung protection
- Peep > 15 with Plat > 30
- Severe TBI and PCO2 > 35-40
- Cardiogenic shock
- Using APRV
- MOF: ARDS plus renal failure

*Lung team packaging patient for transport on ECMO*
Electrolytes

- Derangements in sodium, potassium, magnesium are common. Require evaluation and replacement if present, especially if clinical manifestations present

- Hypocalcemia: Common problem due to massive transfusions and citrate present in transfused blood products
  - Ionized calcium preferred measurement, but adjusted calcium can be used if needed
Renal considerations

- Most relevant renal abnormalities: prerenal azotemia, acute tubular necrosis (ATN), rhabdomyolysis, nephrolithiasis, and iatrogenic complications of medications

- Monitor and be attentive of decreased urine output, elevated creatinine, BUN/Cr 10-20, UNa > 20 mg/dL.

- In general volume repletion to goal urine output is most important intervention.

- Watch closely for development of hyperkalemia, acidemia, volume overload, pericardial rubs, and extreme uremia.

- Indication for hemodialysis if available
Endocrine considerations

- Diabetic ketoacidosis may occur in theater.
  - Aggressive fluid supplementation, insulin drip, and potassium repletion

- Adrenal Insufficiency
  - Generally anticipated in patients that take doses of prednisone in excess of 10-20 mg daily
  - Clinically presents with hypotension, not responsive to pressor therapy, and does not have an appropriate tachycardia
  - Treatment: hydrocortisone 200 mg IV, then 100 mg IV q8h
Cardiac considerations

- Congestive heart failure, non-ST-elevation myocardial infarction, and unstable angina may appear in theater.
- Treatment based on civilian practice to the maximum ability depending on local resources.
- Blunt cardiac injury is treated with supportive care.
- Cardiac tamponade needs urgent drainage.
Deep Vein Thrombosis (DVT) Prophylaxis:
Trauma patients at high risk for thromboembolism

- All trauma patients should receive chemical prophylaxis unless contraindicated.
  - Lovenox 30 mg SQ BID

- If contraindication for chemical prophylaxis or high risk for DVT, should receive compression devices.
  - Consider removable vena cava filter placement for highest risk patients.
Stress Gastritis

- Indications for prophylaxis: coagulopathy, mechanical ventilation > 48 hrs, shock, multisystem trauma, TBI, and burn > 20%
- Pantoprazole 40 mg IV qDay or Ranitidine 50 mg IV SQ q8 hrs
  - Sucralfate not recommended
Ventilator Associated Pneumonia (VAP)

- Minimize duration of ventilation (wean and extubate).
- Use Hi-Lo Tracheal Tube to allow removal of subglottic secretions.
- Provide oral care with chlorhexidine q4h.
- Do not routinely change out ventilator circuitry unless mechanical failure present or visible contamination.
- Keep head of bed 30-45 degrees.
- Minimize empiric use of antibiotics.
- Cohort patients with similar isolates to one area of the ICU.
- Consider terminal cleaning of a part of the ICU after treatment complete.
General Principles

- Surgical and antibiotic treatment should begin as early as possible.
- Optimally, surgical debridement should be achieved within 6 hours of injury.
- Following initial exploration and debridement, the wound should be sufficiently irrigated to ensure that all dead material, bacterial contamination, and foreign material have been washed from the wound.
- Leave skin open in all battlefield wounds.
Pneumonia

- **Pneumonia**: Fever (>38 degrees C) + leukocytosis + two chest radiographs with pneumonic infiltrates + culture of sputum demonstrating a pathogen (4+growth)

- **Aspiration pneumonia**: History of aspiration of gastric contents followed by clinical and new radiologic findings of pneumonia within 48 hours.

- **Pediatric patients**: Fever (>38 degrees C) + leukocytosis or gram stain of sputum or aspirate and two chest radiographs with pneumonic infiltrate and culture of sputum or aspirate.
**VAP:** Any pneumonia in a patient who is intubated or was extubated within 48 hours (including the weaning period); mechanical ventilation can be by tracheostomy or endotracheal tube

**AND at least 2 of the following:**
- Temperature >38 C or <36 C
- Leukocytosis >10,000/mm3, or leukopenia <4,000, or >15% bands
- New or increased production of purulent sputum
- Rhonchi or wheezing

**AND at least 1 CXR finding from below:**
- New or progressive infiltrate, consolidation, cavitation, or pleural effusion

**AND at least 1 of the following:**
- Organism isolated from blood culture
- Isolation of pathogen from trans-tracheal, bronchial brush, biopsy or lavage
- Histopathologic evidence of pneumonia
Prevent Post-op Pneumonia

- Encourage deep breathing.
- Encourage use of incentive spirometry.
- Mobilize as early as possible.

Antibiotic Therapy

- Surgical prophylaxis
- Reduce duration and spectrum based on facility’s microbiology pattern.

Suspected infection

- Obtain cultures prior to initiation of antibiotic therapy, when possible.
- Use broad spectrum for initial therapy.
- Tailor therapy based on culture results.
- 8 days of antibiotic therapy is superior to longer courses.
- All wounds incurred on the battlefield are grossly contaminated with bacteria.

- Most will become infected unless appropriate treatment is initiated quickly.
Prompt surgical source control, including debridement and drainage, are the cornerstone of prophylaxis/treatment of all war wound infections.

Inadequately debrided grenade shrapnel wound POD#2 – Purulent drainage with cellulitis
Post injury, antibiotics are given as prophylaxis for wounds with duration dependent on locations.

- Most wounds the preferred agent is cefazolin 2 g IV q6-8hrs for at 1 day
- Burns and eyes are different, with only topical agents for burns
- If delayed evacuation, ertapenem 1 g IV is a go to medication

Post Debridement – Necrotizing Fasciitis of internal oblique identified
25M AD severely injured after a dismounted IED blast. He has bilateral lower extremity traumatic amputations controlled with tourniquets and has had a massive blood transfusion. Evacuation is delayed to the next level of care.

1. How would this patient be managed at Role 1, 2, and 3 facilities?

2. What critical care issues could arise in the subsequent hospital days?
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References

- Joint Trauma System (JTS) Clinical Practice Guidelines (CPG)
  - [https://jts.amedd.army.mil/index.cfm/PI_CPGs/cpgs](https://jts.amedd.army.mil/index.cfm/PI_CPGs/cpgs)
  - JTS, Respiratory Failure CPG
  - JTS, Anesthesia for Trauma Patients CPG
  - JTS, Hyperkalemia and Dialysis in the Deployed Setting
  - JTS, Ventilator Associated Pneumonia CPG
  - JTS, Prevention of Deep Venous Thrombosis – Inferior Vena Cava Filter CPG


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