Critical Illness

1. Critical Illness

1.1 Critical Illness

1.2 Objectives

Objectives

- Learn about types of Intensive Care Units and the patients that populate them
- Understand the evaluation of the acutely critical patient
- Learn about the different types of shock
- Differentiate between SIRS and Sepsis
- Understand the Sepsis-3 Consensus definitions of sepsis and septic shock
- Learn about Surviving Sepsis Guidelines
1.3 Objectives

Objectives

- Define ARDS with Berlin Classification system
- Understand the causes of ARDS
- Learn treatment strategies for ARDS

1.4 Types of Intensive Care Units

Types of Intensive Care Units

- Medical ICU (MICU)
- Surgical ICU (SICU)
- Neonatal ICU (NICU)
- Pediatric ICU (PICU)
- Cardiac ICU (CICU)
- Burn ICU (BICU)
1.5 ICU Admission Criteria

ICU Admission Criteria

- Mechanical ventilatory support (including nasal continuous positive airway pressure or CPAP to non-invasive, mask ventilation)
- Possibility of a sudden, precipitous deterioration in respiratory function requiring immediate endotracheal intubation and mechanical ventilation
- Need for life support to maintain respiratory function

Blood respiratory monitoring and support
- Need for arterial blood gas monitoring
- Need for advanced respiratory support

Neurological support
- Need for advanced respiratory support
- Need for sedation
- Neurological interventions

Circulatory support
- Need for inotropic drugs to support arterial pressure or cardiac output
- Support for circulatory instability due to hypovolemia from any cause which is unresponsive to intravenous fluid replacement (including post-operative or gastrointestinal hemorrhage or hemorrhage related to a coagulopathy)
- Therapeutic hypotension

Heart rate
- Need for inotropic drugs to support arterial pressure or cardiac output

1.6 ICU Basic Monitoring

ICU Basic Monitoring
- Heart rate
- Blood pressure
- EKG
- Respiration rate
- Pulse oximetry
- Hourly urine output
- Temperature

Sources: BMI VOLUME 318 5 JUNE 1999
1.7 Invasive Monitoring

Invasive Monitoring

- Arterial catheter
  - Measures beat to beat differences in blood pressure. Waveform contour can be analyzed for cardiac output and vascular volume measurements

- Central venous catheter
  - Measures central venous pressure and superior vena cava oxygen saturation

1.8 Invasive Monitoring

Invasive Monitoring

- Swan Ganz (PA) catheter
  - Measures pulmonary artery (PA) pressure, continuous cardiac output, SVO₂ (mixed venous oxygen saturation), and other derived measurements

- End Tidal CO₂ for intubated patients
  - Analyzes exhaled gas from patient to measure the CO₂ content
Where do critically ill patients present?

- Obvious settings
  - ER
  - ICU
  - Trauma Bay
  - OR
- Not so obvious
  - Family Practice office
  - Urgent Care clinic
  - OB ward
  - Pediatric outpatient
  - Pretty much anywhere

1.10 Evaluation of the Acutely Critically Ill Patient

Evaluation of the Acutely Critically Ill Patient

- History is essential
- Physical Exam
  - Neurologic → Glasgow coma scale, gross motor or sensory dysfunction
  - Respiratory → Work of breathing, breath sounds,
  - Cardiac → Auscultation for new murmurs, EKG analysis
  - Abdomen → Distention, tenderness, guarding, rigidity
1.11 Evaluation of the Acutely Critically Ill Patient

Evaluation of the Acutely Critically Ill Patient

- Labs
  - ABG → Acidosis, hypoxemia, hypercarbia
  - Glucose → Hypo and Hyper glycemia
  - Lactic acid → Indicator of tissue perfusion
  - Electrolytes → Several electrolyte perturbation conditions can cause or result from critical illness

1.12 Evaluation of the Acutely Critically Ill Patient

Evaluation of the Acutely Critically Ill Patient

- Portable ultrasound can be performed by the clinician
- Ultrasound pertinent findings:
  - Lung → pneumothorax, edema, effusion, pneumonia, atelectasis
  - Heart → Cardiac dysfunction, pericardial effusion/tamponade, PE, intravascular volume depletion
  - Abdomen → Abdominal free fluid, abdominal aortic aneurysm, many more
1.13 Evaluation of the Acutely Critically Ill Patient

Evaluation of the Acutely Critically Ill Patient

Potential Causes of Critical Illness

- Shock
- SIRS
- Sepsis
- ARDS
1.15 Shock

Shock

- Definition
  - Physiologic state characterized by inadequate substrate for cellular respiration

- Types
  - Hypovolemic → Low preload
  - Cardiogenic → Depressed cardiac contractility
  - Obstructive → Increased afterload
  - Distributive → Severe vasodilation
  - Any of the above combined

1.16 Causes of Shock

Causes of Shock

<table>
<thead>
<tr>
<th>Pathophysiologic type</th>
<th>Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypovolemic</td>
<td>Hemorrhage, trauma</td>
</tr>
<tr>
<td></td>
<td>Dehydration</td>
</tr>
<tr>
<td>Cardiogenic</td>
<td>Myocardial infarction</td>
</tr>
<tr>
<td></td>
<td>Cardiomyopathy</td>
</tr>
<tr>
<td></td>
<td>Valvular disease</td>
</tr>
<tr>
<td></td>
<td>Severe arrhythmias</td>
</tr>
<tr>
<td>Obstructive</td>
<td>Pulmonary embolism</td>
</tr>
<tr>
<td></td>
<td>Tamponade</td>
</tr>
<tr>
<td></td>
<td>Aortic dissection</td>
</tr>
<tr>
<td>Distributive</td>
<td>Inflammatory response (mediation)</td>
</tr>
</tbody>
</table>

Source: Vincenzo et al. Critical Care 2012, 16:239
1.17 SIRS and Sepsis

SIRS and Sepsis

- Definition
  - Perturbations of inflammatory response that can either be associated (Sepsis) or not associated (SIRS) with infection. These perturbations have varying degrees of severity and physiologic consequences.

1.18 SIRS

SIRS

- Systemic Inflammatory Response Syndrome → Meets at least two of the following criteria:
  - Temp > 38° C
  - Heart rate > 90 or two SD > normal for that patient
  - Respiratory rate > 20 or PaCO₂ < 32
  - WBC > 12,000 or > 10% bands
1.19 Sepsis

Sepsis

- Life threatening organ dysfunction caused by dysregulated host response to infection
- Organ dysfunction can be identified as an acute change in SOFA (Sequential [sepsis related] Organ Failure Assessment) Score of greater than or equal to 2 consequent to infection

1.20 Severe Sepsis

| Table 1: Sequential [sepsis-related] Organ Failure Assessment Score
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>System</td>
<td>Score</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Respiratory</td>
<td>PaO₂/FIO₂ (mm Hg)</td>
<td>&gt;400 (55:1)</td>
<td>&lt;400 (55:1)</td>
<td>&lt;200 (44)</td>
<td>&lt;100 (26:7) with respiratory support</td>
</tr>
<tr>
<td>Coagulopathy</td>
<td>Platelets, 10⁹/μL</td>
<td>≥150</td>
<td>≥100</td>
<td>&lt;50</td>
<td>&lt;20</td>
</tr>
<tr>
<td>Laboratory</td>
<td>WBC (mm³), &lt;2.0</td>
<td>1.2–1.9 (22–32)</td>
<td>2.0–3.9 (33–100)</td>
<td>4.0–11.9 (112–204)</td>
<td>12.0–219 (320–930)</td>
</tr>
<tr>
<td></td>
<td>MAP &gt;70 mm Hg</td>
<td>MAP &gt;70 mm Hg</td>
<td>Dopamine &lt;5 or dobutamine (any dose)</td>
<td>Dopamine 5.0–15.0 or epinephrine (10.0–20.0) or norepinephrine (0.15–0.3)</td>
<td>Dopamine 15.0–25.0 or epinephrine &lt;0.5 or norepinephrine &gt;0.5</td>
</tr>
<tr>
<td>Central nervous system</td>
<td>Glasgow Coma Scale score</td>
<td>15</td>
<td>13–14</td>
<td>10–12</td>
<td>6–9</td>
</tr>
<tr>
<td></td>
<td>Urine output, mL/h</td>
<td>&lt;1.0 (150)</td>
<td>1.0–3.0 (150–170)</td>
<td>3.0–4.0 (150–170)</td>
<td>5.0–8.0 (200–440)</td>
</tr>
</tbody>
</table>

Abbreviations: PaO₂, fraction of inspired oxygen; MAP, mean arterial pressure; FIO₂, fractional pressure of oxygen.

Adapted from Vincent et al. [1].

* Catecholamine doses are given as μg/kg/min for at least 1 hour.
* Glasgow Coma Scale scores range from 3 to 15: higher score indicates better neurological function.
1.21 Septic Shock

Septic Shock

- Persistent hypotension requiring vasopressors to maintain a MAP of 65 mmHg or greater and having a serum lactate >2 despite adequate fluid resuscitation
- And having lactate greater than 2

1.22 Mortality

Mortality

- Range from 12.8% in sepsis to 45.7% in septic shock

1.23 Surviving Sepsis Guidelines

Surviving Sepsis Guidelines

- Most recent management strategies for managing sepsis
  - Early recognition
  - Early antibiotic therapy (attempt within 1 hour of recognition but no later than 3 hours)
  - Early source control
  - Early resuscitation with minimum of 30mL/kg of crystalloid
  - Norepinephrine as first choice vasopressor after fluid resuscitation to maintain MAP > 65 mmHg


1.24 Surviving Sepsis

Surviving Sepsis

![Surviving Sepsis Campaign Care Bundles]

### 1.25 ARDS

#### ARDS

<table>
<thead>
<tr>
<th>Timing</th>
<th>Within 1 week of a known clinical insult or new or worsening respiratory symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest imaging</td>
<td>Bilateral opacities—not fully explained by effusions, lobar/lung collapse, or nodules</td>
</tr>
<tr>
<td>Origin of edema</td>
<td>Respiratory failure not fully explained by cardiac failure or fluid overload Need objective assessment (eg, echocardiography) to exclude hydrostatic edema if no risk factor present</td>
</tr>
<tr>
<td>Oxygenation&lt;sup&gt;P&lt;/sup&gt;</td>
<td>Mild: ( P_{AaO_2}/FiO_2 \leq 300 \text{ mm Hg} ) with ( P_{AaO_2}/FiO_2 \geq 5 \text{ cm H}_2\text{O} )</td>
</tr>
</tbody>
</table>

**Table 3. The Berlin Definition of Acute Respiratory Distress Syndrome**

Source: JAMA. 2012;307(23):2526-2533

### 1.26 ARDS

#### ARDS

- **Causes**
  - Sepsis
  - Blood Transfusions
  - Trauma
  - Aspiration
  - Burns and/or smoke inhalation
  - Pancreatitis
  - Pneumonia
  - Near drowning
1.27 ARDS Pathophysiology

ARDS Pathophysiology

- Insult leads to cytokine and inflammatory mediator release and causes migration of neutrophils
- Inflammation causes endothelial leak with tissue edema
- Results in reduced gas exchange
- Diffuse Alveolar Damage (DAD) and hyaline membrane disease are histologic hallmarks

1.28 DAD and Hyaline Membrane Disease

DAD and Hyaline Membrane Disease

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**ARDS Treatment**

- Lung Protective Ventilation Strategies
  - Low tidal volume → 6mL/kg/breath
  - Limit plateau pressure to less than 30 cm H₂O
  - Increased PEEP
- Early neuromuscular blockade in moderate to severe ARDS
- Prone positioning
  - Better outcomes when performed appropriately but difficult to execute without special and expensive equipment
- Conservative fluid strategy if possible