CASE STUDY OF A CRITICAL CARE PATIENT

The Transition into Multiple Organ Dysfunction Syndrome
From the Beside

• Older gentlemen, Asian descent
• Family at the bedside
• On a ventilator
• TPN, NG, ostomy, wound vac on abdominal wound
• Foley, central line
• Nonresponsive, not following commands
• Pitting edema, denuded, weeping
• Day 19

3 hours later: Code Blue, 300+ mL bloody residuals from NG tube, evening attempt to begin weaning fails,
• Hyperkalemia, hyperchloremia, hypocalemic
Introduction of Patient

- 88 year-old male of Chinese decent

- PMH: HTN, hyperlipidemia, and SVTs following reduction of beta blockers

- 11/7/2013: Presented to ED with abdominal pain, N & V, and small BMs. Symptoms had progressively worsened over last 3 weeks.

- Diagnosis: Adenocarcinoma in the splenic flexor (5.8 cm) causing a bowel obstruction.
  - exploratory laparotomy for resection of the mass with end-to-end anastomosis.
<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/7/2013</td>
<td>Admitted w/ab pain, N&amp;V, colectomy, exploratory laparotomy and mass removal</td>
</tr>
<tr>
<td>11/8</td>
<td>Transferred to PVICU (not a candidate for chemo)</td>
</tr>
<tr>
<td>11/9</td>
<td>SVT’s w/adenosine x2 (hx: 1&lt;sup&gt;st&lt;/sup&gt; degree heart block)</td>
</tr>
<tr>
<td>11/12</td>
<td>Acute renal failure (intravascular volume depletion)</td>
</tr>
<tr>
<td>11/16</td>
<td>CT revealed abscess filled with frank, liquefied stool</td>
</tr>
<tr>
<td>11/17</td>
<td>Colectomy</td>
</tr>
<tr>
<td>11/17</td>
<td>Sepsis w/ARDS, anastomotic leak &amp; intrapelvic abscess</td>
</tr>
<tr>
<td>11/18</td>
<td>Exploratory midline laparotomy, terminal ileostomy &amp; right hemicolecction</td>
</tr>
<tr>
<td>11/26</td>
<td>Code blue, (3&lt;sup&gt;rd&lt;/sup&gt; degree heart block) PT resolved</td>
</tr>
</tbody>
</table>
Overview of Patient Case Study

Presents to ED

Pt. is tachypneic and hypotensive at cardiologist’s office

Discharged to ECF

Weaned off ventilator

Wean of respiratory failure

Wean of acute kidney failure

Wean of septic shock

Diagnosed with colon cancer

Removal of mass with post-op complications

Abscess found and drained
Septic Shock

- Systemic Inflammatory Response Syndrome (SIRS) → Sepsis → Septic Shock → Multiple Organ Dysfunction

- Diagnosis Criteria:
  - Proven or suspected source of infection
  - Fever above 101.3°F (38.5°C) or below 95°F (35°C)
  - Heart rate higher than 90 beats a minute
  - Respiratory rate higher than 20 breaths a minute
  - High or low WBC’s and >10% immature bands
  - Low PaCO2

- 10th most common cause of death in U.S. 7% increase in mortality with every 1 hr delay in antibiotic administration

- Sepsis and sepsis related deaths increasing 1.5% each year

- 16.7 billion dollars – estimated national hospital cost in U.S.
SPLANCHNIC CIRCULATION
Pathophysiology
Blood Flow
LOW ARTERIAL PRESSURE

- Sympathetic activity

- Splanchnic resistance

- Splanchnic blood flow

\[ \text{mild} \rightarrow 10\% \]

\[ \text{strong} \rightarrow 75\% \]

\[ \text{intense} \rightarrow 100\% \]

Splanchnic blood flow

Splanchnic resistance

Autoregulatory escape

60 Minutes
Severe Sepsis and Septic Shock

• Infection → toxins → SIRS → damaged endothelium → hypovolemic state → hypermetabolic state → vasoconstriction

• Severe Sepsis can lead to septic shock, continued hypotension despite adequate fluid resuscitation

• This can lead to failure of gastrointestinal tract, liver, spleen and pancreas. Which in turn results in MODS
Decreased Splanchnic Perfusion

- Ischemia leads to intestinal edema and eventually translocation of normal gut flora into systemic circulation

- Intestinal edema further compromises splanchnic circulation, pressure is increased and then exerted onto the abdominal organs

- Ischemic injury and translocation of bacteria further perpetuates inflammatory response
Decreased Perfusion Continued

• Hepatobiliary dysfunction -> ↓ BF and increased abdominal pressure from edema
  – ↓ lactate clearance, ↓ glucose metabolism, responding macrophages perpetuate inflammatory response
  – Limited inflammatory response control
• Pancreatic dysfunction- destruction of exocrine cells; inability to secrete digestive enzymes
• Spleen- not able to filter RBCs nor mount appropriate active immune responses; increased intra-abdominal pressure, can cause spleen to rupture
Relation to Rhabdomyolysis

- Sepsis can cause Rhabdomyolysis
- In preventing kidney damage; fluid resuscitation is needed.
- Fluid resuscitation can lead to increased abdominal pressure
- Poor perfusion -> ↓ Bf and pushes fluids into abdominal tissues which further compresses organs
- Broken down muscle tissue now needs to be filtered by kidneys and can potentially disrupt blood flow to other organs;
Clinical manifestations related to splanchnic circulation

- GI tract: decreased motility, malabsorption
  - Weight loss, minimal bowel sounds, nausea and vomiting, paralytic ileus, GI ulcer, abdominal distention

- Pancreas: maldigestion and constipation symptoms
  - Early rise in glucose, with a later decline

- Spleen: hemorrhage if ruptured; more susceptible to infection process
Clinical Manifestations Related To Splanchnic Circulation

- Hepatobiliary failure-
  - Liver: elevations of bilirubin, jaundice, elevated liver enzymes
  - Gallblader: Cholecystis without gallstones, right upper quadrant pain and tenderness, abdomen, distention, loss of bowel sounds, fever,
Clinical Presentation

MEDS score parameters

<table>
<thead>
<tr>
<th>Variable</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terminal illness (&gt; 50% chance of death in &lt; 1 mo as estimated by treating physician)</td>
<td>6</td>
</tr>
<tr>
<td>Tachypnea or hypoxemia (RR &gt; 20 or O2sat &lt; 90% or needing face-mask or non-rebreather)</td>
<td>3</td>
</tr>
<tr>
<td>Septic shock (SBP &lt; 90 mmHg despite fluid bolus)</td>
<td>3</td>
</tr>
<tr>
<td>Platelet count (&lt; 150,000 cells/mm3)</td>
<td>3</td>
</tr>
<tr>
<td>Bands (&gt;5%)</td>
<td>3</td>
</tr>
<tr>
<td>Age (&gt; 65 yo)</td>
<td>3</td>
</tr>
<tr>
<td>Lower respiratory infection (on CXR or by history)</td>
<td>2</td>
</tr>
<tr>
<td>Nursing home resident</td>
<td>2</td>
</tr>
<tr>
<td>Altered mental status (altered from baseline on any of 3 orientation questions - place, person, time)</td>
<td>2</td>
</tr>
</tbody>
</table>

PT score: 23, high risk
28-day mortality rate: 39%

- Third spacing, pitting edema, ventilator, non-responsive
- WBC 12.8, bands >5%
- AST 64 (bile obstruction)
- Platelets 227,000 (thrombocytopenia)
- Cr 1.35, BUN 50 (renal failure)
- BNP 120 (increased fluid)
How Did This Patient Become Septic?

- PT had colon cancer which caused a small bowel obstruction
- SBO causes intestinal dilation (GI secretions, swallowed air)
- Fluid loss r/t emesis, & edema – metabolic alkalosis
- Peristalsis increases - high hydrostatic pressure (third spacing, loss of fluids & electrolytes vascularly - edema)
- Intestinal stasis – floral overgrowth – bacterial translocation across bowel wall
- SEPSIS
- Other issues: large abdominal wound from surgery, new ostomy, NG tube, Foley, ventilator, central line
Radiographic Confirmation of SBO
## Treatment—Sepsis Protocol—EBP

<table>
<thead>
<tr>
<th>Major Interventions</th>
<th>Within 1st 6 Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>• IV antibiotics (2 or 3)</td>
<td>• Labs/Tests (blood cultures &amp; lactic acid w/in 15 min)</td>
</tr>
<tr>
<td>• IV fluids (for low bp)</td>
<td>• Antibiotics Ceftriaxone, Levofloxacin, metro, Vanco</td>
</tr>
<tr>
<td>• Therapy to support any organ dysfunction (intubation, dialysis, surgery, drainage)</td>
<td>• Fluid bolus NS 30-40ml/kg &amp; continued fluid replacement</td>
</tr>
<tr>
<td></td>
<td>• Norepinephrine, Vasopressin, NPO, Foley, move to ICU</td>
</tr>
</tbody>
</table>
Treatment Specific to Patient

- Primaxin – bactericidal
- Peridex – ventilator induced pneumonia protocol
- TPN
- Heparin - VTE prophylaxis protocol
- Humulin R – inhibits hepatic glucose production
- Lopressor – beta blocker for high bp (PT hx)
- Fentanyl & Norco – analgesics, sedatives
- NPO, Foley, central line, HOB up, ventilator, wound vac, NG tube, q2h residual checks, q4h Foley care, q2d central line dressing change
Family Education

- I/O
- Diet
- Alcohol, drugs abstinence
- Infection prevention
- Signs and systems of infection
- Colonoscopy
Patient Cardiology

- **First Degree Heart Block**
  - Impulses move slowly through the heart, but each electrical impulse is still produced, lengthening the PR interval

- **Second Degree Heart Block**
  - Affects how many impulses actually reach the ventricles, leading to an irregular heart rate

- **Third Degree Heart Block (Complete Block)**
  - Electrical impulses that are initiated in atria never reach ventricles
  - P Waves are not related to QRS complex

- **SVT**
  - Occurs above AVE node \( \rightarrow \) increased heart rate
Pathophysiology—Heart Block

- If the AV node signals are not reaching the ventricles, back up pacemakers in the ventricles begin to compensate. The pace of ventricular pumping is not nearly what it is when the AV node is conducting impulses.
- Decreased ventricular work decreases blood pumped systemically.
- Decreased blood pumped means decreased perfusion to other vital organs and peripheral limbs.
Pathophysiology—SVT

- Originates above Atrioventricular Node (Does not originate within ventricles), Narrow QRS complexes
- Leads to rapid heart rate
- Can deteriorate to ventricular fibrillation leading to death
Treatment—SVT & Heart Block

- Observation – 1° & 3° Heart Block
  - Appears to be self limiting, resulting from Sepsis

- Amiodarone - SVT
  - Antidysrhythmic: Prolongs action potential and repolarization

- Adenosine – SVT
  - Antidysrhythmics: Slows conduction through AV node and interrupts AV reentry, restoring NSR
Role of the Myocardium

• Middle Layer of the Heart Muscle
  • Consists of Cardiac Muscle

• Sepsis Effects on Myocardium
  • Weakens Cardiac Muscle Cells → Decreased CO → Decreased Perfusion to Vital Organs → Multiple Organ Failure
Pathophysiology—Fluid Shift

- Vasodilation due to release of inflammatory chemicals
- Increased capillary permeability
- Edema from fluid entering interstitial tissues
- Hypotension
- Shock
- Coagulopathy
- Decreased perfusion of coronary muscle
- Decreased cardiac output
- Decreased perfusion of other organs
- Pt. will die if left untreated
Cardiogenic Shock

• Heart is incapable of pumping enough blood to meet body requirements
  • CO usually 10 to 20%
• Low Blood Pressure
• Hypoxia
• Rapid Treatment can save the patient
  • Oxygen Supplement
  • Fluid Replacement Therapy
  • Pharmacological Interventions – Dopamine, Norepinephrine, Epinephrine
Septic Shock & Cardiac Function

- About 80% of Cardiac output goes to kidneys, GI tract, skeletal muscle, heart, and the brain.

- Cytokines released into the bloodstream begin the Inflammatory Response and release of Nitrous Oxide
  - Depress cardiac contractility

- Vasodilation caused by Adenosine, Lactic Acid, and H+.

- Altered autoregulation and coronary endothelial function
  - Prostanoids (Cyclooxygenase)
Synopsis of Potential Underlying Mechanisms in Septic Myocardial Infarction

- Cytokine release
- Activation of coagulation system
- Impaired oxygen utilisation
- In CAD-patients: regional ischemia
- Endothelial activation
- Myocardial dysfunction in sepsis
- High NO concentrations
- MDS
- Monocyte activation
- Prostanoids
- Impaired coronary (micro)circulation
- Endothelin upregulation
### Assessment Findings & Labs

<table>
<thead>
<tr>
<th>Lab Result</th>
<th>Admission</th>
<th>Sepsis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lactic</td>
<td>1.3</td>
<td>2.0</td>
</tr>
<tr>
<td>WBC</td>
<td>10.8</td>
<td>14.3</td>
</tr>
<tr>
<td>Hgb</td>
<td>14.4</td>
<td>8.3</td>
</tr>
<tr>
<td>Hct</td>
<td>43.1</td>
<td>24.9</td>
</tr>
<tr>
<td>Na</td>
<td>138</td>
<td>141</td>
</tr>
<tr>
<td>K</td>
<td>5.0</td>
<td>3.4</td>
</tr>
<tr>
<td>Ca</td>
<td>7.1</td>
<td>N/A</td>
</tr>
<tr>
<td>CK-MB</td>
<td>4.9</td>
<td>17</td>
</tr>
<tr>
<td>Troponin</td>
<td>0.024</td>
<td>0.084</td>
</tr>
<tr>
<td>Albumin</td>
<td>N/A</td>
<td>2.0</td>
</tr>
<tr>
<td>Platelets</td>
<td>147</td>
<td>181</td>
</tr>
<tr>
<td>PT</td>
<td>11.3</td>
<td>23</td>
</tr>
<tr>
<td>PTT</td>
<td>28.6</td>
<td>32.5</td>
</tr>
<tr>
<td>INR</td>
<td>1.1</td>
<td>2.1</td>
</tr>
</tbody>
</table>

- Pt’s cardiac output remained close to 74%
- Overall results:
  - Increased Hgb and Hct
  - WBC trending high
  - No ischemia present
  - Troponins and CK-MB increased
Treatment Procedures

Emergency Department
(Phase I: 1st 6 hours)

1. Labs/Tests
2. Antibiotics
3. Initial Fluid Bolus NS
4. MAP
5. Fluid Replacement
6. Norepinephrine
7. NPO and/or Foley Catheter
8. Admit to telemetry floor or ICU

ICU (Phase II: Severe Sepsis)

1. Inpatient admission to ICU
2. Continue Phase I
3. Antibiotics
4. Fluid replacement with central line
5. Vasopressors
6. Low dose steroids
7. Glucose control
8. Transfusion
9. Sodium bicarb and calcium chloride
## Medications

<table>
<thead>
<tr>
<th>Medication</th>
<th>Indication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lotensin (Benazapril)</td>
<td>Ace inhibitor for HTN</td>
</tr>
<tr>
<td>Metoprolol Tartrate (Lopressor)</td>
<td>Beta blocker for HTN *Pt has history of AV block</td>
</tr>
<tr>
<td>Amlodipine Besylate (Norvasc)</td>
<td>Calcium channel blocker for HTN</td>
</tr>
<tr>
<td>Adenosine (Adenocard)</td>
<td>Endogenous nucleoside for treatment of SVTs</td>
</tr>
<tr>
<td>Vancomycin HCl</td>
<td>Antibiotic to treat abdominal infections</td>
</tr>
<tr>
<td>Micafungin Sodium</td>
<td>Antifungal antibiotic to treat Candida fungal infections</td>
</tr>
<tr>
<td>Imipenem/Cilastatin Sodium</td>
<td>Antibiotics for severe infections</td>
</tr>
</tbody>
</table>
Family Education

• Watch for Signs of Sepsis Return – Racing heart feeling (Tachycardia), Respiration rate >20 breaths per minute (Tachypnea), Fever - > 100.1°

• Healthy Eating Habits

• Exercise – 30 minutes 3-5 days per week to help strengthen heart

• Drink plenty fluids to avoid dehydration
References


PULMONARY CIRCULATION
Pathophysiology

Pulmonary veins and arteries

- trachea
- arch of aorta
- left main bronchus
- left pulmonary artery
- left superior lobar bronchus
- left superior pulmonary vein
- left inferior lobar bronchus
- left inferior pulmonary vein
- pulmonary trunk
- left ventricle
- ascending aorta
- right ventricle

- right main bronchus
- right superior lobar bronchus
- right pulmonary artery
- right superior pulmonary vein
- middle lobar bronchus
- right inferior pulmonary vein
- right inferior lobar bronchus
- superior vena cava
- right atrium
- inferior vena cava
- aorta
Pulmonary Circulation
Pulmonary Circulation

V = Ventilation
Q = Perfusion
<table>
<thead>
<tr>
<th>Acute Respiratory Distress Syndrome (ARDS)</th>
<th>Acute Lung Injury (ALI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• PaO2/FiO2= &lt;200</td>
<td>PaO2/FiO2= 200-300</td>
</tr>
</tbody>
</table>

**69/.30=230**

1. Injury/Exudative Phase (1-7 days)
2. Reparative/Proliferative Phase (1-2 weeks)
3. Fibrotic/Chronic/Latent Phase (2-3 weeks)
SIRS → ARDS & ALI

Injury to alveolar-capillary membrane

- Damaged type II alveolar cell
  - ↓ Surfactant production
  - ↓ Alveolar compliance and recoil
    - Atelectasis
  - Hyaline membrane formation
    - ↓ Lung compliance
    - Impairment in gas exchange

- Release of inflammatory mediators
  - ↑ Alveolar-capillary membrane permeability
    - Outward migration of blood cells and fluids from capillaries
      - Pulmonary edema

- Vascular narrowing and obstruction

ALI/ARDS

- Pulmonary hypertension
Assessment

ARDS & ALI

- Labs
- Diagnostics
- Physical assessment

The Patient (ALI)

- Labs: WBC, Hgb, Hct
- Diagnostics: pH, PaCO$_2$, PaO$_2$
- Physical assessment
  - WOB
  - Breath sounds
  - Edema
Treatment

ARDS & ALI
- Complication prevention
- Respiratory therapy
- Supportive therapy

Evidence-Based Practice
- 5 P’s of ARDS therapy
  - Perfusion
  - Positioning
  - Protective lung ventilation
  - Protocol weaning
  - Preventing complications

The Patient (ALI)
- Normal saline, hemodynamic monitoring
- HOB up
- PEEP, low FiO₂
- Attempts to wean
- VTE prophylaxis, TPN, analgesics, PUD prophylaxis

Family Education

• Explanation of necessity of ventilator

• What to expect

• Weaning
Renal System

KIDNEYS

- Bowman’s capsule
- Glomerulus
- Arteriole from renal artery
- Arteriole from glomerulus
- Branch of renal vein
- From another nephron
- Collecting duct
- Loop of Henle with capillary network
- Proximal tubule
- Distal tubule
Renal Functions

- Regulation of body fluid volume and osmolality
- Regulation of electrolyte balance
- Regulation of acid-base balance
- Excretion of waste products (urea, ammonia, drugs, toxins)
- Production and secretion of hormones (erythropoietin, renin, calcitriol)
- Regulation of blood pressure (renin)
Functional Unit of the Kidney—The Nephron

• Glomerular (filtration)

• Proximal (reabsorption)

• Loop of Henle (concentration)

• Distal (reabsorption/secretion)

• Collecting Duct (reabsorption/secretion)
Pathophysiology of Acute Renal Failure Due to Septic/Cardiogenic Shock (SIRS)

- Ischemic injury (Hypoperfusion)
- Direct inflammatory injury (Interleukins, TNF alpha, Interferons)
- Coagulation and endothelial cell dysfunction (Endothelin-vasoconstrictor causes Dysfunction of the coagulation and fibrinolytic cascades contributes to intraglomerular thrombosis)
- Apoptosis (TNF- extrinsic apoptosis)
Types of Shock

• **Cardiogenic shock:** Occurs when either systolic or diastolic dysfunction of the pumping action of the heart results in reduced cardiac output (CO).

• **Clinical manifestations**
  - Increased Na and H$_2$O retention
  - Decreased renal blood flow
  - Decreased urinary output
Types of Shock

- **Hypovolemic shock**: occurs when there is a loss of intravascular fluid volume

- **Clinical manifestations**
  - Decreased urinary output

- **Septic shock**: The presence of sepsis with hypotension despite fluid resuscitation along with the presence of inadequate tissue perfusion.

- Main organisms that cause sepsis are gram-negative and gram-positive bacteria.
# Case Study—Data to Support ARF Due to Dehydration

<table>
<thead>
<tr>
<th>Date</th>
<th>Creatinine</th>
<th>BUN</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/07/13</td>
<td>1.36</td>
<td>23</td>
</tr>
<tr>
<td>11/08/13</td>
<td>2.54</td>
<td>42</td>
</tr>
<tr>
<td>11/13/15</td>
<td>1.36</td>
<td>35</td>
</tr>
<tr>
<td>11/15/13</td>
<td>1.54</td>
<td>55</td>
</tr>
<tr>
<td>11/16/13</td>
<td>1.66</td>
<td>58</td>
</tr>
<tr>
<td>11/17/13</td>
<td>1.64</td>
<td>46</td>
</tr>
</tbody>
</table>

- Increased Creatinine & BUN
- Nausea & Vomiting
- Dehydration
- 11/08/13 Colectomy
Case Study—Data to Support ARF Due to Sepsis

<table>
<thead>
<tr>
<th>Date</th>
<th>Cratinine</th>
<th>BUN</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/17/13</td>
<td>1.94</td>
<td>52</td>
</tr>
<tr>
<td>11/18/13</td>
<td>1.67</td>
<td>47</td>
</tr>
<tr>
<td>11/19/13</td>
<td>1.71</td>
<td>40</td>
</tr>
<tr>
<td>11/20/13</td>
<td>1.78</td>
<td>39</td>
</tr>
</tbody>
</table>

- Increased HR
- SOB
- Septic looking
Treatment

- Fluid replacement therapy
- Sympathomimetic drugs (Norepinephrine, dopamine, phenylephrine)
- Antibiotics
- Nutritional therapy
Family Education

• Monitor daily weight

• Fluid restriction

• Diet

• Limit sodium and potassium

• Assist with position change every 2 hours

• Identify symptoms to be reported.

CEREBRAL CIRCULATION
100,000 Miles of Blood Vessels
100 Billion Neurons

- Each neuron has 1,000-10,000 synapses
- 1 quadrillion synapses
Cerebral Perfusion

- 17% of cardiac output
- 750 milliliters per minute
- 20% of oxygen
- 25% of glucose
Our Patient: Cerebral Perfusion

- Unresponsive
- Recent encephalopathy
- Babinski’s reflex
- Infection
- Peripheral edema
- Heart block
- GI bleeding
- V/P mismatch
- Cardiac output ↓
- Hypovolemia
- Renal failure
- Respiratory failure
- Anemia
- Glucose
- Inadequate nutrition
- Electrolyte imbalances
Autoregulation

Ability to maintain relatively constant blood flow despite changes in perfusion pressure

<table>
<thead>
<tr>
<th>Blood flow</th>
<th>$\uparrow$ O$_2$ extraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO$_2$</td>
<td>$\Rightarrow$ vasodilation $\Rightarrow$ $\uparrow$ blood flow</td>
</tr>
<tr>
<td>CO$_2$</td>
<td>$\Rightarrow$ vasoconstriction $\Rightarrow$ $\downarrow$ blood flow</td>
</tr>
</tbody>
</table>

Normal CPP = 70 - 90 mmHg

< 70 mmHg = ischemia
The Brain & Sepsis

Sepsis

Blood-Brain Barrier Alterations

Circulatory Failure
↓ cerebral blood flow

Metabolic Disturbances
Glucose, electrolytes, acid base

Acute Brain Dysfunction

Environmental Stressors

Medication Toxicity
Sepsis Associated Encephalopathy (SAE)

- Diffuse cerebral dysfunction caused by systemic inflammatory response to an infection

Sepsis Associated Encephalopathy is the most frequent cause of delirium in critical illness

Up to 70% of patients with severe systemic infection


Overlooked as “just ICU delirium”
- Fluctuating mental status changes
- Inattention
- Disorganized thinking
- LOC, neuro changes

Source: Annals of Intensive Care 2013, 3:15
More About Encephalopathy

- Definition: Worsening of brain function

- Possible causes in this patient:
  - Bacterial infection
  - Hypertension
  - Chronic inflammation — cancer, chemo, infx, trauma
  - Metabolic dysfunction - hyperkalemia, hyperchloremia, hypocalcemia
  - Poor nutrition - TPN
  - Lack of blood flow to brain — low CO, heart block, ventilation
  - Renal failure — build up of toxins
  - GI Bleeding
  - Toxicity — build up of ammonia & other toxins, medication toxicity
    - Primaxin (imipenem and cilistatin) - carbapenem antibiotic
      - Neurotoxicity associated with encephalopathy
      - Increased risk with renal failure
Long-term Cognitive Impairment & Sepsis

- Substantial and persistent new cognitive impairment in older adults
- Functional disability
- Downturn in patients’ ability to live independently

Source: JAMA. 2010;304(16):1787-1794
Treatment

• Treat the source
  • Surgery
  • Antibiotics
  • Electrolyte replacement
  • Fluid replacement
  • Glucose
  • Insulin
  • Control hypertension

• Monitor labs
  • ABGs
  • Liver function
  • Kidney function
  • Med toxicity—serum levels
  • CBC
  • Electrolytes
Evidence-Based Treatment Considerations

- Thiamine Supplements
  - Thiamine depletion common in critical illness
  - 50% increase in mortality
  - Severe neurologic disorders such as encephalopathy
  - Should be suspected in severe sepsis, lactic acidosis


- Valproic Acid – new research
  - Reverses cognitive deficits
    - probably via a reduction in inflammation and apoptosis in the brain
  - More studies needed to refine science

What if...?

- Patient’s cardiac output goes way up

<table>
<thead>
<tr>
<th>Condition</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shock</td>
<td>↑ vascular permeability</td>
</tr>
<tr>
<td>Heparin</td>
<td>↑ clotting time</td>
</tr>
<tr>
<td>Hyperlipidemia</td>
<td>↑ atherosclerotic plaque</td>
</tr>
<tr>
<td>Inflammation</td>
<td>↑ vascular vulnerability</td>
</tr>
</tbody>
</table>

Hemorrhagic or Ischemic Stroke
Family Education

• Educate regarding care of other organ systems
  • Nutrition
  • Hydration
  • Exercise
  • Medication
  • Specific therapies and treatments

• Teach signs & symptoms of brain dysfunction
  • Headaches
  • Seizures
  • Confusion
  • Memory problems
  • Behavioral/mood changes
  • Nausea
  • LOC
END-OF-LIFE CARE
Palliative Care vs. Comfort Care

• Palliative Care
  • Patient can still be receiving curative treatment
  • Diagnosis does not need to be terminal

• Comfort Care
  • Curative treatment is withdrawn
  • Terminal diagnosis with typically 6 month life expectancy
Ethical Dilemmas

• Life Supportive Care

  • Machines and Pharmaceuticals: How long is too long?
    • What is occurring in Oakland - Full story, Media, Future

• Pain Medication: Passive Euthanasia?
Ethical Dilemmas Continued

• Right to Die
  • Terminal Diagnosis—Should people be allowed to choose death with dignity?

• Donor Network
  • Keeping people artificially alive until organs can be harvested
SUMMARY
Patient Summary—Important Events

• **11/07/13**: 88-year-old male presents to ED with complaints of abd pain, N/V, small BM
  • Diagnosed with adenocarcinoma
  • Colectomy, exploratory laparotomy, removed mass

• **11/09/13**: SVT x 2 → treated with Adenosine and amiodarone

• **11/17/13**: Anastomtic leak
  • Sepsis
  • Respiratory Failure → ventilation
Patient Summary—Important Events

• **11/22/13**: Pleural effusion
  • Fluid overload → acute kidney failure

• **11/26/13**: Myocardial infarction, code blue → pt recovered

• **12/18/13**: Discharged to ECF

• **01/06/14**: Appointment with PCP → brought back to ER

• Last H/P: R/O sepsis; remains full code
### Definitions

<table>
<thead>
<tr>
<th>Condition</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systemic inflammatory response syndrome (SIRS)</td>
<td>A systemic inflammatory response to a variety of insults (including infection, ischemia, infarct, and injury)</td>
</tr>
<tr>
<td>Sepsis</td>
<td>A systemic inflammatory response to infection</td>
</tr>
<tr>
<td>Severe sepsis</td>
<td>Sepsis + organ dysfunction</td>
</tr>
<tr>
<td>Multiple organ dysfunction syndrome (MODS)</td>
<td>Failure of more than one organ system</td>
</tr>
</tbody>
</table>
**PATHOPHYSIOLOGY MAP**

- **Invading microorganisms**
  - Release of proinflammatory cytokines
    - Tumor necrosis factor (TNF)
    - Interleukin-1 (IL-1)
    - Other proinflammatory cytokines
  - Endothelial damage
  - Activation of CNS and endocrine systems
- **Myocardial depression**
- **Peripheral vasodilation**
- **↑ Capillary membrane permeability**
- **Microemboli**
- **Maldistribution of circulating blood volume**
  - ↓ Cellular oxygen supply
  - ↓ Tissue perfusion
  - Impaired cellular metabolism
- **↑ Cellular oxygen demand**
- **Hypermetabolic state**
- **Selective vasoconstriction**
SIRS → MODS

• Due to uncontrolled inflammatory response
  • Mediators released
  • Endothelium damage
  • Hypermetabolism

• Vasodilation

• Vascular permeability ↑

• Coagulation cascade activated

• Decreased organ blood perfusion
  • hypotension + microemboli + redistributed blood flow
MODS: Respiratory System

- Inflammation
- Endothelial damage
- Increased permeability
- Alveolar edema
MODS: Cardiovascular System

- Vasodilation
- Increased capillary permeability
- Third spacing
- Hypotension + decreased SVR
- Decreased venous return
- Increased CO
MODS: Neurological System

- Hypoxemia
- Inflammatory mediators
- Impaired perfusion

Mental status changes
MODS: Renal System

Acute kidney injury

Decreased perfusion

Inflammatory mediators

Medications
MODS: Gastrointestinal System

- Blood shunted from GI
- Increased risk for ischemic injury
- Decreased perfusion
- Decreased mucosal barrier
- Increased risk for ulcer and GI bleed
End-of-life Care

- Palliative care

- Comfort care

- Life support
  - Example: Jahi McMath
    - 13 year old girl pronounced brain-dead in Children’s Hospital Oakland

- Right to die

- Donor network