SHOCK AND SEPSIS

Sam Lai, MD
July 2016

“Adapted” from:
Dr. Payam Parvinchiha
Dr. William Graham
Objectives

- Understand, broadly, the causes of shock
- Create a quick, understandable framework for shock
- Define sepsis
- Assess the septic patient
- Initiate early sepsis treatment
- Discuss recent changes in sepsis research and guidelines
Definition of Shock

Cellular and tissue *hypoxia*
secondary to
Reduced *oxygen* delivery
and/or
Increased *oxygen* consumption
or
Inadequate *oxygen* utilization
# Types of Shock

<table>
<thead>
<tr>
<th>Category</th>
<th>Etiology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distributive</td>
<td>Septic</td>
</tr>
<tr>
<td></td>
<td>Non Septic</td>
</tr>
<tr>
<td>Cardiogenic</td>
<td>Cardiomyopathic</td>
</tr>
<tr>
<td></td>
<td>Arrhythmogenic</td>
</tr>
<tr>
<td></td>
<td>Mechanical</td>
</tr>
<tr>
<td>Hypovolemic</td>
<td>Hemorrhagic</td>
</tr>
<tr>
<td></td>
<td>Non-Hemorrhagic</td>
</tr>
<tr>
<td>Obstructive</td>
<td>Pulmonary Vascular</td>
</tr>
<tr>
<td></td>
<td>Mechanical</td>
</tr>
</tbody>
</table>
# Types of Shock

<table>
<thead>
<tr>
<th>Etiology</th>
<th>Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non Septic</td>
<td>Neurogenic Shock (spinal cord)</td>
</tr>
<tr>
<td></td>
<td>Anaphylactic Shock</td>
</tr>
<tr>
<td></td>
<td>Drugs/Toxins (Narcotic Overdose)</td>
</tr>
<tr>
<td></td>
<td>Endocrine (Adrenal crisis)</td>
</tr>
</tbody>
</table>
### Types of Shock

<table>
<thead>
<tr>
<th>Category</th>
<th>Etiology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distributive</td>
<td></td>
</tr>
<tr>
<td>Septic</td>
<td></td>
</tr>
<tr>
<td>Non Septic</td>
<td></td>
</tr>
<tr>
<td>Cardiogenic</td>
<td></td>
</tr>
<tr>
<td>Cardiomyopathic</td>
<td></td>
</tr>
<tr>
<td>Arrhythmogenic</td>
<td></td>
</tr>
<tr>
<td>Mechanical</td>
<td></td>
</tr>
<tr>
<td>Hypovolemic</td>
<td></td>
</tr>
<tr>
<td>Hemorrhagic</td>
<td></td>
</tr>
<tr>
<td>Non-Hemorrhagic</td>
<td></td>
</tr>
<tr>
<td>Obstructive</td>
<td></td>
</tr>
<tr>
<td>Pulmonary Vascular</td>
<td></td>
</tr>
<tr>
<td>Mechanical</td>
<td></td>
</tr>
</tbody>
</table>
# Types of Shock

<table>
<thead>
<tr>
<th>Etiology</th>
<th>Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiomyopathic</td>
<td>Post MI</td>
</tr>
<tr>
<td></td>
<td>Severe Heart Failure</td>
</tr>
<tr>
<td></td>
<td>Myocarditis</td>
</tr>
</tbody>
</table>
# Types of Shock

<table>
<thead>
<tr>
<th>Category</th>
<th>Etiology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distributive</td>
<td>Septic</td>
</tr>
<tr>
<td></td>
<td>Non Septic</td>
</tr>
<tr>
<td>Cardiogenic</td>
<td>Cardiomyopathic</td>
</tr>
<tr>
<td></td>
<td>Arrhythmogenic</td>
</tr>
<tr>
<td></td>
<td>Mechanical</td>
</tr>
<tr>
<td>Hypovolemic</td>
<td>Hemorrhagic</td>
</tr>
<tr>
<td></td>
<td>Non-Hemorrhagic</td>
</tr>
<tr>
<td>Obstructive</td>
<td>Pulmonary Vascular</td>
</tr>
<tr>
<td></td>
<td>Mechanical</td>
</tr>
</tbody>
</table>
# Types of Shock

<table>
<thead>
<tr>
<th>Etiology</th>
<th>Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulmonary Vascular</td>
<td>Severe Pulmonary HTN</td>
</tr>
<tr>
<td></td>
<td>Severe Pulmonary Embolism</td>
</tr>
</tbody>
</table>
Objectives

■ Understand the broad causes of shock
■ Create a quick, understandable framework for shock
■ Define sepsis
■ Assess the septic patient
■ Initiate early sepsis treatment
■ Discuss recent changes in sepsis research and guidelines
BP Hemodynamics

MAP = CO x SVR

■ MAP = 1/3 SBP + 2/3 DBP

■ MAP goal is to maintain organ perfusion
# Types of Shock

<table>
<thead>
<tr>
<th>Category</th>
<th>Physiology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distributive</td>
<td>↓ SVR</td>
</tr>
<tr>
<td>Cardiogenic</td>
<td>↓ CO</td>
</tr>
<tr>
<td>Hypovolemic</td>
<td>↓ Venous Return → ↓ CO</td>
</tr>
<tr>
<td>Obstructive</td>
<td>Obstructed outflow → ↓ CO</td>
</tr>
</tbody>
</table>
Approach to Shock

MAP = CO x SVR

CO = HEART RATE x SV

- Is Heart Rate the problem?
  - Bradyarrhythmia?
  - Tachyarrhythmia?
Approach to Shock

MAP = CO \times SVR

CO = HR \times \text{Stroke Volume}

- Is decreased filling the problem?
  - Hypovolemia from trauma?
  - Hypovolemia from hemorrhage?

- Is there an extra-cardiac obstruction?
  - Cardiac Tamponade
  - Constrictive Pericarditis
  - Severe PE
Approach to Shock

\[ \text{MAP} = \text{CO} \times \text{SVR} \]

\[ \text{CO} = \text{HR} \times \text{Stroke Volume} \]

- Is your pump not squeezing well?
  - MI
  - Severe Heart Failure
Approach to Shock

\[
\text{MAP} = \text{CO} \times \text{SVR}
\]

- Are the blood vessels abnormally dilated?
  - *Is there sepsis?*
  - *Anaphylaxis?*
  - *Drug reaction?*
  - *Neurogenic causes?*
Clinical Case

Imagine: It’s your first day on wards, you get the following page:

“Hey Doc, there’s a new patient in S8 Bed 30. He needs a diet order. Just FYI, HR 120, BP 80/40, patient sleeping, thanks”

- When are you going to see the patient?
- What questions do you want to ask?
- What are some orders to consider?
Questions to Ask

- Is there end-organ damage (is he symptomatic?)
  - AMS, Chest pain, decreased UOP, SOB

- Trend of Vital Signs and Telemetry
  - Arrhythmias?

- Recent laboratory work
  - Bandemia?

- What medications are they on?
  - Sedatives?

- Recent procedures?
  - PE, hemorrhage

- Why are they in the hospital?
  - Past Medical History including steroid usage
What could you order?

- CBC
- Lactate, Troponin
- Cultures
- ABG/EKG/CXR
- Cortisol level/ACTH stim test
- IVF/Blood Transfusions
- Bedside IVC check
Clinical Case

At the patient’s bedside

- The patient is 90 y/o male, hx of dementia, lethargic, minimally arousable, and mumbling incoherently. Also doesn’t speak English.
- There is no family at bedside.
Clinical Case
Clinical Case

- Patient transferred earlier today for confusion
- Vitals: 39°C, HR 130, RR 22, BP 80/40, 98% RA

At this point, what do you do?

Call Rapid Response
The Hypotensive Patient

- **GENERAL**
  - What are some signs of end-organ damage when walking into the room?
    - Altered Mental Status!

- **HEENT**
  - What might you see here that signifies hypovolemia?
    - Dry mucous membranes

- **Cardiovascular**
  - What signs would make you think tamponade?
  - What about severe constrictive pericarditis?
  - Are there any arrhythmias?

MAP = CO x SVR
The Hypotensive Patient

- **Lungs**
  - *What could you see here that helps determine PNTX?*
    - U/S findings = loss of sliding/barcode sign

- **Abdomen:**
  - *Rigid abdomen and decreased UOP?*
    - Remember to check the back, palpate the spine and CVA tenderness

- **Extremities/Skin:**
  - *Cap refill, cyanosis*
  - *Look for open sores/lesions/rashes*

\[ MAP = CO \times SVR \]
Clinical Case

- Confused
- Dry mucous membranes
- Symmetric, CTAB
- S1/S2 regular, tachycardic
- Cool extremities
- Abd Soft, mildly distended, nontender, few bowel sounds
- CVA tenderness on right

LABS:
- UA: 200 WBC and few bacteria
- Urine output 10cc/hr
- WBC 25,000
Objectives

- Understand the broad causes of shock
- Create a quick, understandable framework for shock
- Define sepsis
- Assess the septic patient
- Initiate early sepsis treatment
- Discuss recent changes in sepsis research and guidelines
What is Sepsis?

“The clinical syndrome defined by the presence of both infection and a systemic inflammatory response.” – SCCM 2001
What is Sepsis?

“What life-threatening organ dysfunction caused by a dysregulated host response to infection” – Sepsis 3, 2016
Objectives

■ Understand the broad causes of shock
■ Create a quick, understandable framework for shock
■ Define sepsis
■ Assess the septic patient
■ Initiate early sepsis treatment
■ Discuss recent changes in sepsis research and guidelines
Assessing the Septic Patient

■ **SIRS?**
  - $HR > 90$
  - $RR > 20$ or $PaCO_2 < 32$ mm Hg
  - $WBC > 12$, $<4$ or $bands > 10%$
  - $Temperature > 38.0$ or $< 36.0$

■ **SEPSIS:** SIRS + proven or suspected microbial etiology

■ **SEVERE SEPSIS:** Sepsis + evidence of sepsis-induced tissue hypoperfusion or organ dysfunction

■ **SEPTIC SHOCK:** Sepsis with hypotension refractory to adequate fluid resuscitation, or vasopressors needed to maintain SBP $>90$ or MAP $>65$
What is Severe Sepsis?

- Urine output < 0.5 cc/kg/hr for > 2 hrs
- Cr > 2.0 mg/dL
- Bilirubin > 2.0 mg/dL
- Lactic Acid > 2
- Altered mental status
- Sepsis-Induced hypotension (< 90/60)
- Platelet count < 100,000
- INR > 1.5
Assessing the Septic Patient

- **SIRS?**
  - HR > 90
  - RR > 20 or PaCO2 < 32 mm Hg
  - WBC > 12, <4 or bands > 10%
  - Temperature > 38.0 or < 36.0

- **SEPSIS:** SIRS + proven or suspected microbial etiology

- **SEVERE SEPSIS:** Sepsis + evidence of sepsis-induced tissue hypoperfusion or organ dysfunction

- **SEPTIC SHOCK:** Sepsis + sepsis refractory to adequate fluid resuscitation, or vasopressors needed to maintain SBP >90 or MAP >65
Assessing the Septic Patient

- **SIRS?**
  - HR > 90
  - RR > 20 or PaCO₂ < 32 mm Hg
  - WBC > 12, < 4 or bands > 10%
  - Temperature > 38.0 or < 36.0

- **SEPSIS:** SIRS + proven or suspected microbial etiology

- **SEVERE SEPSIS:** Sepsis + evidence of sepsis-induced tissue hypoperfusion or organ dysfunction

- **SEPTIC SHOCK:** Sepsis with hypotension refractory to adequate fluid resuscitation, or vasopressors needed to maintain SBP > 90 or MAP > 65
Assessing the Septic Patient

- **Sepsis**
  - SOFA score = 2 or increased by 2 from baseline

- **Septic Shock**
  - Persisting hypotension
  - Requiring vasopressors to keep MAP > 65
  - Lactic Acid > 2 mmol/L even with adequate volume resuscitation
Assessing the Septic Patient

Table 1. Sequential [Sepsis-Related] Organ Failure Assessment Score

<table>
<thead>
<tr>
<th>System</th>
<th>Score</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Respiration</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Pao₂/Fio₂, mm Hg (kPa)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coagulation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Platelets, ×10³/μL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liver</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bilirubin, mg/dL (μmol/L)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiovascular</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Central nervous system</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glasgow Coma Scale score c</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Renal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Creatinine, mg/dL (μmol/L)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urine output, mL/d</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: Fio₂, fraction of inspired oxygen; MAP, mean arterial pressure; Pao₂, partial pressure of oxygen.

a Adapted from Vincent et al. ²⁷

b Catecholamine doses are given as μg/kg/min for at least 1 hour.

c Glasgow Coma Scale scores range from 3-15; higher score indicates better neurological function.
Assessing the Septic Patient

<table>
<thead>
<tr>
<th>System</th>
<th>Score</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>≥400 (53.3)</td>
<td>&lt;400 (53.3)</td>
<td>&lt;300 (40)</td>
<td>&lt;200 (26.7) with respiratory support</td>
<td>&lt;100 (13.3) with respiratory support</td>
</tr>
<tr>
<td>Respiration</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pao2/Fio2, mm Hg (kPa)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coagulation</td>
<td></td>
<td>≥150</td>
<td>&lt;150</td>
<td>&lt;100</td>
<td>&lt;50</td>
<td>&lt;20</td>
</tr>
<tr>
<td>Platelets, ×10^3/μL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liver</td>
<td></td>
<td>&lt;1.2 (20)</td>
<td>1.2-1.9 (20-32)</td>
<td>2.0-5.9 (33-101)</td>
<td>6.0-11.9 (102-204)</td>
<td>&gt;12.0 (204)</td>
</tr>
<tr>
<td>Bilirubin, mg/dL (μmol/L)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiovascular</td>
<td></td>
<td>MAP ≥70 mm Hg</td>
<td>MAP &lt;70 mm Hg</td>
<td>Dopamine &lt;5 or dobutamine (any dose)</td>
<td>Dopamine 5.1-15 or epinephrine ≤0.1 or norepinephrine ≤0.1</td>
<td>Dopamine &gt;15 or epinephrine &gt;0.1 or norepinephrine &gt;0.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Central nervous system</td>
<td></td>
<td>15</td>
<td>13-14</td>
<td>10-12</td>
<td>6-9</td>
<td>&lt;6</td>
</tr>
<tr>
<td>Glasgow Coma Scale score</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Renal</td>
<td></td>
<td>&lt;1.2 (110)</td>
<td>1.2-1.9 (110-170)</td>
<td>2.0-3.4 (171-299)</td>
<td>3.5-4.9 (300-440)</td>
<td>&gt;5.0 (440)</td>
</tr>
<tr>
<td>Creatinine, mg/dL (μmol/L)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urine output, mL/d</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;500</td>
<td>&lt;200</td>
</tr>
</tbody>
</table>

Abbreviations: Fio2, fraction of inspired oxygen; MAP, mean arterial pressure; Pao2, partial pressure of oxygen.

a Adapted from Vincent et al.27

b Catecholamine doses are given as μg/kg/min for at least 1 hour.

c Glasgow Coma Scale scores range from 3-15; higher score indicates better neurological function.
Assessing the Septic Patient

- Wait, there has to be an easier way?
- qSOFA Score
  - RR > 22
  - SBP < 100
  - Altered Mental Status
  - If 2 of the above are true, then?
    - Escalate therapy
    - Search for causes
Assessing the Septic Patient

Patient with suspected infection

qSOFA ≥2? (see A)

Yes
Assess for evidence of organ dysfunction

SOFA ≥2? (see B)

Yes
Sepsis

Despite adequate fluid resuscitation, 1. vaspressors required to maintain MAP ≥65 mm Hg AND 2. serum lactate level >2 mmol/L?

Yes
Septic shock

No

No

Sepsis still suspected?

Yes
Monitor clinical condition; reevaluate for possible sepsis if clinically indicated

No

Monitor clinical condition; reevaluate for possible sepsis if clinically indicated
Objectives

■ Understand the broad causes of shock
■ Create a quick, understandable framework for shock
■ Define sepsis
■ Assess the septic patient
■ Initiate early sepsis treatment
■ Discuss recent changes in sepsis research and guidelines
Clinical Case

- Confused
- Dry mucous membranes
- Symmetric, CTAB
- S1/S2 regular, tachycardic
- Cool extremities
- Abd Soft, mildly distended, nontender, few bowel sounds
- CVA tenderness on right

LABS:
- UA: 200 WBC and few bacteria
- Urine output 10cc/hr
- WBC 25,000
Surviving Sepsis

Within 3 Hours

1. Measure lactic acid
2. Obtain blood cultures before antibiotics
3. Start broad-spectrum antibiotics
4. Administer 30cc/kg crystalloid for low BP or lactate > 4
Surviving Sepsis

Within 6 Hours

If the patient is hypotensive after fluids or lactic > 4
1. MAP Goal > 65 with pressors/fluids

If the patient is persistently hypotensive?
1. CVP 8-12 or 12-15 in ventilated patients (fluid boluses)
2. SCVO2 > 70% (PRBC transfusion or Dobutamine)
3. UOP > 0.5 mL/kg/hr
Within 6 Hours

- Keep SpO2 at least 93%
- Insert central line and arterial line. Monitor ScvO2 continuously
- CVP at least 8? (No)
- 500ml fluid boluses every 30 min until CVP at least 8
Within 6 Hours

- Keep SpO2 at least 93%
- Insert central line and arterial line. Monitor ScvO2 continuously
- CVP at least 8?
  - Yes
    - SBP >90? MAP >65?
      - Yes: 500ml fluid boluses every 30 min until CVP at least 8
      - No: Vasopressors
    - No: 500ml fluid boluses every 30 min until CVP at least 8
Within 6 Hours

- Keep SpO2 at least 93%
- Insert central line and arterial line. Monitor ScvO2 continuously
- CVP at least 8?
  - No: 500ml fluid boluses every 30 min until CVP at least 8
  - Yes: SBP >90? MAP >65?
    - No: Vasopressors
    - Yes: ScvO2 at least 70%?
      - Yes: Hb <10? Then give red cells
      - No: Hb >10? Then give dobutamine
      - Consider sedation, paralysis, intubation, ventilation
Surviving Sepsis

Vasopressor Choice

1. Levophed
2. Epinephrine
3. Vasopressin
4. Dopamine
5. Phenylephrine
Surviving Sepsis

Steroids

1. Use if patient is not responding to fluids and vasopressors
2. You do not need to do a ACTH stimulation test
3. Start Hydrocortisone 50 mg IV q6h
EGDT?

Is EGDT the best method?

ProCESS Trial- NEJM 2014- US
ARISE Trial- NEJM 2014- Australia
ProMISe Trial- NEJM 2015- UK

The above trials showed no difference in mortality within 90 days with EGDT compared to standard care.
Surviving Sepsis

Within 6 Hours

If the patient is hypotensive after fluids or lactic > 4

1. MAP Goal > 65 with pressors/fluids

If the patient is persistently hypotensive?

1. CVP 8-12 or 12-15 in ventilated patients (fluid boluses)
2. SCVO2 > 70% (PRBC transfusion or Dobutamine)
3. UOP > 0.5 mL/kg/hr
Surviving Sepsis

Within 6 Hours

If the patient is persistently hypotensive?

EITHER

Repeat focused exam (after initial fluid resuscitation) by licensed independent practitioner including vital signs, cardiopulmonary, capillary refill, pulse, and skin findings.

OR TWO OF THE FOLLOWING

Measure CVP

Measure ScvO2

Bedside cardiovascular ultrasound

Dynamic assessment of fluid responsiveness with passive leg raise or fluid challenge
Clinical Case

- Confused
- Vitals: 39°C, HR 130, RR 22, BP 80/40, 98% RA

At this point, what do you do?

Rapid! → Fluids → Cultures → Abx → Pressors → ICU
Summary

- Use a systematic approach to the hypotensive patient, based on: \( \text{MAP} = \text{CO} \times \text{SVR} \)
- Shock can be Hypovolemic, Cardiogenic, Distributive, and/or Obstructive
- qSOFA = RR > 22, AMS and SBP < 100
- Stabilize the patient prior to digging in to solve the cause
- Key to managing patients with septic shock is to treat early with fluids, antibiotics, and pressors if needed
- Specific hemodynamic goals are less important than ensuring starting treatment ASAP.