Shock

William Schecter, MD
The Cell as a furnace

O₂
1 mole

Glucose

Cell

CO₂

ATP
38 moles

H₂O
Shock = Inadequate Delivery of O2 and Glucose to the Cell

\[ \text{Cell} \rightarrow \text{Lactic Acid} \]

\[ \text{ATP} \quad 2 \text{ moles} \]
Treatment of Shock

Restoration of blood blow and substrate delivery to the cell
Circulatory System

- Pump
- Pressure Gauge
- Pipe
- Fluid
Pump Problem

- Heart Failure
- Pericardial Tamponade
- Pulmonary Embolus
- Tension Pneumothorax
Case Presentation

• 46 year old woman presented to ER with abdominal pain
• After 6 hours of observation, patient has near cardiac arrest.
• Resuscitated. Profound Hypotension. Distended abdomen
• What would you do??????
Pipe Problem

- Vasodilation due to vasoactive drugs
  - Anesthetics
  - Antihypertensive drugs
- “Septic Shock”
- Neurogenic Shock
  - Spinal/Epidural Anesthesia
  - Spinal Cord Injury
Case Presentation

• 51 year old paraplegic man struck by car crossing the street in his wheel chair. Thrown 30 feet.
• Initial vital signs stable. CT of head, abdomen and chest normal. Films of Axial skeleton normal.
• Sent to ICU for observation. 2 hours later you get a call. Patient’s BP =70 and HR =120.
• What would you do????
Fluid Problem

- HEMORRHAGE!!!!
- BURN
- Pancreatitis
- Sepsis
Case Presentation

• 22 year old woman involved in a high speed roll over motor vehicle accident with an explosion resulting in a 20% burn
• Arrives in ER intubated, BP= 0, P= 130, absent breath sounds on the right.
• What would you do????
Monitoring the Shock Patient

- Continuous blood pressure monitor
- EKG
- Pulse Oximetry
- Foley Catheter
- Orthostatic Vital Signs
- CVP
Continuous Blood Pressure Monitor

http://uscneurosurgery.com/graphics/procedures/aline/procedures%20a%20line%20insertion.htm
Treatment

• Solve the underlying problem
  • Stop bleeding
  • Drain pericardium
  • Drain pus/Antibiotics
• Give Fluid/Blood
• Monitor CVP and Urine Output
Class 1 Hemorrhage

- Mental Status normal
- BP, Pulse normal
- Urine Output Normal

Loss of up to 15% of Blood Volume (<750 cc)
Class 2 Hemorrhage

- Bp may be normal
- Pulse pressure (Systolic Pressure - Diastolic Pressure) decreased
- HR increased
- Agitated
- Urine output 20-30 cc/hour

Loss or 20% of blood volume (750-1200 cc)
Class 3 Hemorrhage

- Confused
- Hypotensive
- Tachycardic
- Sweating
- Urine output less than 20cc/hour

Loss of 20-30% of blood volume (1500 cc)
Class 4 Hemorrhage

- Unconscious
- No blood pressure
- No palpable pulse
- Sweaty
- anuric

Loss of 40% of blood volume (2000 cc)
Vascular Access

- Two large bore iv catheters (14 gauge)
- Large bore (7 Fr) femoral vein catheter
Saphenous Vein Cutdown

http://www.emedicine.com/ped/topic3050.htm
Interosseous Needle

http://www.emedicine.com/ped/topic3050.htm
Central Venous Access

http://www.emedicine.com/ped/topic3050.htm
What is Resuscitation

• Organ Resuscitation
  – Heart
  – Brain
  – Kidney

• Organism Resuscitation – Restoration of Blood Flow to ALL vascular beds
  – Splanchnic bed (intestines, liver, kidney)
  – Extremities (“Dopamine Hands and Feets”)
End Points of Resuscitation

- Clinical End Points
  - Mental Status
  - Blood Pressure
  - Pulse
  - Urine Output
End Points of Resuscitation

- Advanced Physiologic End points
  - CVP
  - Pulmonary Capillary Wedge Pressure
  - Cardiac Output
  - A-VdO$_2$
  - Cerebral Perfusion Pressure (MAP-ICP)
  - Tissue O$_2$ Probes
A-$V_dO_2$

The lower the Cardiac Output the greater the $O_2$ consumption
End Points of Resuscitation

• Biochemical End Points
  – Global Biochemical End Points
    • pH
    • Lactate
    • Base Deficit
  – Splanchnic Biochemical End Points
    • Gastric Mucosal pH
    • Gastric Mucosal PCO₂
History of 20th Century Thought on the Cause of “Shock”

• George W. Crile
• Late 19th and early 20th century
• Saline infusions necessary to treat “shock”
Walter B. Cannon, PhD, MD

- Walter Cannon
- “Wound Toxin” causes shock
- Early 20th century
Alfred Blalock

- 1930’s
- fluid problem due to wound edema
- No evidence of a wound toxin
Carl Wiggers, PhD

- Wiggers shock model
- 1947
- You have to replace more fluid than you withdraw in order to resuscitate an animal from hemorrhagic shock
G Tom Shires, MD

- 1970’s
- Shock causes loss of integrity of cell membrane
- Salt and water migrate from interstitium to intracellular space
Hypotensive Resuscitation?
Walter B. Cannon

- 1918 Harvard Medical Unit France
- “If the pressure is raised before the surgeon is ready to check any bleeding that may take place, blood that is sorely needed may be lost”
Henry K. Beecher

- U.S. Army Shock Research Unit North Africa and Italy, World War II
- “When the patient must wait for a considerable period, elevation of his systolic blood pressure to 85 mmHg is all that is necessary”
Hypotensive Resuscitation??

- Rapid cessation of hemorrhage is the key to survival
- Delay in the field or the ER to “stabilize” the patient in shock with penetrating trauma leads to poor outcome
- Large volume resuscitation prior to control of hemorrhage leads to increased bleeding
Combat Fluid Resuscitation Conference 1 – USUHS - Recommendations

- Fluid resuscitation for BP<85mmHg, decreasing BP, or decreasing mental status without head injury
- No fluids in presence of strong radial pulse
- Fluids for weak or absent radial pulse or decreasing mental status without head injury
- Choice of fluids: 500cc of colloid by gravity (Hetastarch colloid of choice for early care)

Combat Fluid Resuscitation Conference 2 – Toronto – 2001

Recommendations

• Battlefield fluid resuscitation of choice should be an initial 250cc of 7.5% HTS + 6% Dextran (HSD) with 2nd dose of HSD only in those patients who fail to stabilize

• Follow HSD with isotonic crystalloid

Israel Defense Forces Doctrine

- In uncontrolled hemorrhagic shock, aggressive fluid resuscitation prohibited.
- In controlled hemorrhagic shock, fluid resuscitation is aimed toward normalization of hemodynamic parameters.
- Estimated evacuation time < 1 hour: immediate evacuation after A & B.
- Estimated evacuation time > 1 hour: crystalloid infusion, but limited to hypotensive resuscitation in uncontrolled hemorrhage.

US Military Doctrine

• Significant Wound in coherent soldier with palpable radial pulse: saline lock, hold fluids

• Significant wound without radial pulse or in incoherent soldier: 500cc of Hextend
  – Return of pulse or improvement in mental status: hold fluids
  – No improvement: additional 500 cc of Hextend

• No hypotensive resuscitation for head injury patient

Summary

• The goal of the treatment of shock is restoration of oxygen delivery to the cell
• Most patients in shock who are injured are bleeding!!!
• The key determinant of survival is the time between onset and cessation of hemorrhage
• Remember the Pump, pipes and fluids to sort out unusual causes of hypotension
CONCLUSION

• Attempt to restore normotension with aggressive saline infusion markedly increases blood loss

• Survival is not improved with restoration of normotension