The Abdomen – A Forgotten Closed Compartment
Early Animal Models of Intraabdominal Hypertension (IAH)

- **Haven Emerson** Arch Intern Med 1911;7:754-784
  - Pressures > 20-34 mm hg
  - Fatal to small animals
  - Respiratory failure/Circulatory collapse

- **Thorington** Am J Med Sci 1923;165:880-90
  - Oliguria in dogs
  - 15-30mm Hg
  - Anuria with pressure > 30
Early Observations: Human IAH

- **Gross (1948)** Forced closures of large omphaloceles could cause cardiovascular collapse in infants

- **Richards (1982)** 4 AAA patients with post-op hemorrhage developed anuria which reversed with reoperation

- **Kron (1984)** Described bladder pressure measurement
IAH: Who gets it?

- Major Trauma
- Independent risk factors:
  - >5 liters crystalloid in 24 hrs
  - >10 U PRBCs in 24 hrs
  - Hypothermia (<33)
  - Acidosis (pH < 7.2)
  - Obesity (BMI > 30)
IAH: Other Scenarios

- Post-op hemorrhage
- Septic Shock
- Severe Burns
- Severe Pancreatitis
- Portal Hypertension
  - Ligation / thrombosis PV
  - Intrinsic liver disease
ACS: Cardiovascular Pathophysiology

- ↓ Venous return
- ↓ Cardiac filling
- ↓ Cardiac output
- ↑ PVR
- Transiently reversible with volume
Pulmonary Pathophysiology

- ↑ Airway pressures
- ↓ Compliance
- ↓ P/F, ↑ CO₂
- Restrictive pulmonary disease
- Reversible with decompression
Renal Pathophysiology

- Vascular Resistance
- Blood flow
- GFR
- Urine flow
- Renin
Renal, cont:

• At IAP > 20
  • Renal vascular resistance is 5x normal
  • Increased venous resistance
  • Increased cortical arteriolar resistance
  • Decreased renal blood flow
  • FG (filtration gradient) drops in proportion to twice IAP
  • GFR drops by 75%
The Gut

- Splanchnic venous outflow is impeded
- Splanchnic blood flow diminished
- Associated with bacterial translocation in animals
- Can lead to infarction
- Evidence of bowel mucosal ischemia can be seen at modest increases in IAP
ACS

Sustained IAP >20 (Grade III or IV IAH) +

Adverse physiological consequences
(New organ dysfunction)
Modern Natural History Data

- 83 ICU Patients prospectively followed
- Mixed med/surg population
- 46% developed IAH (IAP>12)
- No specific therapies directed at IAH
- Mortality associated with IAH = 53%
- Mortality without IAH = 27%
- Mortality of ACS = 80%

Vidal, Crit Care Med, 2008
ACS – First Classification System

Grade I (10-15): Fluid Responsive
Grade II (15-25): Transient response to fluid
Grade III (25-35): Urgent Decompression
Grade IV (>35): Emergent Decompression

Burch, 1996
Current IAH Grading Scale (WSACS)

- “IAH is graded as follows:
  - Grade I  IAP 12 - 15 mmHg
  - Grade II IAP 16 - 20 mmHg
  - Grade III IAP 21 - 25 mmHg
  - Grade IV IAP > 25 mmHg.”

The IAH grades have been revised downward as the detrimental impact of elevated IAP on end-organ function has been recognized.
ACS: Primary vs Secondary

- **Primary**: Due to Abdominal injury or condition
  - Major hepatic injury
  - Perforated viscus
  - Primary insult likely determines outcome
- **Secondary**: Develops during resuscitation
  - Capillary leak
  - Massive transfusion
  - Vigorous crystalloid resuscitation
  - Early recognition and treatment
Pathophysiology – Multiple Compartments

- Increased IAP affects many compartments
  - Extremities: Venous return
  - Thorax
    - Pleural
    - Pericardial
  - Intracranial
- “Polycompartment Syndrome”
ACS: How is it recognized?

- Appropriate suspicion:
  - Recognize the at risk patient
  - Mitigate IAH before it progresses to ACS
  - Intermittent (q4 hrs) or continuous bladder pressures
  - Oliguria, increased airway pressures, frank abdominal distension are late signs
IAP: How is it measured?

- Direct measurements: impractical
- Gastric/Rectal measurements suboptimal
- Bladder pressures: surrogate for IAP
  - Instill 25 cc into empty bladder/clamp/use manometer
  - May be unreliable in pts with abnormal bladder compliance
    - Elderly
    - Postoperative
    - Pelvic Packing
- Gold Standard (WSACS): Bladder pressure in a pt with
  - Neuromuscular blockade
  - Supine position
  - End Expiration
  - Transducer at midaxillary line
Required Reading:

Provides standard lexicon and definitions
Establishes evidence-based guidelines
Recognizes areas where evidence is lacking
Emphasizes RX of IAP before it progresses to frank ACS (goal IAP <15)

Estimates the effect of IAP on measured filling pressures (50%)

Emphasizes prompt surgical decompression when ACS does develop
Algorithm-driven Rx of IAP and ACS
Factors Affecting Intraabdominal Pressure

- Inciting Event
- Abdominal Wall Compliance
- Obesity
- Air, fluid, blood, bowel edema
- Level of sedation and analgesia
- Patient Positioning

Geisel, “Hop on Pop” 1963
93 ventilated patients at risk for ACS

- Prospectively measured IAP in different positions
- Using preemptive strategy, only one patient developed ACS
ICU Management

- **Patient positioning**
  - Supine (or <20 deg HOB) appears best

- **Patient comfort**
  - Deep sedation
  - Good Analgesia
  - Trials of NM blockers appropriate
More on neuromuscular blockade

- Single prospective study
- Bolus administration of cisatracurium
- Decreased IAP from 18 to 14
- No improvement in UOP
- No improvement in APP
ICU Management

• Abdominal Contents
  – Good gastric decompression
  – Colonic decompression
  – Enteral feeding acceptable

• Fluid Management
  – Hypertonic crystalloids, colloids have been recommended
  – Aim for zero to negative fluid balance by day 3
  – Consider CRRT
More on Fluid Management

• Balogh et al., 2003
  – Analysis of dataset of supranormal O2 delivery
  – Supranormal resuscitation
    • More crystalloid
    • Worse intestinal perfusion
    • Increased ACS
    • Increased MOF and death
Catheter Drainage

• Described in small case series

• Reed (2005)
  • DPL catheter placed in 8 consecutive pts with IAP > 20
  • Results:
    • IAP fell by mean 6 mm Hg
    • Abdominal perfusion pressure increased by 15 mm Hg
    • Four patients (50%) still required laparotomy

• DH practice: use bedside ultrasound. Two groups:
  • Ascites: → pigtail catheter
  • Bowel edema → laparotomy
Decompressive Laparotomy

• When other measures fail to alleviate ACS, prompt surgical decompression is mandatory

• Gold standard: midline laparotomy in OR with temporary closure

• Bedside ICU decompression a reasonable option
  • Bring the OR to the patient
  • Prompt improvement can be expected
  • Subsequent surgical interventions in OR

• “Minimally invasive” approaches
  • Endoscopic subcutaneous division of linea alba
  • 50% success described
  • Proceed with caution
Modern Outcomes

• Incidence in at-risk population falling
• Mortality from ACS is falling
• Potential contributors:
  – Early recognition
  – “Hemostatic Resuscitation”
  – Judicious use of fluids
  – Improved management of the open abdomen
Now What?
Modified grading system for open abdomen

A modification of a 2009 proposal, now adopted by WSACS

1 No fixation
   1A: Clean, no fixation
   1B: Contaminated, no fixation
   1C: Enteric leak, no fixation

2 Developing fixation
   2A: Clean, developing fixation
   2B: Contaminated, developing fixation
   2C: Enteric leak, developing fixation

3 Frozen abdomen
   3A: Clean, frozen abdomen
   3B: Contaminated, frozen abdomen

4 Established enteroatmospheric fistula, frozen abdomen
ACS: Summary

- Persistent IAP >12 is abnormal
  - Conservative measures warranted
  - Must be monitored
- IAP >20 with organ dysfunction
  - = ACS
  - Life threatening condition
  - Demands prompt resolution
- ACS treatment
  - Continues to improve
  - Has likely decreased mortality
THANK YOU