Intra-abdominal Hypertension and Abdominal Compartment Syndrome: A Potentially Fatal Mix

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Objectives

- Differentiate between intra-abdominal hypertension (IAH) and abdominal compartment syndrome (ACS)
- Identify patient populations at risk for IAH/ACS
- Understand the pathophysiological process of IAH/ACS
- Methods to measure the IAP
- Management of IAH and ACS
Abdominal compartment syndrome: What is it?

A disease process that dramatically increases organ failure and death for medical and surgical ICU patients.
Abdominal Compartment Syndrome (ACS):

• ACS occurs as a result of the accumulation of fluid in the abdominal space from trauma or surgical procedures, or the increasing of abdominal contents due to tissue edema from an inflammatory process or massive fluid resuscitation or from space occupying lesions.

• As this pressure increases within the abdomen capillary perfusion is compromised and tissue ischemia and/or death occurs.

• If undetected or untreated multi-organ failure and patient death may ensue.
Definition of ACS:

• The syndrome defined as: Adverse physiological effects caused by massive interstitial and retroperitoneal swelling which leads to organ or multi-organ failure caused by sustained increase in the IAP more than 20 mmHg with or without decreased (<60) APP.

• The World Society of Abdominal Compartment Syndrome, [www.wsacs.org](http://www.wsacs.org)
Historical Analysis

- **Wendt** – 1876 – first identified the impact on renal function
- **Gross** – 1948 – described the “loss of the abdominal domain” – pioneered the open abdomen procedures
- **Soderberg/Westin** – 1970’s – identified the correlation between IAH and intra-vesicular pressure
- **Kron/Harmon** – 1980’s – discovered that compromised renal function was due to decreased perfusion not structure compression
IAH: Prevalence rate in the ICU

- The overall prevalence of IAH was 58.8% (IAP >12 mm Hg).
- Prevalence was 65% in surgical patients and 54.4% in medical patients.
- However, the medical patients had a higher prevalence of an increased IAP (>15 mm Hg) than did the surgical patients (29.8% vs 27.5%).
- Medical patients had a higher prevalence of ACS than did the surgical patients (10.5% vs 5%).
IAH/ACS Mortality rate:

• Compared with patients without IAH, patients with IAH were sicker and had a higher mortality rate (53% vs 27%; \( P = .02 \)).
• According to logistic regression, IAH was an independent predictor of mortality (\( P = .003 \)).
• ACS developed in 10 patients (12%), and 8 of the 10 (80%) died.

Abdominal Compartment Syndrome

Etiology origin:

• **Primary ACS** - associated with injury or disease in abdomen/pelvis requiring early surgical or interventional radiological screening

• **Secondary ACS** is from conditions not originating in the abdomen/pelvis

• **Recurrent ACS** is the redevelopment of ACS following previous surgical or medical treatment of primary or secondary ACS

• The World Society of Abdominal Compartment Syndrome, www.wsacs.org
Common Causes of ACS

- Primary causes:
  - Abdominal trauma with bleeding
  - Pancreatitis
  - Ruptured abdominal aortic aneurysm
  - Retroperitoneal hematoma
  - Obstructions/ileus
  - Pneumoperitoneum
  - Abscesses
  - Visceral edema
  - Severe colitis
Common Causes

- **Secondary Causes**
  - Acute respiratory distress syndrome
  - Major trauma or burns
  - Massive fluid resuscitation
  - Hypothermia <33 degrees Celsius
  - Acidosis with pH < 7.2
  - Hypotension
  - Massive blood transfusion > 10 units
  - Coagulopathy
  - Sepsis
Common Causes

- **Chronic Causes**
  - Obesity
  - Liver failure with ascites
  - Malignancies
What is a normal intra-abdominal pressure (IAP)?

5 - 7 mmHg is normal in a critically ill adult
Intra-abdominal Hypertension (IAH) and Acute Compartment Syndrome (ACS):

• Defined as sustained or repeatedly elevated abdominal pressure

• >12 mmHg is abnormal and is graded:
  • Grade I 12 - 15 mmHg
  • Grade II 16 - 20 mmHg
  • Grade III 21 - 25 mmHg
  • Grade IV >25 (ACS)
Understanding Abdominal Compartment Syndrome

Abdominal Perfusion Pressure APP:

- **APP** = **MAP** – **IAP** normal = 60 mmHg.
- **APP** – Abdominal perfusion pressure
- **MAP** – Mean arterial pressure
- **IAP** – Intra-abdominal pressure
- A critical IAP that leads to organ failure is variable by patient and a single threshold cannot be applied globally to all patients
- **APP** is superior to IAP, arterial pH, base deficit & lactate in predicting organ failure & patient outcomes
Intra Abdominal Hypertension IAH = IAP > 12 mmHg

- Due to diminished perfusion pressure, sustained intra abdominal pressure >12 has significant effects on abdominal organs and cardiac output with subsequent dysfunction of both abdominal and extra-abdominal organs.

- **Critical Values**
  - ~25mmHg show clinically significant distention

- **Length of time** of IAH is more significant than the absolute pressure
  - IAH and abdominal compliance varies from patient to patient (Ivatury, 2006)
Physiologic Insult/Critical Illness

Ischemia

Inflammatory response

Capillary leak

Tissue Edema
(Including bowel wall and mesentery)

Intra-abdominal hypertension

Fluid resuscitation
Pathophysiologic Consequences of ACS

- **Cardiovascular**
  - Reduced Cardiac Output
    - Compression of the inferior vena cava and portal vein
    - Reduced blood return to the heart (decreased preload)
    - Afterload increased from mechanical compression of vascular beds and vasoconstriction
Pathophysiology

- **Cardiovascular**
  - Reduced Stroke volume
  - Tachycardia
  - Increased pressure on great vessels making hemodynamic monitoring challenging with falsely elevated and misleading pressures
  - Increased risk for thromboembolic events secondary to venous stasis
Pathophysiology

Pulmonary

- Reduced lung compliance secondary to diaphragmatic elevation
- Hypoventilation and ventilation-perfusion mismatch
- Increased work of breathing
- Hypoxia and hypercarbia
- ARDS
- Mechanical ventilation often required
Pathophysiology

- Respiratory (MV)
  - Ventilation difficulty
  - Increased peak airway secondary to decreased lung compliance
  - Increased risk of barotrauma
Pathophysiology

- **Renal**
  - Increased IAH leads to decreased renal blood flow and decreased glomerular filtration
  - Oliguria may be observed with IAP of 15 - 20
  - An IAP of >30 leads to anuria
  - Increase of antidiuretic hormone and activation of renin-angiotensin-aldosterone system
  - Increased water retention
Pathophysiology

• **Abdominal Visceral**
  - Reduced blood flow which leads to
  - Intestinal ischemia
  - Decreased blood flow to all abdominal organs
  - Viscous cycle
Pathophysiology

- **Central Nervous System**
  - Increased thoracic and central venous pressure leads to
  - Decreased cerebral outflow of blood
  - Increased intracranial pressure which leads to decreased cerebral perfusion pressure
Measuring Intra-Abdominal Pressure

Be prepared to measure IAP often, even with very low level of suspicion.
Importance of accurate measurement

• Physical examination yields low levels of detection of IAH/ACS
• Early detection and intervention reduces morbidity and mortality.
• Diagnosis is dependent on frequent and accurate measurement of IAP (watching trends)
• Cost effective, safe and accurate
• Be prepared to measure IAP often, even with very low level of suspicion.
When to measure IAP

- New ICU admission with
- Evidence of clinical deterioration and
- Pt has two risk factors for IAH/ACS
  - Decreased abdominal wall compliance
  - Increased intra-luminal contents
    - ileus, gastroparesis, obstruction
  - Increased abdominal contents
    - Pneumoperitoneum, hemoperitoneum, ascities, liver dysfunction
  - Capillary Leak/fluid resuscitation
Types of Measurements

- **Direct Pressure via intraperitoneal catheters**
- **Indirect Pressure**
  - Gastric Measure
  - IVC
  - Rectal
  - Urinary bladder pressure - Gold Standard
Intestinal Mucosal pH

• Significantly Reduced in IAH
• Measurement of pHi may help in early detection of splanchnic hypoperfusion in patients with IAH
  – IAH & intestinal ischemia may lead to bacterial translocation & free oxygen radical production $\rightarrow$ sepsis $\rightarrow$ MODS
    • gastric tonometry

Sieh et al 2001
Urinary Bladder Pressure: easy and cheap:

- Most technically reliable
- Correlate closely with pressures measured directly in the abdominal cavity
- Reliably and reproducible
- Transduced through a Foley catheter
- Open (intermittent measuring) or closed (continuous measuring) Systems
- Position patient flat & supine
- Read Mean pressure
- End Expiration
Equipment needed for open measurement

- Disposable transducer
- 12” pressure monitoring tubing
- 4-way stopcock
- Red dead-ender
- 60 cc, lure-lock syringe, sterile
- Sterile normal saline
- Clamp, non-sterile
Figure 2: Intra-abdominal pressure waveform; pressure measured at end-expiration is 15 mm Hg.
Management Considerations:

• Early detection via frequent monitoring of at risk patients.

• Screen for IAH/ACS in new ICU admissions with new or progressive organ failure: easy and cheap.

• Look for trends of increasing abdominal pressures.

• Preserve organ perfusion and treat clinical conditions with grades I & II IAH
Management Considerations for IAH/ACS

1. Medical management to all patients
2. Early surgical consultations for ACS at risk patients
3. Early intervention for ACS or Grade III

Medical treatment options to reduce IAP

1. Improve abdominal wall compliance
   - Sedation & analgesia
   - Neuromuscular blockade
   - Avoid head of bed > 30 degrees

2. Evacuate intra-luminal contents
   - Nasogastric decompression
   - Rectal decompression
   - Gastro-/colo-prokinetic agents

3. Evacuate abdominal fluid collections
   - Paracentesis
   - Percutaneous drainage

4. Correct positive fluid balance
   - Avoid excessive fluid resuscitation
   - Diuretics
   - Colloids / hypertonic fluids
   - Hemodialysis / ultrafiltration

5. Organ Support
   - Maintain APP ≥ 60 mmHg with vasopressors
   - Optimize ventilation, alveolar recruitment
   - Use transmural (tm) airway pressures
     \[ P_{plat}^{tm} = P_{plat} - IAP \]
   - Consider using volumetric preload indices
     - If using PAOP/CVP, use transmural pressures
       \[ PAOP_{tm} = PAOP - 0.5 \times IAP \]
       \[ CVP_{tm} = CVP - 0.5 \times IAP \]
**Abdominal Compartment Syndrome (ACS)**

**Definitions**
- **IAH** - intra-abdominal hypertension
- **ACS** - abdominal compartment syndrome
- **IAP** - intra-abdominal pressure
- **APP** - abdominal perfusion pressure (MAP-IAP)

**Primary ACS** - A condition associated with injury or disease in the abdomino-pelvic region that frequently requires early surgical or interventional radiological intervention.

**Secondary ACS** - ACS due to conditions that do not originate from the abdomino-pelvic region.

**Recurrent ACS** - The condition in which ACS redevelops following previous surgical or medical treatment of primary or secondary ACS.

**Multi-surgical interventions open abdomen**

1. **IDENTIFY AND TREAT UNDERLYING ETIOLOGY FOR PATIENT'S ACS**
   - Does patient have Primary ACS?
     - **YES**
       - Perform / revise abdominal decompression with temporary abdominal closure as needed to reduce IAP.
     - **NO**
       - Patient has Secondary or Recurrent ACS.

2. **Is IAP > 25 mmHg with progressive organ failure?**
   - **YES**
     - Continue medical treatment options to reduce IAP.
     - Measure IAP/APP at least every 4 hours while patient is critically ill.
     - If APP can be maintained ≥ 60 mmHg, perform balanced resuscitation of patient preload, contractility, and afterload using crystalloid / colloid / vasoactive medications. AVOID EXCESSIVE FLUID RESUSCITATION.
     - If IAP < 12 mmHg consistently, IAH has resolved.
     - Decrease frequency of IAP measurements and observe patient for deterioration.
   - **NO**
     - IAP ≤ 25 mmHg, continue medical treatment options to reduce IAP.

3. **Can APP be maintained ≥ 60 mmHg?**
   - **YES**
     - IAH has resolved.
     - Decrease frequency of IAP measurements and observe patient for deterioration.
   - **NO**
     - Continue medical treatment options to reduce IAP.
Surgical Intervention

- Immediate
  - Rapid surgical decompression OR
  - Bedside
  - Volume resuscitation “washout cocktail”
  - Inotropic support
  - DO
    - \( \text{VO}_2 \)
  - Rewarming
  - Ventilation support
  - Survey of all organ systems
  - Monitor for recurrence
Management Considerations

• Anticipate patient to return with an alternative surgical closure or “open” abdomen.
• The abdominal contents will not be sutured into the abdominal cavity.
• Alternative closures vary from surgeon to surgeon.

Examples:
The “Bogata Bag” – A 3 L IV bag, open and sterilized and applied to the abdominal opening.
Management Considerations

• KCI Vac Pac
• Sponge overlies abd. Dressing/contents
• Attached to continuous suction canister
• Covered over with occlusive dressing
Management Considerations

• Ioban Dressing
• An occlusive dressing with iodine impregnation
• Surgical towels will overlie abdominal contents with JP drains - Ioban overlies abdomen
Case Study

• A healthy 25-year-old was taken to a level I trauma center after a 10mfoot fall from his window and then being struck by an air conditioner that fell on top of him.
• ASSESSMENT:
  • GCS 6
  • RTS 8
Case Study

- **INJURIES:**
  - R scapula fx
  - R rib fx 4-9
  - L inferior and superior rami fx
  - Multiple temporal and occipital subdural hematomas/contusions
  - Grade II splenic laceration/Grade III liver laceration
Case Study

• COURSE OF CARE:
  - Initial fluid resuscitation of 11.5 liters
  - Intubation with mechanical ventilation
  - Pulmonary artery catheter was placed
  - Ventriculostomy was placed
## Over Time

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Case Study

- OUTCOME:
  - Closure utilizing vacuum seal
  - Definitive closure with mesh 2 weeks later
  - Regained consciousness, following command, MAE, to rehab and returned one year later to pre-injury state for mesh removal with ventral hernia repair
Case Study

- 22 year old man that fell 25 feet at a construction site striking his right flank on 2 x 4’s.
- On admission:
  - Primary Survey
    - unremarkable
  - Secondary Survey
    - facial, hand lacerations
    - Large contussed area over right flank
- Vital signs – HR 112, BP 102/62, T 36° po
- Labs – ABGs 7.32, 34,352, 24, -5, 100% NRB, Hg 12.2, Crit 38.4
- 2 liter crystalloid resuscitation
Studies

- CXR – fracture of ribs 4-7 on the right side
- Pelvis – WNL
- Cervical spine – WNL
- FAST – free fluid
- CT – abdomen - Grade IV liver laceration
- Angiography with embolization of liver vascular bleeding
Course of Care

- Day 3 – Stable, eating, OOB
- Day 7 – increased confusion, ↓ PaO2, ↑ PaCO2, HR 130’s, BP 70’s, ↓ U/O, mottled
- CT Scan large volume free fluid/blood
- Intubated
- Volume resuscitated with fluid/blood
- To OR – splenectomy, liver packing, Bogota bag closure
## Post Operative Course

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Bladder pressure – 32 – bag opened

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To OR for re-exploration, bleeders ligated, repacked, vacuum pack applied

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Bladder pressure – 16
Continued Care Day 32

- Complications
  - Hepatic dysfunction
  - Ventilator dependence
  - MRSA pneumonia
- Awake, alert
- Tolerating nutrition
- Wound covered with mesh
- Ventilator weaning program
- PT/OT strength training
Recurrent AACS

- “…if it happened once it will more likely happen again.” Porter, 1997.
- Higher risks
IAH/ACS:
Summery and Conclusions:

• Know the difference between IAH and ACS
  - IAH = Abdominal pressure >12 and graded via severity
  - ACS = Abdominal pressures > 20 - 25 mmHg

• Identify At risk patient populations
  abdominal trauma/major burns
  Pancreatitis
  Ruptured AAA
  abdominal obstructions/ischemia
  etc....
IAH/ACS:
Summary and Conclusions:

• Understand the pathophysiology of the injury:
  - Ischemia/inflammation - inflammatory response - capillary leak + fluid resuscitation = tissue edema in an uncompromising cavity = ACS = tissue/cell death.
  - Perform an accurate assessment of abdominal pressure using Abdominal bladder pressure monitoring via Foley catheter.
  - Perform the measurement for any suspicion of increased IAP and measure frequently
IAH/ACS: Summery and Conclusions:

• Anticipate the outcome and inform the family
• Perform medical management as soon as possible
• Obtain urgent surgical evaluation
• Be familiar with open abdomen post OP management
• Perform frequent clinical assessments after surgical intervention as patient may need to have multiple surgical interventions
Ancoro Imparo

Michelangelo age 87
Thank You!
www.abdominalcompartmentsyndrome.org