Intra-abdominal Hypertension and Compartment Syndrome in the Trauma Patient:

Is Your Patient at Risk?

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Objective

- Brief review of pathophysiology
- Definitions of IAH/ACS
- Define the risk in trauma patients
- IAP measurement
- Prevention and treatment strategies
Intra-abdominal hypertension and the abdominal compartment syndrome: updated consensus definitions and clinical practice guidelines from the World Society of the Abdominal Compartment Syndrome
The Continuum

IAH  →  ACS
Keys to Success

- *Early Identification of Patients at Risk*

- *Early/Ongoing Assessment*
  - IAP (Bladder Pressure Measurement)

- *Early Therapeutic Intervention*
  - Non-surgical
  - Surgical
Shock

**Inability of the cells to meet their metabolic demands**

- Reductions in Oxygen Delivery
- Increases in Oxygen Utilization
- Combination of Both

- O₂ deprivation (oxygen debt)
- Cellular acidosis
- Cellular dysfunction
- Cellular death
- Organ dysfunction
- Organ failure
Trauma/Injury Trigger

Hemorrhage

Shock

- I.V. Fluid
- Packing
- Manipulation

Visceral ischemia

Reperfusion edema

Visceral edema

IAH/ ACS
Inflammatory Response

“Two Hit Theory”

Primary Insult (trauma)

Secondary Insult (shock)

Inflammatory Response
CAPILLARY LEAK

INTRA-ABDOMINAL TISSUE EDEMA
4 Risk Factor Categories

- Reduced Abdominal Wall Compliance
- Capillary Leak/Fluid Resuscitation
- Increased Intraluminal Contents
- Increased Abdominal Contents
Risk Factors
Clinical Scenarios

- Abdomen closed post-op
- Temporary abdominal closure
- Volume Resuscitation/Massive Transfusion
- Lethal Triad (acidosis, coagulopathy, hypothermia)
- Damage control stage 4 (closure)
Damage Control Laparotomy

Stage 1
- Control of hemorrhage
- Control of contamination
- Packing
- Temp closure

Stage 2
- Rewarming
- Correct coagulopathy
- Ventilation
- Hemodynamics

Stage 3
- Re inspection
- Definitive injury repair
- Abdominal Closure

Stage 4
- Abdominal Reconstruction
Reduced Abdominal Wall Compliance

- Closure of the abdomen post-laparotomy
- Burns to the thoraco-abdominal wall
- Temporary abdominal closure
Abdominal Bedside Tote

Photo by John Gallagher
Bogota/Silo Bag Closure

trauma.org Image Bank
Burn Injury

- Hershberger et al. (2007) Journal of Burn Care Research
- Ennis et al. (2008) Journal of Trauma
- Ball et al. (2006) Journal of Trauma
Capillary Leak/Fluid Resuscitation

- Crystalloid Resuscitation
- Massive Transfusion

Inflammatory Response
Capillary Leak

Acidosis
Hypothermia
Coagulopathy

Lethal Triad

SHOCK
Increased Abdominal Contents

- Hemoperitoneum
- Burns (ascites)
Increase Intraluminal Contents

- Ileus
- Gastroparesis
- Obstructions
Intra-abdominal Pressure Variations

- Normal: 5 – 7mmHg
  - Normal in Obesity: 9 – 14 mmHg

- HOB elevation: 2 - 5 mmHg above baseline

- PEEP > 15 mmHg
  - Most profound when IAP is > 12mmHg baseline
Intra abdominal Hypertension

A pathologic elevation of intra-abdominal pressure

- Sustained or reproducible IAP $\geq$ 12 mmHg
Intra abdominal Hypertension

IAP ≥ 12 mmHg

- **Grade I:** 12 - 15 mmHg
- **Grade II:** 16 – 20 mmHg
- **Grade III:** 21 - 25 mmHg
- **Grade IV:** > 25 mmHg

World Society of the Abdominal Compartment Syndrome
Abdominal Perfusion Pressure (APP)

\[ \text{APP} = \text{MAP} - \text{IAP} \]

Target APP > 60 mmHg

APP < 50 mmHg is associated with increased mortality
Pediatric Considerations

- Lower MAP and lower threshold for hypoperfusion

- IAH and ACS occur at lower IAP
  - ACS is IAP of > 10 mmHg with new onset organ dysfunction

Abdominal Compartment Syndrome

An increase in intra-abdominal pressure that exceeds the capacity of the compartment, resulting in the impaired perfusion and function of multiple organ systems.
Abdominal Compartment Syndrome

Presence of both....

- IAP > 20 mm Hg  \textit{Regardless of APP}

- \textit{New onset} single/multiple organ system failure
Abdominal Compartment Syndrome

Primary

Secondary

Recurrent
Primary Abdominal Compartment Syndrome

Associated with injury or disease in the abdominopelvic region

Photo by John Gallagher
Secondary Abdominal Compartment Syndrome

Develops from

*conditions outside the abdomen*

- Massive fluid resuscitation
- Burns
- Sepsis
SACS Post Injury

- Lower SBP
- Penetrating chest
- Vascular Injuries
- Multiple extremity fractures
Secondary Abdominal Compartment Syndrome

- Inflammatory process that may be more subtle
  - Trauma:
    » SACS represents 58% of post injury ACS
    » 38 – 68 % mortality

- Resuscitation outside the OR
  - IR and ICU
  - More crystalloid
  - Longer times to control of bleeding
22 y.o. unrestrained driver, ejected in a MVC:

- Unresponsive
- Heart rate: 130
- Blood pressure: 80/50 mmHg

- L. hemothorax - 750 ml from the chest tube
- Abdominal ultrasound positive for fluid LUQ
- Taken to OR for splenectomy
- Admitted to the SICU
22 y.o. male post MVC transferred into the SICU after progressive hemodynamic deterioration

- BP 90/50  HR 122  T 102°  F  Sat 88%
- Pale, diaphoretic
Breathing becomes labored, mental status decreases

- Intubated
- Central line placed
  » CVP is 3 mm Hg
- Urinary catheter placed
  » 200 ml dark urine
4 liters additional LR is infused
- MAP: 60, HR: 110, CVP: 10,
- Urine output: 15 ml/hr

- Norepinephrine started
  - MAP: 65, HR 116, CVP 11
  - Urine output 20 ml for last 2 hours

Bladder pressure monitoring device attached:
- IAP 30 mmHg
Recurrent Abdominal Compartment Syndrome

Abdominal Compartment Syndrome that re-develops after previous medical or surgical treatment
Recurrent Abdominal Compartment Syndrome

- Can develop even with an “expanded” (open) abdomen with temporary closure
- Increased morbidity and mortality

Open Abdomen

Expanded Abdomen
Dynamic Tension
Organ Systems Compromised

- Gastrointestinal
- Pulmonary
- Cardiovascular
- Renal
- Neurological
Gastrointestinal Effects

- Increased IAP (Intra-abdominal Pressure)
- Compression of mesenteric vessels
- Gastric mucosal acidosis (pHi)
- Mesenteric ischemia

Diagram:
- Lacteal
- Capillary
- Artery
- Vein
- Crypt
Pulmonary Effects

- Increased Intra-abdominal pressure
- Pressure on Diaphragm
- Lung expansion
Cardiovascular Effects

Increased IAP

↓ Pre-load

↑ Afterload

May occur with IAPs of as low as 10 mmHg
Cardiovascular Assessment Findings

- Normotensive
- ↑ CVP, PA, PCOP, SVR, PVR
- ↓ C.O.

\[
\begin{align*}
\text{CVP}_{\text{corrected}} &= \text{CVP}_{\text{measured}} - \frac{\text{IAP}}{2} \\
\text{PCOP}_{\text{corrected}} &= \text{PCOP}_{\text{measured}} - \frac{\text{IAP}}{2}
\end{align*}
\]
Renal Impact of Elevated IAP
Neurologic Effect

Increased IAP

Reduced venous return from the brain

Cerebral hyperemia

Increase in ICP
Neurological Manifestations

Refractory Intracranial Hypertension

Elevated ICPs

CPPs

Brain tissue oxygen
Early/Ongoing Assessment

- Early Initiation of IAP monitoring in patients with 2 or more risk factors
- Serial measurement until IAH risk is past
Bladder Pressure Monitoring

- The current standard for monitoring IAP

- Comparable to direct intraperitoneal pressure measurements, but is non-invasive \((\text{Bailey, Crit Care 2000})\)

- More reliable and reproducible than clinical judgment \((\text{Kirkpatrick, CJS 2000; Sugrue World J Surg 2002})\)
Intra-Abdominal Pressure Measurement

- Performed in the supine position
- Zero at the level of the mid-axillary line (pelvis)
- Expressed in \( \text{mmHg} \) (1 mmHg = 1.36 cmH2O)
- Measured at End-expiration
- Measure 30 – 60 sec after instillation of saline
The correct transducer position at the iliac crest in the mid-axillary line in the supine position and with head of bed elevation.

Photo by John Gallagher
Instilled Fluid Volume

- **Adults**
  - No greater than 25 ml of saline

- **Children**
  - 3ml minimum volume
  - 1 ml/kg for children up to 25
Considerations

- Neurogenic or contracted bladder
- Injuries to the bladder
- HOB elevations
AbViser®
Intra-Abdominal Pressure Monitoring Kit
Manometry Measurement

Foley Manometer Holtech Medical
Modified Pressure Monitor System

Bladder Pressure Monitoring Setup

- Bag of NSS
- Calibration port
- Pigtail
- Transducer
- Needleless Catheter Sample port
- Connect luer-lok tubing to catheter sample port
- 20 to 30 ml Syringe

Illustration by John J. Gallagher
Bladder Pressure Waveform

Figure 2

IAP Waveform

The IAP read at end-expiration is 15 mmHg in this mechanically ventilated patient.
Keys to Accuracy

- Standardized measurement device
- Standardized clinical protocol

Kimball et al. (2007) Intensive Care Medicine
Monitoring Protocols

Trigger Conditions

Monitoring System

- Frequency of Monitoring
- Reporting Thresholds

Criteria for Termination of Monitoring

Ongoing staff proficiency
**Pitfalls**

- Failing to identify patients at risk
  - Temporary abdominal closure
  - Volume resuscitation
  - Post-op abdominal closure

- Requiring an order to monitor IAP
- Staff unfamiliar with the monitoring procedure
- Terminating monitoring too soon
Management Strategies

- Optimize systemic perfusion/organ function
- Non-surgical interventions to reduce IAP
- Surgical decompression
Ventilation Strategies

Decreased thoracic compliance

Normal lung tissue compliance

- Lung Protective Strategies
  - Limit ventilation pressures
  - Optimize PEEP
Non-surgical Measures

Optimize Abdominal Perfusion Pressure (APP)

- **Volume**
  - Optimize preload ⟷ Improve cardiac index
  - Worsen edema

- **Vasopressors**
  - Achieve APP > 60 mmHg after euvolemia
  - Risk of intestinal ischemia
**Cardiac Output**

**Stroke Volume**

- **Preload**
  - **Volume**
    - SV
    - SVV
    - PPV
    - EDV
    - Doppler
    - Echo

- **Afterload**
  - **Resistance**
    - SVR
    - PVR

- **Contractility**
  - **Stroke Work (I)**
    - RVSW
    - LVSW

X HR
Improve Abdominal Wall Compliance

- Analgesia/Sedation
- Remove/Expand Abdominal Closure
- Escharotomy (Burn Patients)
- Positioning
  - HOB not greater than 30 degrees
  - Reverse trendelenberg
  - Abdomen unsupported while prone
- Neuromuscular Blocking Agents
Correct Positive Fluid Balance

- Avoid excessive fluid resuscitation
- Aim for zero/negative fluid balance
  - Diuretics (hemodynamically stable)
- Colloids/Hypertonic fluids
- Fluid restriction
- CRRT
Evacuation of Abdominal Collections

- U/S and CT guided percutaneous drainage
- Surgical removal of space occupying lesions

- Ascites evacuation
- Abscess removal
- Hematoma removal
Evacuation of Intraluminal Contents

- Gastric/Rectal decompression
- Colonoscopic decompression
- Gastroprokinetics / Coloprokinetic
- Correct electrolyte abnormalities
  - Potassium
  - Magnesium
  - Calcium/Phos

Maintain enteral nutrition unless progression to ACS
Surgical Treatment Measures

- Surgical Decompression
  - IAP > 20 mmHg & organ dysfunction
- Removal of packing
- Drainage of intra-abdominal collections
Conclusions

- Majority of Critically Ill Patients are **AT RISK**

- IAH and ACS increase morbidity, mortality and ICU length of stay

- Early detection and intervention can reduce these complications in many patients
  - **Monitoring Bladder Pressure key to early detection**

- Early treatment of IAH with non-surgical strategies can prevent progression to ACS
Resources

World Society of Abdominal Compartment Syndrome

www.wsacs.org
Thank You

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