Abdominal Compartment Syndrome: Physiologic Consequences and Clinical Management

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Compartment Syndrome

Elevated pressure within a closed anatomic space compromising capillary perfusion
Examples of Compartment Syndrome

- Extremity Injury
- Circumferential Burn
- Tight Cast
- Intra-cranial Hypertension
- Abdominal Compartment Syndrome

Volkmann’s Ischemic Contracture
http://www.wheelessonline.com/image2/volk1.jpg
Intracranial Pressure

- Monroe-Kelly Doctrine
- CPP = MAP - ICP
APP = MAP - IAP
Intra-abdominal Hypertension

- Tissue Edema (Bowel, Retroperitoneum)
- Fluid Collecting in Peritoneal Cavity
Abdominal Compartment Syndrome

Organ Failure due to Intra-abdominal Hypertension (IAH)
Pathophysiology of Abdominal Compartment Syndrome

http://www.abdominal-compartment-syndrome.org/acs/overview.html
Physiologic Consequences

Cardiac Effects

- Increased CVP
- Decreased Preload

Cardiac Output vs Intra-abdominal Pressure

Pulmonary Effects

- Increased IPP
- Increased PAP
- Decreased TLC
- Decreased FRC
- Decreased Chest Wall Compliance

Pleural Pressure and IAP

Renal Effects of IAH

- vena cava compression
- Renal venous hypertension
- Decreased CO
- Glomerular Filtration Gradient = MAP – 2 x IAP*

*Effect of IAP on both Proximal tubular pressure and glomerular filtration pressure

Cullen DJ et al. Crit Care Med 1989;17:118-21
http://www.abdominal-compartment-syndrome.org/acs/renal.html
Gut Effects of IAH

- Venous congestion
- Direct compression on mesenteric and hepatic capillaries
- Decreased CO
- Hypoxia

Diebel LN, Dulchavsky SA, Wilson RF. J Trauma 1992;33:45-8
Effect if IAH on ICP

- Increased ICP
- Decreased CPP
- Consider decompressive laparotomy


Effect of IAH and ACS on Outcome

- Patients with IAH had increased mortality
- The mortality rate was significant even in patients with low APACHE scores

## Grading of IAH

<table>
<thead>
<tr>
<th>Grade</th>
<th>IAP</th>
<th>Rx</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>12-15 torr</td>
<td>Non-operative</td>
</tr>
<tr>
<td>II</td>
<td>15-20 torr</td>
<td>Non-operative</td>
</tr>
<tr>
<td>III</td>
<td>21-25 torr</td>
<td>Consider decompression</td>
</tr>
<tr>
<td>IV</td>
<td>&gt;25 torr</td>
<td>Decompressive Laparotomy</td>
</tr>
</tbody>
</table>

Non-operative Management

- Sedation
- Analgesia
- Intestinal decompression
- Paracentesis
- Neuromuscular blockade
- Judicious fluid resuscitation
Abdominal Compartment Syndrome

Bladder Pressure as Surrogate for Intra-abdominal Pressure

Malbran ML, Deeren DH. Crit Care 2006;10:R98

Decompressive Laparotomy
Open Abdomen Management

• A variety of different clinical scenarios
• Outcome and physiologic consequences different depending on clinical situation
• No scaling system yet described to allow comparison of different studies
Is there evidence that Decompressive Laparotomy improves outcome?

<table>
<thead>
<tr>
<th>Author</th>
<th>N</th>
<th>Mortality Rate Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ivatury et al.</td>
<td>77</td>
<td>36% -12%</td>
</tr>
<tr>
<td>Tao et al.</td>
<td>23</td>
<td>80% -16.7%</td>
</tr>
<tr>
<td>Cipolla et al.</td>
<td>17</td>
<td>73% - 5.9%</td>
</tr>
</tbody>
</table>
Options for Temporary Wound Coverage

• Skin-only Closure
• Plastic Abdominoplasty
• Absorbable mesh
• Non-absorbable mesh with protection of underlying viscera
• Vacuum Pack
• Vacuum-assisted wound management
Temporary Abdominal Closure

Towel Clip Closure

Temporary Skin Closure

Plastic Silo
Absorbable Mesh
The “VAC-PAC” Dressing

- Plastic Sheet covering the bowel
- Surgical Towel placed over the plastic
- Compression of the abdominal contents
- Control of fluid losses - suction drains

The “VAC-PAC” Dressing

Pictures courtesy of Michael Rotondo, MD
Unintended Fortuitous Consequence of the Vac-Pac

- The plastic sheet delays adhesion formation between the visceral block and the abdominal wall
Vacuum-Assisted Wound Closure

• 2001 Vacuum Assisted Wound Closure (VAWC)
  – VAWC device (KCI Vacuum-Assisted Closure, San Antonio, TX)
  – 14 trauma patients, dressing changed q 48 hours
  – Achieved delayed fascial closure in 13 (92%)
    • 9 ± 1.9 days
    • 2.8 ± VAWC dressing changes
  – 2 wound infections
  – No fistulas or evisceration
Current Approach
Principles Leading to a Revolution in the Management of the Open Abdomen

- Preservation of the Peritoneal Cavity
- Vacuum Assisted Wound Management
- Prevention of lateral fascial retraction
- Progressive graded abdominal closure
- Biologic Dressings

Prevention of Lateral Fascial Retraction

Marlex outside, PTFE inside
“Reefing” Marlex to slowly approximate the fascia
Delayed Primary Fascial Closure

Peritonitis

Delayed primary fascial closure
Approximately 6 weeks later
Options for “Biologic Dressings” for the Open Abdomen

- Advancement Skin Flaps
- Homologous Split Thickness Skin Graft
- Autologous Split Thickness Skin Graft
- Acellular Dermal Matrix

- Myofascial Advancement Flaps
- Rotation Skin and Muscle Flaps
- Free Muscle flaps
Omentum as a Biologic Dressing
Homologous Split Thickness Skin as a Biologic Dressing

Acellular Dermal Matrix as a Biologic Dressing

Skin and Muscle Flap Coverage

Rectus Abdominus Muscle Transposition Flap

Delayed Random Rotation Skin Flap
## Preferred Approach to Open Abdomen Management

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Grade of Recommendation</th>
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<tbody>
<tr>
<td>1. Leave fascia open and close skin over viscera if possible</td>
<td>I B</td>
</tr>
<tr>
<td>2. Preserve the omentum, if possible, for visceral coverage</td>
<td>I B</td>
</tr>
<tr>
<td>3. Use a Vac-Pac coverage of the open abdomen after the initial decompressive laparotomy</td>
<td>II A</td>
</tr>
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## Preferred Approach to Open Abdomen Management

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<td>4. At the second procedure, cover viscera with cadaver skin if no omentum and a prolonged open abdomen is anticipated</td>
<td>II C</td>
</tr>
<tr>
<td>5. Ensure that there is “gutter to gutter” visceral coverage with a fenestrated plastic sheet</td>
<td>I B</td>
</tr>
<tr>
<td>6. Use non-absorbable mesh sutured to fascia to prevent lateral fascial retraction</td>
<td>I C</td>
</tr>
<tr>
<td>7. Reef the mesh together to approximate the fascial edges slowly at serial Wound V.A.C. Dressing changes in the OR.</td>
<td>I B</td>
</tr>
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Editorial Opinion

A cautionary note: the use of vacuum-assisted closure systems in the treatment of gastrointestinal cutaneous fistula may be associated with higher mortality from subsequent fistula development

Abstract. During the past several years, vacuum-assisted closure (VAC) systems have been increasingly used in the treatment of gastrointestinal cutaneous fistulas, particularly those associated with open abdomen. Recently, I experienced 2 cases in which the original fistula closed after treatment by the VAC system. However, these patients, who had exposed bowel, developed an additional fistula that required surgery. In a recent article from an intestinal-failure unit in the United Kingdom, Rao et al. reported on a series of 29 patients treated with VAC, 6 of whom developed new gastrointestinal cutaneous fistulas. Four of these 6 patients died. My own experiences, plus the report of Rao et al., suggest the possibility that the use of the VAC system in patients with exposed bowel and an open abdomen may be associated with subsequent fistula development. Although the numbers are small, it also raises the question that development of a fistula in a patient treated with VAC may result in higher mortality.

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The use of vacuum-assisted closure (VAC) systems for the past decade in the United Kingdom, and for a somewhat shorter period of time in the United States, has become an essential part of the care of patients with open abdominal wounds. Although VAC has not yet been approved by the United States Food and Drug Administration for all of the situations in which it is used, the use semiocclusive drape is then placed over the entire wound, and a small hole is fashioned through which an 18F tube can be inserted, which transmits suction from a vacuum pump that creates negative suction ≤125 mm Hg. If the bowel is exposed, a somewhat different foam and tubing is used, presumably to protect the bowel. The dressing is changed every 72 hours with the patient under sedation.
Problem of “Entero-atmospheric” Fistula

• Absence of overlying soft tissue with good blood supply precludes spontaneous healing
• Exposed abdominal viscera predisposes to development of additional holes in the GI tract
• Complex wound, catabolism, high morbidity and mortality
Prevention of an Entero-atmospheric Fistula

Viscera Protection with Cadavre Skin as a Biologic Dressing

Wound V.A.C.

Delayed Primary Closure of Wound
Summary

• IAH and ACS are relatively common problems
• Frequent monitoring of bladder pressures as a surrogate for IAP is standard of care
• Decompressive Laparotomy may be necessary for patients with IAP > 25 torr
• Access to the wound should be limited to senior surgeons