The Management of the Abdomen That Won’t Close

Chaitan K. Narsule, M.D.  PGY-V  December 17, 2008
Objectives

- Indications for an Open Abdomen
- Physiology of the Open Abdominal Wound and the Evolution of Temporary Abdominal Closure
- Morbidity and Mortality of the Open Abdomen
- Closure of the Open Abdomen
- Abdominal Wall Reconstruction
Indications for an Open Abdomen
Indications for an Open Abdomen

- Damage Control Laparotomy for Trauma
- Decompressive Laparotomy for Abdominal Compartment Syndrome
- Necrotizing Infection of the Abdominal Wall
- Acute Mesenteric Ischemia
- Severe Abdominal Infection

Schecter et al. JACS. 2006;390-399
Indications for an Open Abdomen

- **Damage Control Laparotomy for Trauma**

- **Decompressive Laparotomy for Abdominal Compartment Syndrome**

- **Necrotizing Infection of the Abdominal Wall**

- **Acute Mesenteric Ischemia**

- **Severe Abdominal Infection**

Schecter et al. *JACS*. 2006;390-399
Damage Control Laparotomy

- Evolved from change in spectrum of trauma over past 50 years
  - Emergence of semiautomatic handguns with multiple penetrating wounds
  - High-energy blunt trauma with multiple-organ injury and fractures

Shapiro et al. J Trauma.
2000;49:969-978
Fig. 2. The four phases of damage control (current).
Damage Control Laparotomy

Goals:

- Achieve rapid but definitive hemostasis
- Close all hollow viscus injuries and perform only necessary bowel resections
- Prevent, or treat, the evolving lethal triad via ICU resuscitation
- Proceed with definitive repair after stabilization and correction of all physiologic parameters

The Lethal Triad

Hypothermia

Acidosis

Coagulopathy
Indications for an Open Abdomen

- Damage Control Laparotomy for Trauma
- Decompressive Laparotomy for Abdominal Compartment Syndrome
- Necrotizing Infection of the Abdominal Wall
- Acute Mesenteric Ischemia
- Severe Abdominal Infection

Schecter et al. JACS. 2006;390-399
Abdominal Compartment Syndrome

- **Incidence:** 5.5% to 35%

- **Primary**
  - From intraabdominal and retroperitoneal disease processes or extensive surgical procedures, which lead to accumulation of intracavitary or interstitial fluid or gas

- **Secondary**
  - Can follow systemic medical emergencies remote from abdominal cavity
  - Well-established complication of massive fluid resuscitation

Hojman & Rabinovici. In *Current Surgical Therapy*. 2008;970-975
Abdominal Compartment Syndrome

Table 2 Risk factors for IAH/ACS

<table>
<thead>
<tr>
<th>Risk Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acidosis (pH &lt; 7.2)</td>
</tr>
<tr>
<td>Hypothermia (core temperature &lt; 33°C)</td>
</tr>
<tr>
<td>Polytransfusion (&gt; 10 U packed red blood/24 h)</td>
</tr>
<tr>
<td>Coagulopathy (platelets &lt; 55,000/mm³ or activated partial thromboplastin time two times normal or higher or prothrombin time &lt; 50% or international standardized ratio &gt; 1.5)</td>
</tr>
<tr>
<td>Sepsis (American-European Consensus Conference definitions)</td>
</tr>
<tr>
<td>Bacteremia</td>
</tr>
<tr>
<td>Intra-abdominal infection/abscess</td>
</tr>
<tr>
<td>Peritonitis</td>
</tr>
<tr>
<td>Liver dysfunction/cirrhosis with ascites</td>
</tr>
<tr>
<td>Mechanical ventilation</td>
</tr>
<tr>
<td>Use of positive end expiratory pressure (PEEP) or the presence of auto-PEEP</td>
</tr>
<tr>
<td>Pneumonia</td>
</tr>
<tr>
<td>Abdominal surgery, especially with tight fascial closures</td>
</tr>
<tr>
<td>Massive fluid resuscitation (&gt; 51 colloid or crystalloid/24 h)</td>
</tr>
<tr>
<td>Gastroparesis/gastric distention/ileus</td>
</tr>
<tr>
<td>Volvulus</td>
</tr>
<tr>
<td>Hemoperitoneum/pneumoperitoneum</td>
</tr>
<tr>
<td>Major burns</td>
</tr>
<tr>
<td>Major trauma</td>
</tr>
<tr>
<td>High body mass index (&gt; 30)</td>
</tr>
<tr>
<td>Intra-abdominal or retroperitoneal tumors</td>
</tr>
<tr>
<td>Prone positioning</td>
</tr>
<tr>
<td>Massive incisional hemia repair</td>
</tr>
<tr>
<td>Acute pancreatitis</td>
</tr>
<tr>
<td>Distended abdomen</td>
</tr>
<tr>
<td>Damage control laparotomy</td>
</tr>
<tr>
<td>Laparoscopy with excessive inflation pressures</td>
</tr>
<tr>
<td>Peritoneal dialysis</td>
</tr>
</tbody>
</table>

Malbrain *et al.* *Intensive Care Med.* 2006;1722-1732
Abdominal Compartment Syndrome

- Sustained IAP > 20 mm Hg
- New organ dysfunction or failure

Malbrain et al. Intensive Care Med. 2006;1722-1732
Abdominal Compartment Syndrome

Pathophysiology

Central Nervous System Dysfunction

Respiratory Dysfunction

Cardiovascular Dysfunction

Renal Dysfunction

Bowel Dysfunction

Musculoskeletal Dysfunction
Abdominal Compartment Syndrome

**Table 1: Grading System for Intra-Abdominal Pressure**

<table>
<thead>
<tr>
<th>Grade</th>
<th>Bladder Pressure (mm Hg)</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>10–15</td>
<td>Maintain normovolemia</td>
</tr>
<tr>
<td>II</td>
<td>16–25</td>
<td>Hypervolemic resuscitation</td>
</tr>
<tr>
<td>III</td>
<td>26–35</td>
<td>Decompression</td>
</tr>
<tr>
<td>IV</td>
<td>&gt;35</td>
<td>Decompression and reexploration</td>
</tr>
</tbody>
</table>

**Table 2: Percentage of Patients with Respective Organ Dysfunction per Intra-Abdominal Pressure Grade**

<table>
<thead>
<tr>
<th>Grade</th>
<th>UO &lt;0.5</th>
<th>PAP &gt;45</th>
<th>SVR &gt;1,000</th>
<th>DO2I &lt;600</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>II</td>
<td>0</td>
<td>40</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>III</td>
<td>65</td>
<td>78</td>
<td>65</td>
<td>57</td>
</tr>
<tr>
<td>IV</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>


PAP, Peak airway pressure (cm H₂O); DO2I, oxygen delivery index (ml O₂/min/m²); SVR, systemic vascular resistance (dyne/sec/cm⁻⁵); UO, urine output (ml/kg/hr).
Abdominal Compartment Syndrome

Organ dysfunction

Responsive to resuscitation
- Risk factors not present → No ACS
- Risk factors present
  - Measure bladder pressure
    - <25 mm Hg → Observe and repeat measurements
    - >25 mm Hg → Initiating condition not quickly reversible → Decompressive laparotomy
      - Initiating condition quickly reversible → Fluids and/or paralytics

Unresponsive to resuscitation

Hojman & Rabinovici. In Current Surgical Therapy. 2008;970-975
Indications for an Open Abdomen

- Damage Control Laparotomy for Trauma
- Decompressive Laparotomy for Abdominal Compartment Syndrome
- Necrotizing Infection of the Abdominal Wall
- Acute Mesenteric Ischemia
- Severe Abdominal Infection

Schechter et al. JACS. 2006;390-399
Indications for an Open Abdomen

- Damage Control Laparotomy for Trauma
- Decompressive Laparotomy for Abdominal Compartment Syndrome
- Necrotizing Infection of the Abdominal Wall
- Acute Mesenteric Ischemia
- Severe Abdominal Infection

Schecter et al. JACS. 2006;390-399
Indications for an Open Abdomen

- Damage Control Laparotomy for Trauma
- Decompressive Laparotomy for Abdominal Compartment Syndrome
- Necrotizing Infection of the Abdominal Wall
- Acute Mesenteric Ischemia
- Severe Abdominal Infection

Schecter et al. JACS. 2006;390-399
Severe Abdominal Infection

- **Open management:**
  - Indicated when a single laparotomy cannot effectively control the source of infection
  - Enables repeated access to peritoneal cavity
  - Facilitates repeated debridement of nonviable tissue, peritoneal toilet, and effective drainage
  - Can be performed in the operating room or in the SICU

Schechter *et al.* *JACS.* 2006;390-399
Severe Abdominal Infection

**Arch Surg 1993;128:193-198**

- 239 pts with intraabdominal sepsis & APACHE II >10
  - “Open-abdomen” management = 44% mortality
  - “Closed-abdomen” management = 31% mortality
  - $\chi^2 = 1.33$

**Am Surg 2004;70:137-140**

- 81 pts retrospectively reviewed 1998-2002 & compared to historical controls
  - ICU mortality: open – 25%, closed – 17%, $P=0.335$
  - Hospital mortality: open – 33%, closed – 25%, $P=0.299$
Physiology of the Open Abdominal Wound and the Evolution of Temporary Abdominal Closure
Physiologic Considerations of the Open Abdominal Wound

- In the first week following an indicated initial operation...
  - Bowel is edematous and massively distended
  - Edema worsens in immediate postop period, dissecting up leaves of mesentery
  - Packs may be needed to control hemorrhage

Miller et al. J Trauma. & Schecter et al. JACS.
2002;53:843-849
2006;390-399
Physiologic Considerations of the Open Abdominal Wound

- After the first week...

  - Distension & edema diminish if systemic inflammatory response subsides
  - Fascia retracts laterally
  - Bowel loops begin to adhere to each other and to posterior aspect of anterolateral wall

Schechter et al. JACS. 2006;390-399
Physiologic Considerations of the Open Abdominal Wound

- Beyond the second week…
  - Granulation tissue covers a fused visceral block
  - Block stuck to a retracted, immobile abdominal wall
  - FROZEN ABDOMEN!

Schechter et al. JACS. 2006;390-399
Goals for Temporary Abdominal Closure

- Tension-free closure without elevating intraabdominal pressure
- Prevent evisceration, control third-space losses, lower bacterial counts, & minimize desiccation or damage to the viscera
- Minimize risk of developing IAH or ACS
- Minimize trauma to abdominal wall and fascia, quantify third-space losses, & facilitate closure of the abdomen
- Allow rapid re-exploration at the bedside

Ivatury et al. Current Surgical Therapy. 2008:1019-1028
Temporary Abdominal Closure

- Skin-only closure
- Plastic abdominoplasty
- Vacuum pack (a.k.a. “the vac-pack”)
- Vacuum-assisted wound management

Schecter et al. JACS. 2006;390-399
Skin-Only (Towel Clip) Closure

Plastic Abdominoplasty

Plastic Abdominoplasty

Plastic Abdominoplasty
Vacuum-Pack Technique

**FIG 1.** The polyethylene sheet is perforated multiple times with a scalpel blade.

**FIG 2.** The polyethylene sheet is then placed over the peritoneal viscera and beneath the peritoneum of the abdominal wall.

Barker et al. J Trauma. 2000;201-207
**Vacuum-Pack Technique**

**FIG 3.** A moist surgical towel(s) is folded to fit the abdominal wall defect, placed over the polyethylene sheet, and positioned below the skin edges.

**FIG 6.** With 100 to 150 mm Hg continuous negative pressure applied to the drains, the plastic polyester adhesive drape is placed over the wound and adjacent abdominal wall skin resulting in a semirigid dressing called the vacuum pack.
A Revolution in Open Abdomen Management...
Preservation of the Peritoneal Space

- Delays adhesion formation between visceral block and anterolateral abdominal wall
- Preserves medial mobility of the abdominal wall
- Extends window for delayed primary closure from one week to one month
- Allows for progressive abdominal closure through gradual fascial approximation

Schechter et al. JACS. 2006;390-399
Vacuum-Assisted Wound Management

- Applies negative pressure to open abdominal wound
- Improves blood flow and lowers bacterial counts in the wound
- Accelerates granulation tissue formation

- Applies medial traction to fascia

Schecter et al. *JACS.* 2006;390-399
Vacuum-Assisted Closure (V.A.C.)

Step 1:
Apply fenestrated non-adherent layer under the fascia and over the omentum or exposed internal organs.
The encapsulated foam helps minimize dressing shift within the abdomen and allows for easy dressing changing.

Step 2:
Secondary foam distributes negative pressure over the abdomen. Perforations in the foam enable appropriate sizing of the foam to fit the wound size. One or two layers can be used as required.

Step 3:
Apply semi-occlusive drape over the abdominal opening. Cut a two cm hole in drape, four pieces of drape included per dressing.

Step 4:
Apply the TR.A.C. Pad* and initiate V.A.C.* therapy.

Encapsulated Foam with Non-Adherent Layer

V.A.C.* Drape

Perforated Black Foam

TR.A.C. Pad

Open Abdomen
Vacuum-Assisted Closure (V.A.C.)
Morbidity and Mortality of the Open Abdomen
Enteroatmospheric Fistula: The Achilles Heel of the Open Abdomen

- **Enterocutaneous fistula**: a communication between the GI tract and the skin

- **Enteroatmospheric fistula**: a hole in exposed bowel in the middle of an open abdomen

Schechter et al. *JACS*. 2006;390-399
Enteroatmospheric Fistula

- No well-vascularized soft tissue overlying the fistula
- No tract; precludes possibility of spontaneous healing
- Ongoing succus → complex wound, severe catabolism, and very high mortality

Schecter et al. JACS. 2006;390-399
Fistulas: Treatment Goals

- Resuscitation and correction of electrolyte disturbances
- Control of sepsis
- Nutritional support
- Meticulous skin care
- Definitive care

Enteroatmospheric Fistula: 
Principles of Management

- Prevention
- Attempt to seal the fistula
- Control fistula effluent

Schecter et al. *JACS*. 2006;390-399
A novel approach to the problem of intestinal fistulization arising in patients managed with open peritoneal cavities

Stephen Girard, M.D.*, Matthew Sideman, M.D.*, David A. Spain, M.D.*

*Department of Surgery, University of Louisville School of Medicine, Louisville, KY 40292, USA

Manuscript received October 16, 2001; revised manuscript April 29, 2002
The Floating Stoma

Fig. 1. Photograph showing proximal and distal loops sutured directly to the openings in the plastic bag, creating an ileostomy and a mucous fistula.

Fig. 2. Photograph showing an ileostomy bag fitted around the stoma.

Subramaniam et al. J Trauma. 2002;53:386-388
Enteroatmospheric Fistula: *Principles of Management*

- Cover fistula with well-vascularized soft tissue
- Resect chronic fistula when patient is fit and infection free
- Daily attention by experienced staff

Schecter et al. *JACS.* 2006;390-399
Myofascial Flap Coverage of ECF

Myofascial Flap Coverage of ECF

Myofascial Flap Coverage of ECF

Myofascial Flap Coverage of ECF

Myofascial Flap Coverage of ECF

Myofascial Flap Coverage of ECF

Myofascial Flap Coverage of ECF

Giant Ventral Hernia
Morbidity and Mortality of DCL in Survivors

- 250 laparotomies for penetrating abdominal injury (1997-2000, Emory)
- 17.9% DCL rate

Nicholas et al. J Trauma. 2003:55;1095-1110
ICU & Hospital LOS and the Open Abdomen

<table>
<thead>
<tr>
<th></th>
<th>ICU LOS</th>
<th>Range</th>
<th>HLOS</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>6.1</td>
<td>0-115</td>
<td>18.1</td>
<td>1-243</td>
</tr>
<tr>
<td>Open Abdomen</td>
<td>11.1</td>
<td>0-115</td>
<td>33.8</td>
<td>1-243</td>
</tr>
<tr>
<td>Closed Abdomen</td>
<td>2.6</td>
<td>0-59</td>
<td>12.4</td>
<td>1-139</td>
</tr>
<tr>
<td>Open Survivors</td>
<td>28.6</td>
<td>2-115</td>
<td>56.8</td>
<td>8-243</td>
</tr>
<tr>
<td>Closed Survivors</td>
<td>2.8</td>
<td>0-59</td>
<td>13.5</td>
<td>1-139</td>
</tr>
</tbody>
</table>

Nicholas et al. J Trauma. 2003:55;1095-1110
Closure of the Open Abdomen
Open Abdomen
  ↓
Vacuum Pack*
  ↓
Re-operation
  ↓
Able to Close Abdomen?
  ↓
Yes
  ↓
Close fascia
  ↓
No
  ↓
VAFC
  ↓
Re-operation
  ↓
Able to Close Abdomen?
  ↓
Yes
  ↓
VAFC (attempt partial closure)
  ↓
No
  ↓
Repeat Every 3-5 Days Until**
Closure of the Open Abdomen

- Planned Ventral Hernia: Absorbable Mesh Closure and Skin Grafting
- Vacuum Pack Technique
- V.A.C. Assisted Fascial Closure
- Wittmann Patch (and other nonabsorbable mesh prostheses)
Planned Ventral Hernia:
*Absorbable Mesh Closure and Skin Grafting*

- Inability to approximate linea alba primarily
- Absorbable mesh sewn to fascial edge in tension-free manner
- Visceral mass allowed to granulate
- Split-thickness placed for wound closure
Planned Ventral Hernia:
Absorbable Mesh Closure and Skin Grafting

Figure 1. Diagram of the four-staged management scheme for treating acute abdominal wall defects.
Planned Ventral Hernia: Absorbable Mesh Closure and Skin Grafting

- No wound-related mortality
- Fistula rate = 9%
- 21 pts underwent reconstruction
- Recurrent hernias:
  - 33% of mesh abdominoplasty (N=12)
  - 11% of components separation technique (N=9)

24 pts died from initial disease

Planned Ventral Hernia: Absorbable Mesh Closure and Skin Grafting

- Disadvantages
  - Return to OR after long delay (8-12+ months)
  - Large open wound is a huge catabolic drain
  - Granulating bowel is vulnerable to injury and fistula formation
    - sepsis, increased catabolism, complex wound management
  - Planned hernia approach places heavy burden on hospital resources

Schecter et al. JACS. 2006;390-399
Vacuum-Pack Technique

- 216 vac packs performed in 112 pts
- 69% achieved primary closure
- 2.8% for IAH
- 5.3% for inability to achieve tension free closure
- 22.3% underwent Vicryl mesh closure
- 20% for DCL
- 55% for reexploration
- 4.5% developed ECF
- 5.3% for inability to achieve tension free closure
- 4.5% developed intraabdominal abscesses
- 16.7% for combination of factors
- No wound related mortality

Barker et al. J Trauma. 2000;201-207
Vacuum Assisted Fascial Closure: 

Advantages

- Allows fascia to be brought together in stages to avoid tension
- Achieves closure in 10-12 days, preventing long term exposure of edematous bowel to atmosphere and formation of fistula
- Obviates need for abdominal wall reconstruction in many cases
- Fewer dressing changes; easier ICU care

Ivatury. J Trauma. 2003:55;1160-1161
Vacuum Assisted Fascial Closure: Disadvantages

- Is VAFC superior to vacuum pack closure to justify its higher cost?

- Can technique be applied to patients who have bowel edema, not from ascities and third-space fluids, but due to sepsis and multiorgan failure?
V.A.C. Assisted Fascial Closure

- 26 month study period (Memorial Herman Hospital, Texas)
- 86% primary closure in 29 pts using VAWC at mean of 7 ± 1 days
- 7% fistula rate

Suliburk et al. J Trauma.
2003:55;1155-1160
V.A.C. Assisted Fascial Closure

- Wake Forest Experience, 2001-2003

- 53 of 212 laparotomies performed for trauma managed w/open abdomen

- 88% Closure rate with VAFC (38 pts)

- Mean time 9.5 days

- 4.6% wound dehisence

- 2.3% ventral hernia rate
Primary Closure of Open Abdomen

FIG. 1. Outline of the study.
Primary Closure of Open Abdomen

**Table 2. Overall Outcomes for Patients Requiring Open Abdomen**

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Open Abdomen (n = 93)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Death</td>
<td>14.0% (13/93)</td>
</tr>
<tr>
<td>Any complication</td>
<td>63.4% (59/93)</td>
</tr>
<tr>
<td>Any abdominal complication</td>
<td>45.2% (42/93)</td>
</tr>
<tr>
<td>Complications</td>
<td></td>
</tr>
<tr>
<td>Superficial SSI</td>
<td>16.1% (15/93)</td>
</tr>
<tr>
<td>Deep SSI</td>
<td>20.4% (19/93)</td>
</tr>
<tr>
<td>Intra-abdominal abscess</td>
<td>34.4% (32/93)</td>
</tr>
<tr>
<td><strong>Entero-atmospheric fistula</strong></td>
<td>15.1% (14/93)</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>19.4% (18/93)</td>
</tr>
<tr>
<td>Sepsis</td>
<td>30.1% (28/93)</td>
</tr>
<tr>
<td>ARDS</td>
<td>9.7% (9/93)</td>
</tr>
<tr>
<td>DVT</td>
<td>2.2% (2/93)</td>
</tr>
<tr>
<td>PE</td>
<td>2.2% (2/93)</td>
</tr>
<tr>
<td>Ventilator days, median (range)</td>
<td>5 (1–54)</td>
</tr>
<tr>
<td>ICU days, median (range)</td>
<td>10 (1–100)</td>
</tr>
<tr>
<td>Hospital days, median (range)</td>
<td>22 (1–304)</td>
</tr>
</tbody>
</table>

The statistics in the table are per cent (number of cases/number of patients in group) unless stated otherwise.

SSI, surgical site infection; ARDS, acute respiratory distress syndrome; DVT, deep venous thrombosis; PE, pulmonary embolism; ICU, intensive care unit.

**Table 5. Independent Predictors of Definitive Abdominal Closure Failure after Stepwise Logistic Regression**

<table>
<thead>
<tr>
<th>Step</th>
<th>Variable Selected</th>
<th>$R^2$</th>
<th>Adjusted Odds Ratio (95% CI)</th>
<th>$P$ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Deep surgical site infection</td>
<td>0.42</td>
<td>17.4 (2.6–115.8)</td>
<td>0.003</td>
</tr>
<tr>
<td>2</td>
<td>Intra-abdominal abscess</td>
<td>0.10</td>
<td>7.4 (1.1–51.0)</td>
<td>0.042</td>
</tr>
</tbody>
</table>

$R = $ correlation coefficient.
Wittmann Patch
Wittmann Patch

Tensile Strength of Artificial Burr

Pounds Required to Disrupt the Burr

<table>
<thead>
<tr>
<th>Adhering Surface in cm²</th>
<th>5</th>
<th>10</th>
<th>13</th>
<th>27</th>
<th>37</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Usual Burr Surfaces are < 100 - 500 cm²)
Wittmann Patch

Table 2 Incidence of Delayed Fascial Closure According to Method of Temporary Wound Coverage

<table>
<thead>
<tr>
<th>Method</th>
<th>n</th>
<th>Delayed Fascial Closure (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Patch</td>
<td>23</td>
<td>30</td>
</tr>
<tr>
<td>Sterile IV bag</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>Vac-pack</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>V.A.C.</td>
<td>9</td>
<td>67</td>
</tr>
<tr>
<td>Absorbable mesh</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Wittmann Patch</td>
<td>36</td>
<td>78</td>
</tr>
</tbody>
</table>

![Graph](image)

![Figure 1](image)

Weinberg et al. J Trauma. 2008;65:345-348

  - 26 pts
  - 83% delayed primary fascial closure rate
  - Mean time 13.1 days
Nonabsorbable Mesh

Polypropylene

Expanded Polytetrafluoroethylene (ePTFE)

Ivatury et al. Current Surgical Therapy. 2008:1019-1028
Abdominal Wall Reconstruction
Suitability for Reconstruction?

Patient A

Patient B
Patient B
Abdominal Wall Reconstruction

- Human Acellular Dermis (Alloderm)
- Component Separation Reconstruction
- Autologous Fascia Grafts
- Flap Reconstruction
- Bipedicle Flap Closure and Delayed Retrorectus Prosthetic Mesh Repair
Abdominal Wall Reconstruction

- Human Acellular Dermis (Alloderm)
- Component Separation Reconstruction
- Autologous Fascia Grafts
- Flap Reconstruction
- Bipedicle Flap Closure and Delayed Retrorectus Prosthetic Mesh Repair
Table 1: Initial Hospitalization Data

<table>
<thead>
<tr>
<th>Pt #</th>
<th>Initial Size (area cm²)</th>
<th># Pieces of HADM</th>
<th>Days to HADM Placement</th>
<th>Hospital LOS</th>
<th>ICU LOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>450</td>
<td>6</td>
<td>18</td>
<td>84</td>
<td>55</td>
</tr>
<tr>
<td>2</td>
<td>760</td>
<td>15</td>
<td>15</td>
<td>62</td>
<td>23</td>
</tr>
<tr>
<td>3</td>
<td>270</td>
<td>3</td>
<td>10</td>
<td>31</td>
<td>21</td>
</tr>
<tr>
<td>4</td>
<td>75</td>
<td>2</td>
<td>2</td>
<td>16</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>468</td>
<td>4</td>
<td>17</td>
<td>23</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>108</td>
<td>1</td>
<td>38</td>
<td>135</td>
<td>103</td>
</tr>
<tr>
<td>7</td>
<td>345</td>
<td>5</td>
<td>1</td>
<td>135</td>
<td>76</td>
</tr>
<tr>
<td>8</td>
<td>405</td>
<td>6</td>
<td>21</td>
<td>85</td>
<td>58</td>
</tr>
<tr>
<td>9</td>
<td>770</td>
<td>9</td>
<td>18</td>
<td>90</td>
<td>62</td>
</tr>
<tr>
<td>10</td>
<td>800</td>
<td>9</td>
<td>32</td>
<td>95</td>
<td>88</td>
</tr>
<tr>
<td>Mean (± SEM)</td>
<td>425.1 ± 75.8</td>
<td>6 ± 1.3</td>
<td>17.2 ± 3.7</td>
<td>75.6 ± 13.5</td>
<td>49.5 ± 11.0</td>
</tr>
</tbody>
</table>

Table 2: Follow-up Data and Outcomes

<table>
<thead>
<tr>
<th>Pt #</th>
<th>30 Days Recurrence</th>
<th>6 Months Recurrence</th>
<th>1 year</th>
<th>Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>None</td>
<td>None</td>
<td>Laxity</td>
<td>Abscess requiring perc drain</td>
</tr>
<tr>
<td>2</td>
<td>None</td>
<td>Yes</td>
<td>Laxity</td>
<td>HADM infection</td>
</tr>
<tr>
<td>3</td>
<td>None</td>
<td>LTF</td>
<td>Laxity</td>
<td>Skin-flap hematoma</td>
</tr>
<tr>
<td>4</td>
<td>None</td>
<td>Laxity</td>
<td>Laxity</td>
<td>None</td>
</tr>
<tr>
<td>5</td>
<td>No follow-up</td>
<td>Laxity</td>
<td>Laxity</td>
<td>None</td>
</tr>
<tr>
<td>6</td>
<td>None</td>
<td>Expired</td>
<td>Expired</td>
<td>Wound infection/dehiscence</td>
</tr>
<tr>
<td>7</td>
<td>Yes</td>
<td>Laxity</td>
<td>Laxity</td>
<td>None</td>
</tr>
<tr>
<td>8</td>
<td>None</td>
<td>None</td>
<td>LTF</td>
<td>None</td>
</tr>
<tr>
<td>9</td>
<td>None</td>
<td>Expired</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>10</td>
<td>None</td>
<td>LTF</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

LTF, lost to follow-up; HADM, human acellular dermal matrix.
Abdominal Wall Reconstruction

- Human Acellular Dermis (Alloderm)
- Component Separation Reconstruction
- Autologous Fascia Grafts
- Flap Reconstruction
- Bipedicle Flap Closure and Delayed Retrorectus Prosthetic Mesh Repair
Component Separation Reconstruction

- Elevated laterally based skin flap
- External oblique
- Internal oblique
- Rectus abdominis
- Lap sponge over intestines in area of defect

---

Component Separation Reconstruction
Component Separation Reconstruction

- 4 year period
- 22 patients underwent reconstruction
- Defects 6-14 cm (width) x 10-24 cm (height)
- Minor complications:
  - Surgical site infection in 2 pts
  - Wound seroma in 1 pt
- Recurrent incisional hernia in 1 patient at 8 months

Modified Component Separation Technique

Modified Component Separation Technique

- 14 fistula (5% of total, 8% of survivors)
- 0% wound related mortality
- 73 of 120 underwent reconstruction
- 4% recurrent hernia rate

Abdominal Wall Reconstruction

- Human Acellular Dermis (Alloderm)
- Component Separation Reconstruction
- Autologous Fascia Grafts
- Flap Reconstruction
- Bipedicle Flap Closure and Delayed Retrorectus Prosthetic Mesh Repair
Autologous Fascia Grafts

- 1923 – Gallie & LeMesurier
  - Used strips of fascia as living sutures for inguinal hernia repair

- 1956 – Hamilton
  - Used fascia lata grafts for abdominal wall reconstruction
  - In series of 45 pts with incisional hernias:
    - 6% recurrence rate
    - 0% recurrence rate in 8 pts with infected wounds

Autologous Fascia Grafts

- Largely abandoned due to:
  - Readily available mesh prostheses
  - Donor wound morbidity

- Situations in which fascia grafts are useful:
  - Large defects >10 cm
  - Contaminated wounds
  - Presence of ECF/EAF
  - Exposed mesh from previous hernia repair

Autologous Fascia Grafts
Autologous Fascia Grafts

- 32 patients over 9 years (University of Maryland)

- Abdominal wall reconstruction with autologous fascia lata grafts

- Mean graft size: 10 x 17cm
Autologous Fascia Grafts

1998;101;979-986
Autologous Fascia Grafts

- Recurrent hernia rate 9%
- No cases of lateral knee instability
- Follow-up period of 27 months (3 to 106 months)
- Laparotomy performed through intact patch in 3 pts
  - No evidence of subsequent recurrent hernia

<table>
<thead>
<tr>
<th>Abdomen</th>
<th>Thigh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cellulitis (3)</td>
<td>Hematoma (1)</td>
</tr>
<tr>
<td>Seroma (2)</td>
<td>Skin dehiscence (1)</td>
</tr>
<tr>
<td>Skin dehiscence (7)</td>
<td>Seroma (2)</td>
</tr>
<tr>
<td>Small bowel obstruction (1)</td>
<td></td>
</tr>
</tbody>
</table>
Abdominal Wall Reconstruction

- Human Acellular Dermis (Alloderm)
- Component Separation Reconstruction
- Autologous Fascia Grafts
- Flap Reconstruction
- Bipedicle Flap Closure and Delayed Retrorectus Prosthetic Mesh Repair
Flap Reconstruction

2000:232;586-596
Flap Reconstruction

Flap Reconstruction

### Flap Reconstruction


#### Flaps

<table>
<thead>
<tr>
<th>Flaps</th>
<th>Zones</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1A</td>
</tr>
<tr>
<td><strong>Latissimus dorsi</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Rectus abdominis</strong></td>
<td>•</td>
</tr>
<tr>
<td>Superiorly based</td>
<td></td>
</tr>
<tr>
<td>Inferiorty based</td>
<td></td>
</tr>
<tr>
<td>Advancement</td>
<td></td>
</tr>
<tr>
<td><strong>External oblique adv.</strong></td>
<td></td>
</tr>
<tr>
<td>Transposition</td>
<td></td>
</tr>
<tr>
<td>Expansion</td>
<td>•</td>
</tr>
<tr>
<td><strong>Tensor fascia lata</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Rectus femoris</strong></td>
<td></td>
</tr>
</tbody>
</table>
Flap Reconstruction

Flap Reconstruction

2000:232,586-596
Table 3. RECURRENT BY TECHNIQUE

<table>
<thead>
<tr>
<th>TECHNIQUE</th>
<th>TYPE I</th>
<th></th>
<th>TYPE II</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Recurrence</td>
<td>Total Repairs</td>
<td>Recurrence Rate</td>
<td>Recurrence</td>
<td>Total Repairs</td>
</tr>
<tr>
<td>Direct</td>
<td>2</td>
<td>10</td>
<td>20%</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Mesh</td>
<td>2</td>
<td>26</td>
<td>7%</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>Flap</td>
<td>0</td>
<td>9</td>
<td>0%</td>
<td>3</td>
<td>42</td>
</tr>
<tr>
<td>Combined*</td>
<td>1</td>
<td>3</td>
<td>33%</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Totals</td>
<td>5</td>
<td>50</td>
<td>10%</td>
<td>4</td>
<td>60</td>
</tr>
</tbody>
</table>

* Combined = Flap+Mesh.
Immediate Closure of the Open Abdomen with Bilateral Bipedicle Anterior Abdominal Skin Flaps and Subsequent Retrorectus Prosthetic Mesh Repair of the Late Giant Ventral Hernias

Suvit Sriussadaporn, MD, Rattaplee Pak-art, MD, and Sukanya Bunjongsat, MD
Bilateral Bipedicle Anterior Abdominal Skin Flaps...
Retrorectus Prosthetic Mesh Repair...
...of Late Giant Ventral Hernias

![Images of surgical procedures](A, B, C)

**Table 1: Details of Patients**

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age (yr)</th>
<th>Gender</th>
<th>Causes of the Open Abdomen</th>
<th>Development of Giant Ventral Hernia</th>
<th>Timing for Ventral Hernia Repair (mo)</th>
<th>Follow-Up Time (mo)</th>
<th>Recurrent Hernia</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30</td>
<td>Male</td>
<td>Blunt abdominal trauma</td>
<td>Yes</td>
<td>24</td>
<td>72</td>
<td>No</td>
</tr>
<tr>
<td>2</td>
<td>25</td>
<td>Male</td>
<td>Blunt abdominal trauma</td>
<td>Yes</td>
<td>48</td>
<td>60</td>
<td>No</td>
</tr>
<tr>
<td>3</td>
<td>53</td>
<td>Female</td>
<td>Severe peritonitis</td>
<td>Yes</td>
<td>12</td>
<td>52</td>
<td>No</td>
</tr>
<tr>
<td>4</td>
<td>38</td>
<td>Male</td>
<td>Penetrating abdominal trauma</td>
<td>Yes</td>
<td>27</td>
<td>17</td>
<td>No</td>
</tr>
<tr>
<td>5</td>
<td>52</td>
<td>Female</td>
<td>TB peritonitis with entero-cutaneous fistula</td>
<td>Yes</td>
<td>14</td>
<td>8</td>
<td>No</td>
</tr>
<tr>
<td>6</td>
<td>35</td>
<td>Female</td>
<td>Penetrating abdominal trauma</td>
<td>Yes</td>
<td>9</td>
<td>4</td>
<td>No</td>
</tr>
<tr>
<td>7</td>
<td>22</td>
<td>Male</td>
<td>Blunt abdominal trauma</td>
<td>Yes</td>
<td>14</td>
<td>1</td>
<td>No</td>
</tr>
<tr>
<td>8</td>
<td>44</td>
<td>Male</td>
<td>Blunt abdominal trauma</td>
<td>Yes</td>
<td>24</td>
<td>2</td>
<td>No</td>
</tr>
<tr>
<td>9</td>
<td>34</td>
<td>Male</td>
<td>Blunt abdominal trauma</td>
<td>Yes</td>
<td>7</td>
<td>2</td>
<td>No</td>
</tr>
</tbody>
</table>

* Interval from closure of the open abdomen to repair of the giant ventral hernias.

** Interval from date of repair of the giant ventral hernias to December 2001.
Conclusions
Conclusions

- Most open abdomens following trauma or ACS can eventually achieve primary fascial closure.

- Open abdomens persist due to ongoing SIRS, sepsis, or fascial loss.

- Vacuum-pack closure delays natural history of open abdominal wounds.
Conclusions

- VAFC/VAWC associated with high delayed fascial closure rates, though studies are limited.

- Open abdomens should never be closed under tension.

- Nonabsorbable mesh (e.g. prolene) should not be used in the management of the open abdomen.
Conclusions

- Efforts to achieve delayed primary fascial closure should be exhausted before pursuing a planned ventral hernia strategy.

- A variety of abdominoplasty options exist to reconstruct complex abdominal wall defects.
Acknowledgements
This presentation is available for further review at:

www.chaitannarsule.com/surgery
The Management of the Abdomen That Won’t Close

Chaitan K. Narsule, M.D.    PGY-V    December 17, 2008