Abdominal Damage Control in Pediatric Trauma

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Disclosure Information
Speaker:
No Disclosures

Accreditation Statement
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Objectives
• Describe principles of damage control
• Describe clinical situations in which damage control strategies improve survival
• Describe methods of abdominal wall reconstruction for patients treated with damage control methods
Definition: What is damage control?

- Origin: naval and maritime disasters
- Repair whatever is necessary to keep the ship afloat
- Repairs are temporary and crude
- Definitive repair is performed later
- “the actions needed to deal with any problem that may jeopardize an endeavor” (wikipedia)

USS Cole: damage control prevented sinking after terrorist attack

Vascular fellow practicing damage control techniques
This is NOT damage control…

AN ENGROSSING STORY OF TEENAGE FRIENDSHIP AND ADULT BETRAYAL, FEATURING A HIGH-POWERED CRISIS CONSULTANT WHO GETS SWEPT UP IN MURDER AND SCANDAL INVOLVING A WEALTHY POLITICAL FAMILY.

...Or is it?

• Maggie Silver is solidly middle class, with a mortgage to pay and an ill mother to support. She is doing her best to scramble up the ladder at an elite PR firm in Southern California whose clients are movie stars and famous athletes. Now, Maggie tackles her toughest client yet: Senator Henry Paxton, a distinguished statesman who also happens to be the father of Anabelle, Maggie’s estranged best friend from high school.

• Senator Paxton’s young female aide has been found murdered, and Maggie must run damage control to prevent the scandal from growing.

Damage control – trauma definition

• Fix the pathophysiology now
• Keep the ship (patient) afloat (alive)
  • Stop the hemorrhage
  • Stop the contamination
  • Stop the coagulopathy
• Fix the pathology later
  • Bowel reconstruction
  • Abdominal wall reconstruction
Damage control – operative definition

• Fix the **pathophysiology** now
  • Keep the ship (patient) afloat (alive)
    • **Control** the blood loss (coagulopathy)
    • **Control** the heat loss
    • **Control** the acidosis
• Fix the **pathology** later
  • Bowel Reconstruction
  • Abdominal wall reconstruction

The origins of damage control: Pediatric Surgery

• Staged abdominal reconstruction for congenital abdominal wall defects
• Management of Congenital Diaphragmatic Hernia patients with Extracorporeal Membrane Oxygenation (ECMO)
Gastroschisis

- Pathophysiology:
- A newborn with bowel evisceration due to gastroschisis will develop:
  - Hypothermia
  - Fluid Losses
  - Acidosis
  - Death

But (due to limited abdominal domain) primary closure may lead to:
- Abdominal compartment syndrome
- renal failure
- respiratory failure
- acidosis
- death
Solution: neonatal damage control

Gastroschisis – daily reduction

Gastroschisis
Gastroschisis Damage Control Case #2

- Return everything to the abdomen
- Gastrostomy Tube and proximal stoma
- No Reconstruction
- Intravenous nutrition + "sham" feeds
- Wait 10-12 weeks
- Go back and put things together
Newborn with severe respiratory distress

Name 3 problems on this chest film

**Congenital Diaphragmatic Hernia**

- Pathology:
  - Abdominal contents in right chest
  - Mediastinal compression – poor lung growth
  - Decreased lung volume

- Pathophysiology:
  - Persistent fetal circulation
  - Hypoxia
  - Respiratory failure
  - Hypothermia
  - Death

Immediate post-natal repair of diaphragm with reduction of abdominal contents may result in:

- Abdominal compartment syndrome
- Worsening respiratory failure (due to elevation of the diaphragms) with acidosis
- Continuing/worsening hypoxia
- Shock, hypothermia
- Death
**Congenital Diaphragmatic Hernia**

- Damage Control — **Correct the pathophysiology**:
  - Persistent fetal circulation: Circulate the blood outside the body with a roller pump
  - Hypoxia: oxygenate the blood outside the body
  - Respiratory failure: treat acidosis
  - Hypothermia: warm blood before circulating it back to the patient

- Solution: ECMO
ECMO

Blood is withdrawn from the internal jugular vein
• Oxygenated
• Warmed
• pH balanced
• Propelled (pumped)
And returned via the common carotid artery

• Definitive repair of diaphragm can be delayed for days

Damage Control in Pediatric Trauma

• Literature review
• Pubmed search of “damage control trauma” yields 9002 results
• Pubmed search of “damage control trauma pediatric” yields 227 results
• Limit above to “human species:” 138 results
• Search “Damage control laparotomy:” 57 results
• Search “Damage control laparotomy pediatric:” 1 result

The one “pediatric DCL” article is about premature newborns with this disease. (What is the diagnosis?) 1500 gm, 4 days old
Necrotizing Enterocolitis

- #1 killer of hospitalized premature infants
- Operative management includes:
  - Resection and stomas
  - “second look” laparotomy
  - Open abdomen (rare)
- Note: hypothermia or hemorrhage will kill these patients quickly
Lethal Triad

Hypothermia

Coagulopathy

Acidosis

Lethal Triad

• Hypothermia – children have less insulation, higher metabolic rate, more prone to hypothermia, which leads to coagulopathy...
• Coagulopathy – cold patients bleed, bleeding patients get transfused, transfusions make patients cold...
• Acidosis – hypothermia and hypovolemia causes acidosis, which depresses organ function, leading to coagulopathy (liver) and acidosis (heart)

Lethal Triad (Case Study 1)

14 year old male – injured in the winter
• “skitching” (skating + hitch hiking = “skitching”)
• Struck and run over by vehicle on snowy street
• Transported to trauma center by EMS
• Arrived in shock (heart rate 155, poor perfusion, complaining of abdominal pain and right shoulder pain)
Lethal Triad Case Study

14 year old male – struck by vehicle

- Trauma resuscitation:
  - IV resuscitation initiated
  - Patient remains tachycardic with worsening abdominal pain
  - Taken to CT scanner to evaluate abdomen
Hypothermia Case Study - Pack

- Exploratory Laparotomy for pneumoperitoneum
- No bowel injury found, actively bleeding liver
- “Several” units PRBC transfused
- Liver packed
- Open abdomen with negative pressure dressing connected to “large” canister
- taken to PICU
- Body temperature = 93 degrees on arrival to PICU

Warming measures used on this patient

- Warm ambient temperature in patient room
- Forced air blanket “sandwich”
- Warming lights
- Thermal hat
- Warmed IV fluids including all blood products
- Warmed ventilator circuit

Effect of body temperature on bleeding

At 93 degrees, 500 ml wound canister filled every 15 minutes (2 liters per hour)

Above 97 degrees, 500 ml canister filled every 4 hours (125 ml/hour)

Patient survived

Patient survived
Damage Control Laparotomy - Pediatrics

Indications:
• Abdominal compartment syndrome
• Uncontrolled abdominal hemorrhage
• Uncontrolled sepsis
• Lethal triad

Phases of Damage Control Laparotomy:
• Acute
• Maintenance
• Reconstruction

Acute Phase
• Patient in ICU with ventilator support
• Daily chest imaging (pleural effusions)
• Every other day dressing changes + mini laparotomy and washout
• Nutrition: enteral is preferred (g-tube?)
**Damage Control Laparotomy - Pediatrics**

**Maintenance Phase**
- Stable patient (inpatient or outpatient)
- Enteral feeds (g-tube)
- Twice weekly dressing changes under conscious sedation
- Split thickness skin graft to wound if necessary

**Reconstruction phase**
Approximately 1 year after initial injury
Elective procedure
Pre-op CT scan
Pinch test

**Abdominal Wall Reconstruction - neonates**
Skin flaps covering PTFE patch

6 weeks after operation #1
Abdominal Wall Reconstruction

Options
- Early Closure
  - “Delayed” primary closure
  - Closure with prosthetic
- Late Closure (6 months to 1 year later)
  - Ventral Hernia Repair with prosthetic
  - Ventral Hernia Repair without prosthetic ("component separation")

Abdominal reconstruction algorithm for adults
Dicocco et al.
Surgery, 2012;151:118-25
Abdominal Wall Reconstruction

9 year old girl with ruptured appendix
• Appendectomy at outside hospital
• Arrived in septic shock, organ failure
• Found to have bowel perforation and severe peritonitis
• Abdominal wash out, bowel resection, stoma, g-tube
• Abdomen left open with negative pressure dressing

1 year post appendectomy
Abdominal Wall Reconstruction with Autologous Tissue
Abdominal Wall Construction

Case History
- 17 year old football player with GSW to abdomen and IVC injury
- Treated at adult Level 1 trauma center
- Transferred to NCH for rehab
- Rehab physician calls trauma team because the wound “looks funny”

“entero-atmospheric fistula”
Abdominal Wall Reconstruction

- Initial exam: open abdomen with "entero-atmospheric" fistula
- Treated on Pediatric Trauma Service for nearly 1 year (wound care + IV nutrition + skin graft)
  - fistula takedown
  - hernia closure with bioprosthetic patch
  - post op wound infection with recurrence of hernia

Abdominal Wall Construction

Case History continued
- Followed as an outpatient for another 18 months
- Smoking cessation encouraged and achieved
- Plan: Delayed closure of ventral hernia with component separation
“pinch test”

“rectus squeeze test”
Rectus muscles closed at midline
Internal oblique
Cut edge of external oblique

Abdominal Wall Reconstruction - child
6 year old female
Lap belt injury from high speed MVC
- Grade 4 kidney injury on right
- Failed non-operative management
- Evidence of continuing hemorrhage
- Developed abdominal compartment syndrome
  - Anuria
  - Maximal ventilator settings (oscillator)
Abdominal Wall Reconstruction – child

- Decompressive laparotomy at bedside in PICU
- Returned to conventional ventilator
- Transported to operating room emergently
- Right nephrectomy performed
- Abdomen left open

6 months later: split thickness skin graft to close wound
• Infiltrate local anesthetic subcutaneously around the borders of the hernia
• 0.25% bupivicaine with epinephrine 1:200,000
  • (1 ml/kg)
  • improves dissection
  • Improves hemostasis
  • Decreases narcotic requirement
Component Separation for Omphalocele

- 7 year old male born with omphalocele
- Treated without operation
- Presents to surgery clinic for evaluation
- Referred to plastic surgery for tissue expanders
Post-operative care

- NG tube until bowel function returns
- Drains stay in until output is minimal
- Abdominal wall binder (worn approximately 24/7)
- PCA for pain management
- DVT prophylaxis for teens

Conclusions

1. Damage Control is a component of the initial resuscitation of the severely injured pediatric trauma patient
2. The goal of damage control is to save the patient’s life
Conclusions

1. Damage Control is a component of the initial resuscitation of the severely injured pediatric trauma patient
2. The goal of damage control is to save the patient’s life
3. The lethal pathophysiology must be corrected before the patient’s physiologic reserve is exhausted
4. Definitive repair can wait until later

Conclusions – Pediatric Damage Control

1. Damage Control is an extension of surgical practices that have been used to treat newborn emergencies for decades
2. The goal is to save the patient’s life – definitive reconstruction can wait
3. Hypothermia is a bigger problem in children compared to adults
4. Children tolerate “damage control hernias” better than adults
Conclusions – Pediatric Damage Control

Before performing an abdominal wall reconstruction, make sure the patient is ready. (pinch test, rectus squeeze)

The abdominal wall reconstruction techniques described for adults appear to be easily adapted for children.

Thank You!
The End