Minimally Invasive Surgery and Its Role in Pediatric Trauma

Anthony L DeRoss, MD
Assistant Professor of Surgery and Pediatrics
Division of Pediatric Surgery
Rainbow Babies and Children’s Hospital
Case Western Reserve University
School of Medicine
Cleveland, Ohio
Objectives

• Participants will understand:
  – Basic concepts of minimally invasive surgery
  – Applications of minimally invasive surgery in the treatment of trauma patients
  – Limitations of minimally invasive surgery in trauma
History

- Hippocrates
- 400 BC
- Used anoscope to evaluate hemorrhoids

- Speculum found in Pompeii ruins (AD 70)
- Abulkasim used reflected light for cervical exam (AD 1000)

History

History

• Philip Bozzini (1806)
  – Endoscope with a light source
  – Lichtleiter (light conductor)
  – Mirrors and reflected candlelight
  – Cystoscopy and vaginoscopy

• Antoine Jean Desormeaux
  – Flame light source
  – Alcohol and turpentine
  – Urologic procedures
History

• George Kelling (1901)
  – German surgeon
  – *Coelioskope*
  – Canine model
  – Insufflated with sterile air
  – Cystoscope in abdomen
History

• Hans Christian Jacobaeus (1911)
  – Swedish internist
  – Laparothorakoskopie
  – Human subjects

History

- Fiber optics (1950s)
- Flexible endoscopy (1960s)
- In-vitro fertilization (1970s)
- Charge-coupling device (CCD) camera (1982)

http://www.google.com/imgrs?q=colonoscope&hl=en&biw=1280&bih=827&tbm=isch&tbnid=D1wl8bbiDu2T oM:&imgrefurl=http://www.1800endoscope.com/endoscopes/colonoscopes/CF100L.htm&docid=KmgXrGXWJ1V- RM&w=1024&h=768&ei=j1xT16zBevJ0AH3j7HxBw&zoom=1
Why MIS?

• Less Pain (Less Narcotic Use)
• Less Wound Complications
• Shorter Hospital Stay
• Earlier Return To School
• Better Cosmesis
Elective MIS

Laparoscopic Cholecystectomy
10mm to 3mm
2-3 mm Instruments
Urgent MIS?

• Lengthy set-up?
• Lengthy procedure?
• After-hours?
• Dangerous?
Laparoscopic Appendectomy

- Gained popularity in the late 1990's
Clinical Case

- 14 year old male
- Acute onset of abdominal pain
- Peritonitis
- Thermodynamically stable
- 2 AM
- X-ray...
Clinical Case

• 6 year old
• 2 days
  – Nausea
  – Vomiting
  – Abdominal pain
  – No stool
  – No flatus
Clinical Case
MIS?

MIS is NOT POSSIBLE because . . .

- Bowel too distended?
- No visibility?
- Risk of bowel injury?
MIS?

MIS is POSSIBLE because . . .

- Bowel becomes less distended with insufflation
- Single adhesive band?
Small Bowel Obstruction
Small Bowel Obstruction
Omphalomesenteric Band
MISSION POSSIBLE!

- Intussusception
- Incarcerated inguinal hernia
- Ovarian cyst
- Ovarian torsion
- Pyloric stenosis
- Ladd’s procedure
- Congenital diaphragmatic hernia
- Esophageal atresia
- Tracheoesophageal fistula
But What About Trauma?

- Elective MIS ✓
- Urgent MIS ✓
- EMERGERNT MIS ?
Maybe the injury is not as serious as expected…
Or maybe it’s more serious…
Laparoscopy for Blunt Injury?
Pancreatic Injury
Pancreatic Injury
Penetrating Injury
Dr. Mark Wulkan, Emory Univ, Atlanta, GA
Where’s the Data?

There are no randomized controlled studies.
Where’s the Data?

• Berci, et. al. (1991)
  – Adult study
  – 25% incidence of positive findings laparoscopically
  – Successfully managed without intervention
  – Would have resulted in non-therapeutic laparotomies

Where’s the Data?

• Marwan A, et. al. (2010)
  – Retrospective review 1997-2009 (4836 admissions)
  – Level I pediatric trauma center
  – Looked at all trauma laparotomies and laparoscopies
  – Laparoscopies grouped diagnostic or therapeutic
  – Diagnostic success
    • attaining the correct diagnosis
  – Therapeutic success
    • ability to repair the lesion by laparoscopy
  – Avoidance of laparotomy
    • correct diagnosis was obtained
    • problem corrected by laparoscopy without conversion to open

Marwan et al. JTrauma, 69(4), October 2010, 761-764
Where’s the Data?

- Marwan A, et. al. (2010)
  - 92 patients were explored surgically
  - Laparotomy 71 (77%)
  - Laparoscopic 21 (23%)
  - Blunt 47 (51%)
  - Penetrating 35 (38%)
Where’s the Data?

• Marwan A, et. al. (2010)
  – 21 diagnostic laparoscopies
    • 19 acute – all successful
    • 2 delayed – conversion to open to reach diagnosis
  – ISS
    • Diagnostic and therapeutic laparoscopy ISS = 8.58 ± 2.53
    • Laparotomy ISS = 21.54 ± 1.56 (p 0.002)
  – Length of stay (days)
    • Laparoscopic 3.41 ± 0.96
    • Laparotomy 14.74 ± 2.18 (p 0.001)
  – Deaths
    • Laparoscopy 0/21
    • Laparotomy 6/71 (8.5%) (p 0.33)
<table>
<thead>
<tr>
<th>Mechanism</th>
<th>Age</th>
<th>Diagnostic Success</th>
<th>Therapeutic Success</th>
<th>ISS</th>
<th>Reason to Convert</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSW</td>
<td>9.0</td>
<td>+</td>
<td>+</td>
<td>4</td>
<td>—</td>
<td>Retrieval of pellet</td>
</tr>
<tr>
<td>Stab wound</td>
<td>2.8</td>
<td>+</td>
<td>+</td>
<td>13</td>
<td>Reduction of omentum, repair of abdominal wall</td>
<td></td>
</tr>
<tr>
<td>MVC, rollover</td>
<td>7.8</td>
<td>+</td>
<td>—</td>
<td>27</td>
<td>Grade 1 liver laceration, colon hemotoma, no injury</td>
<td></td>
</tr>
<tr>
<td>MVC</td>
<td>8.2</td>
<td>+</td>
<td>—</td>
<td>24</td>
<td>Grade 1 liver laceration, contusion of mid jejunum</td>
<td></td>
</tr>
<tr>
<td>MVC, seat-belt sign</td>
<td>5.2</td>
<td>+</td>
<td>—</td>
<td>10</td>
<td>Duodenal jejunal perforation</td>
<td>Exploratory laparotomy—resection of third and fourth portion duodenum</td>
</tr>
<tr>
<td>GSW to abdomen</td>
<td>5.2</td>
<td>+</td>
<td>+</td>
<td>9</td>
<td>—</td>
<td>Repair of 2 enterotomies, 1 colostomy</td>
</tr>
<tr>
<td>MVC, seat-belt injury 3 wk before admission</td>
<td>8.9</td>
<td>-</td>
<td>-</td>
<td>9</td>
<td>Dense adhesions in RLO</td>
<td>Exploratory laparotomy—resection proximal ileum and reanastomosis</td>
</tr>
<tr>
<td>Bicycle, stab wound to abdomen</td>
<td>9.5</td>
<td>+</td>
<td>—</td>
<td>4</td>
<td>—</td>
<td>Omental injury—retrieval of nail</td>
</tr>
<tr>
<td>Bicycle injury 2 wk before admission</td>
<td>9.3</td>
<td>-</td>
<td>—</td>
<td>9</td>
<td>Dense adhesions</td>
<td>Exploratory laparotomy, missed small bowel injury, repair</td>
</tr>
<tr>
<td>Lawnmower injury/fall</td>
<td>3.0</td>
<td>+</td>
<td>—</td>
<td>18</td>
<td>Matted small bowel with perforation</td>
<td>Exploratory laparotomy, repair of 5 small bowel enterotomies</td>
</tr>
<tr>
<td>MVC seat-belt injury</td>
<td>12.2</td>
<td>+</td>
<td>+</td>
<td>1</td>
<td>—</td>
<td>Single jejunal perforation—repair</td>
</tr>
<tr>
<td>Fall/penetrating wound of abdomen</td>
<td>6.1</td>
<td>+</td>
<td>—</td>
<td>4</td>
<td>—</td>
<td>No peritoneal violation</td>
</tr>
<tr>
<td>GSW right scrotum groin</td>
<td>13.4</td>
<td>+</td>
<td>—</td>
<td>5</td>
<td>—</td>
<td>No peritoneal violation</td>
</tr>
<tr>
<td>MVC</td>
<td>13.0</td>
<td>+</td>
<td>—</td>
<td>17</td>
<td>Left colon degloving injury</td>
<td>Exploratory laparotomy, jejunal laceration repair, anastomosis</td>
</tr>
<tr>
<td>GSW L1Q</td>
<td>15.9</td>
<td>+</td>
<td>—</td>
<td>1</td>
<td>—</td>
<td>No peritoneal violation</td>
</tr>
<tr>
<td>ATV penetrating injury handlebar</td>
<td>14.4</td>
<td>+</td>
<td>—</td>
<td>10</td>
<td>—</td>
<td>No peritoneal violation</td>
</tr>
<tr>
<td>Stab-wound RUQ ice pick</td>
<td>15.4</td>
<td>+</td>
<td>—</td>
<td>1</td>
<td>—</td>
<td>No peritoneal violation</td>
</tr>
<tr>
<td>Abdominal kick, CT no free fluid, worsening pain</td>
<td>7.7</td>
<td>+</td>
<td>—</td>
<td>10</td>
<td>Jejunal perforation with major contamination</td>
<td>Exploratory laparotomy, repair of jejunal laceration, anastomosis</td>
</tr>
<tr>
<td>MVC passenger</td>
<td>5.0</td>
<td>+</td>
<td>—</td>
<td>19</td>
<td>Bilious sanguinous fluid</td>
<td>Exploratory laparotomy, repair of transected duodenum</td>
</tr>
<tr>
<td>MVC passenger</td>
<td>11.4</td>
<td>+</td>
<td>—</td>
<td>10</td>
<td>Mesenteric disruption, active bleeding</td>
<td>Exploratory laparotomy—repair of mesenteric laceration</td>
</tr>
<tr>
<td>GSW to RUQ</td>
<td>10.2</td>
<td>+</td>
<td>+</td>
<td>4</td>
<td>—</td>
<td>Retrieval of pellet, cholecystectomy</td>
</tr>
</tbody>
</table>

GSW, gunshot wound; MVC, motor vehicle crash; ATV, all terrain vehicle; RU(L)Q, right upper (lower) quadrant; CT, computed tomography.
Where’s the Data?

- Marwan A, et. al. (2010)
  - Conclusions
    - Laparotomy was avoided in 62% of patients
    - No missed injuries
  - Helpful in excluding peritoneal violation in stable patients with penetrating trauma

Marwan et al. JTrauma, 69(4), October 2010, 761-764
Where’s the Data?

• Largest published series to date (Feliz A, et. al.)
  – 5-year retrospective review, 7127 admissions
  – Level 1 pediatric trauma center database
  – 113 children (blunt and penetrating mechanisms)
  – 32 patients underwent initial diagnostic laparoscopy
  – 9 (28%) had no injury observed
  – 3 had an injury that required no further therapy
  – 6/32 patients had their injury repaired laparoscopically
  – Laparotomy was therefore avoided in 17 (56%)
  – No missed injuries

Table 1  Demographic information of children undergoing initial laparoscopic exploration or laparotomy

<table>
<thead>
<tr>
<th>Demographics</th>
<th>Laparotomy</th>
<th>Laparoscopy</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>81</td>
<td>32</td>
</tr>
<tr>
<td>Male (%)</td>
<td>58 (72)</td>
<td>22 (69)</td>
</tr>
<tr>
<td>Female (%)</td>
<td>23 (28)</td>
<td>10 (31)</td>
</tr>
<tr>
<td>Age (y)</td>
<td>9.2 ± 4.1</td>
<td>8.7 ± 3.3</td>
</tr>
<tr>
<td>ISS</td>
<td>19.3 ± 12.2</td>
<td>11.3 ± 8.3**</td>
</tr>
<tr>
<td>TRISS</td>
<td>0.831 ± 0.305</td>
<td>0.941 ± 0.168*</td>
</tr>
<tr>
<td>Mechanism</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blunt (%)</td>
<td>74 (91)</td>
<td>26 (81)</td>
</tr>
<tr>
<td>Penetrating (%)</td>
<td>7 (9)</td>
<td>6 (19)</td>
</tr>
<tr>
<td>Glasgow Coma Score</td>
<td>12 ± 5</td>
<td>14 ± 3*</td>
</tr>
<tr>
<td>Length of ICU stay (d)</td>
<td>3.7 ± 7.1</td>
<td>0.6 ± 1.6**</td>
</tr>
<tr>
<td>Length of hospital stay (d)</td>
<td>12.5 ± 11.4</td>
<td>7.4 ± 5.6**</td>
</tr>
</tbody>
</table>

* P = .02.  
** P < .003.
<table>
<thead>
<tr>
<th>Laparoscopic operations</th>
<th>n (%)</th>
<th>Injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnostic laparoscopy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>9 (28)</td>
<td>None</td>
</tr>
<tr>
<td>Nontherapeutic</td>
<td>3 (9)</td>
<td>3 Mesenteric or retroperitoneal hematomas</td>
</tr>
<tr>
<td>Positive laparoscopic repair</td>
<td>6 (19)</td>
<td>3 Perforated viscera</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 Mesenteric defect</td>
</tr>
<tr>
<td>Positive conventional repair</td>
<td>14 (44)</td>
<td>1 Foreign body</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10 Perforated viscera</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 Diaphragmatic rupture</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 Distal pancreatic injury</td>
</tr>
</tbody>
</table>
Fig. 1  Algorithm for laparoscopy in blunt abdominal trauma.
Where’s the Data?

Fig. 2 Algorithm for laparoscopy in penetrating abdominal trauma (abdominal stab or tangential GSWs).
General Guidelines

• Management of identified injuries is dependent upon the minimally invasive skills and judgment of the surgeon.

• Hemodynamically unstable patients should be explored using a conventional laparotomy.

• Typical indications for laparoscopy:
  – To explain free fluid
    (free fluid alone should not mandate exploration)
  – Pain out of proportion to expectations
  – Lap belt sign

Gaines BA and Rutkoski JD. Seminars in Pediatric Surgery (2010) 19, 300-303
Technical Aspects

• General anesthetic
• Maintain c-spine precautions
• Type and cross
• Orogastric tube and Foley catheter
• Preparation for conversion to open
Technical Aspects

• Start with 3 trocars
  – 5mm umbilical
  – 2 additional 3-5mm ports (SP and LLQ)
• Systematic exploration
  – Liver
  – Spleen
  – Diaphragm surfaces
  – Peritoneal surfaces
  – SB from ICV to LOT with mesentery
  – Colon, duodenum, stomach
  – Pancreas and lesser sac (may require additional port)
    (use of pre-op CT)

Gaines BA and Rutkoski JD. Seminars in Pediatric Surgery (2010) 19, 300-303
http://images.med.cornell.edu/body/cornellsurgery/colonrectal/abd_lap.gif
Technical Aspects

• If injury is identified
  – Laparoscopy
    • Repair simple bowel perforation
    • Evaluate rectal injuries
  • Assist with creation of stoma
  • Minor solid organ injuries
    – Topical hemostatic agents
    – Vicryl splenorrhaphy bag
  • Distal pancreatectomy

Gaines BA and Rutkoski JD. Seminars in Pediatric Surgery (2010) 19, 300-303
Technical Aspects

- If injury is identified
  - Thoracoscopy
    - Removal of foreign bodies
    - Evaluation and repair of the diaphragm
    - Release of lung trapped in fibrinous exudate

Gaines BA and Rutkoski JD. Seminars in Pediatric Surgery (2010) 19, 300-303
http://www.worldofstock.com/slides/PHE4076.jpg
The Future Is Now!
Special Acknowledgment

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