Selective Nonoperative Management of Penetrating Abdominal Trauma

Kings County Hospital Center
Verena Liu, MD
10/13/2011
Case Presentation

28M admitted on 8/27/2011 s/p GSW to right upper quadrant and left back

PMH/PSH- none
Meds- none
SH- denies tobacco, drug use, alcohol occasionally
NKDA
Case Presentation

Exam:
VS- temp 99.0 BP 130/80 HR 100
HEENT- EOMI, PERRLA
Chest- CTA b/l
Abd/back- 1 GSW RUQ right anterior axillary line at T10, 1 GSW back left paravertebral L3-L4, abdomen soft, no guarding, no rigidity, tender at GSWs
Ext- warm, pp+
Case Presentation

Labs:
VBG- 7.30/49/51/80%/21/-2
CBC- 9/14/43/249
BMP- 142/3.2/103/22/18/1.15/92
LFTs- 6.9/4.4/44/44/51/0.3
Amylase/lipase- 30/71
Lactate- 8.1
CT abdomen/pelvis

GSW at the right lateral thoracic wall tracking through the abdomen with exit wound in the back. Liver hematoma with perihepatic fluid. Perisplenic hematoma. Hemoperitoneum surrounding loops of bowel at the hepatic flexure. Pneumoperitoneum. Bullet tract extends through liver but trajectory does not appear to align with bowel.
Hospital Course

8/28/2011- admitted to SICU for observation, serial abdominal exams and serial cbc
8/29/2011- in SICU, NPO
  VS- 102.8 BP 120-140/70-80 HR 60-70
  cbc 13/13/40/190 and cbc 14/13/41/186
  abdomen soft, non-tender
8/30/2011- regular diet, transferred to floor
  cbc 11/12/38/174
  abdomen soft, non-tender
8/31/2011- tolerating diet, + BM
  VS- 102.2 BP 133/79 HR 111
  cbc 9/12/36/170
  abdomen soft, non-tender
CT abdomen/pelvis

Thickening and inflammation involving the ascending colon with evidence of active extravasation of contrast from the medial wall of the colon with foci of free air. Stable grade 2 hepatic laceration.
Operation

- Exploratory laparotomy
- Walled-off collection of stool in the right upper quadrant at the hepatic flexure, large hole 3-4 cm in the right colon, necrotic edges
- Right hemicolecctomy with primary anastomosis in the right lower quadrant, irrigation of abdominal cavity, fascial closure, skin stapled intermittendly, packing in between staples
Postoperative Course

POD#1-3 – NPO, NGT removed POD#2, on mefoxin
POD#4- regular diet, return of bowel function, mefoxin discontinued
POD#5- febrile to 102.8, WBC 15
POD#6- CT abdomen/pelvis – no evidence of anastomotic leak, peritoneal fluid collections 4.1 x 3.4 cm at distal ileum, 9.6 x 2.5 cm fluid collection anterior to transverse colon
POD#7- febrile to 101.7, WBC 19, started on zosyn
POD#8- afebrile, WBC 20, wound completely opened for foul-smelling drainage, wound cx- enterobacter cloacae, sensitive to zosyn
Postoperative Course

POD#11- afebrile, WBC 14

POD#12- afebrile, WBC 17, abdominal CT- s/p right hemicolecction, anastomosis intact. Interval decrease in fluid collections, RLQ collection now 0.9 x 1.2 cm, collection anterior to transverse colon now 4.2 x 1.6 cm

POD#15- completed 1 week course of zosyn, switched to cipro PO

POD#16- WBC 11, discharged home on PO cipro
Selective nonoperative management of penetrating abdominal trauma: historical perspective

Until end 19th century: expectant management with rest, wound dressings, blood letting and opium

Beginning 20th century: operative management standard of care

1960s: observant and expectant treatment for penetrating abdominal injury, mainly SW, advocated by Shaftan and Nance and Cohn, but mandatory or routine laparotomy remained standard of care at many institutions

Arguments for and against selective nonoperative treatment of penetrating abdominal trauma

Pro:
• High incidence of nontherapeutic laparotomy from civilian, low velocity wounding: 23-53% for SW, 5.3-27% for GSW
• Complication rate 2.5-41% for nontherapeutic laparotomies

Contra:
• High incidence (>90%) of significant intraabdominal injuries after GSWs
• Nontherapeutic laparotomy is harmless procedure
• Delay in diagnosis is a/w high morbidity and mortality
• Abdominal exam is unreliable

Selective nonoperative management is standard of care for patients with abdominal stab wounds who are stable without signs of peritonitis, but controversy remains in the application of these same principles to GSW victims.

Recommendations for SNOM based on literature search including articles published from 1960-2007 by Como et al:

- Patients who are hemodynamically unstable or who have diffuse abdominal tenderness should be taken for emergent laparotomy.
- Patients who are hemodynamically stable with an unreliable clinical examination (i.e. brain injury, intoxication, need for sedation/anesthesia) need further diagnostic evaluation or should undergo exploratory laparotomy.
- Routine laparotomy is not indicated in hemodynamically stable patients with abdominal SW without peritonitis or diffuse tenderness.
- Routine laparotomy is not indicated in hemodynamically stable patients with abdominal GSW without peritonitis if wounds are tangential or isolated to the right upper quadrant.
- Serial physical exam is reliable in detecting significant injuries after penetrating trauma to the abdomen.
- In patients selected for NOM, abdominopelvic CT should be strongly considered.
- The majority of patients with penetrating abdominal trauma managed nonoperatively can be discharged after 24h observation.
- Diagnostic laparoscopy may be considered as a tool to evaluate diaphragmatic lacerations and peritoneal penetration.

Nonoperative management of Abdominal GSWs to the Right Upper Quadrant

- Prospective series of 13 stable patients with GSW to the right thoracoabdominal area admitted from 1990-1993 without peritoneal signs
- All patients had right chest tube placed
- CT confirmed intraabdominal injuries to solid organs (liver, kidney)
- Patients were managed without laparotomy, follow-up CT scan was performed 3-14 days later, which showed partial or complete resolution of liver injuries

Selective Nonoperative Management of Penetrating Abdominal Solid Organ Injuries

- Prospective study including 152 patients with penetrating abdominal trauma admitted to level 1 trauma center over 20 months period were evaluated for SNOM (GSW 70%, SW 30%)
- 91 patients (60%) underwent immediate laparotomy, 61 (40%) underwent CT scan evaluation
- 43 patients had no CT findings of hollow viscus injury and were selected for observation
- 2 patients with left thoracoabdominal injuries underwent laparoscopy to rule out diaphragmatic injury

FIGURE 1. Algorithm for the management of penetrating abdominal trauma.
Selective Nonoperative Management of Penetrating Abdominal Solid Organ Injuries

CT scan evaluation - findings diagnostic or highly suspicious for significant injuries requiring laparotomy:

- Free intraperitoneal or retroperitoneal air
- Free intraperitoneal fluid in the absence of solid organ injury
- Localized bowel wall thickening
- Bullet tract close to a hollow viscus with surrounding hematoma
- Contrast blush in the presence of hemodynamic instability

FIGURE 2. CT scan evaluation of penetrating solid organ injuries.
Selective Nonoperative Management of Penetrating Abdominal Solid Organ Injuries: Severity of solid organ injuries selected for nonoperative management

<table>
<thead>
<tr>
<th>TABLE 5. Patients and Severity of Solid Organ Injuries Selected for Nonoperative Management (n = 43)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Patients (n = 152)</td>
</tr>
<tr>
<td>------------------------</td>
</tr>
<tr>
<td>Liver injuries</td>
</tr>
<tr>
<td>I, II</td>
</tr>
<tr>
<td>Grade III–V</td>
</tr>
<tr>
<td>All grades</td>
</tr>
<tr>
<td>Spleen injuries</td>
</tr>
<tr>
<td>Grade I, II</td>
</tr>
<tr>
<td>Grade III–V</td>
</tr>
<tr>
<td>All grades</td>
</tr>
<tr>
<td>Kidney</td>
</tr>
<tr>
<td>Grade I, II</td>
</tr>
<tr>
<td>Grade III–V</td>
</tr>
<tr>
<td>All grades</td>
</tr>
<tr>
<td>All patients</td>
</tr>
</tbody>
</table>

* A total of 32 patients had more than one solid organ injury.
† Including 2 patients with laparoscopic repair of the diaphragm.

Selecteive Nonoperative Management of Penetrating Abdominal Solid Organ Injuries: Results

**TABLE 7. Management of 185 Penetrating Solid Organ Injuries**

<table>
<thead>
<tr>
<th>Organ</th>
<th>No. of Patients</th>
<th>Nonoperative Management [n (%)]</th>
<th>Operative Management [N (%)]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Simple Surgical Techniques</td>
</tr>
<tr>
<td>Liver</td>
<td>111</td>
<td>32 (28.8)</td>
<td>27 (24.3)</td>
</tr>
<tr>
<td>Spleen</td>
<td>28</td>
<td>1 (3.6)</td>
<td>9 (32.1)</td>
</tr>
<tr>
<td>Kidney</td>
<td>46</td>
<td>8 (17.4)</td>
<td>19 (41.3)</td>
</tr>
<tr>
<td>All organs</td>
<td>185</td>
<td>41 (22.2)</td>
<td>55 (29.7)</td>
</tr>
</tbody>
</table>

Selective Nonoperative Management of Penetrating Abdominal Solid Organ Injuries: Conclusions

- 40% of liver injuries, 30% of renal injuries and 10% of splenic injuries do not have any associated significant intra-abdominal injuries.
- Especially liver injuries can be managed nonoperatively, even if high-grade.
- Angiographic embolization by interventional radiology may play a critical role in the successful management of these patients.
- Renal and splenic injuries can be managed nonoperatively, but this might need further evaluation.
- CT scan aids in the selection of patient with isolated solid organ injuries.

Selective Nonoperative management for Patients with abdominal GSWs

- Retrospective study including 1,856 patients with abdominal GSWs admitted at a level 1 trauma center over 8 years period (1993-2000) who were evaluated for SNOM
- 792 patients (42%) were selected for nonoperative management (followed by serial abdominal exam and CT scan after 1998)

Failure of SNOM:
- new abdominal tenderness
- progression of localized to generalized tenderness or tenderness away from the wound
- drop in hct
- drop in BP
- increase in WBC, fever

Selective Nonoperative management for Patients with abdominal GSWs: Results

Table 1. EXPERIENCE WITH 1,856 PATIENTS WITH ABDOMINAL GUNSHOT GUNSHOT (AGSW)

<table>
<thead>
<tr>
<th></th>
<th>All AGSW (n = 1,856)</th>
<th>Anterior AGSW (n = 1,405)</th>
<th>Posterior AGSW (n = 451)</th>
<th>P Value Between Anterior and Posterior AGSW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediate laparotomy</td>
<td>1,064 (57%)</td>
<td>921 (66%)</td>
<td>143 (32%)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Initially not operated</td>
<td>792 (42%)</td>
<td>484 (34%)</td>
<td>308 (68%)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Delayed laparotomy</td>
<td>80 (4%)</td>
<td>65 (5%)</td>
<td>15 (3%)</td>
<td>.24</td>
</tr>
<tr>
<td>Finally operated</td>
<td>1,144 (62%)</td>
<td>986 (70%)</td>
<td>158 (35%)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Finally not operated</td>
<td>712 (38%)</td>
<td>419 (30%)</td>
<td>293 (65%)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Negative laparotomy among operated patients*</td>
<td>163 (14%)</td>
<td>124 (13%)</td>
<td>39 (25%)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Negative laparotomy after immediate exploration †</td>
<td>140 (13%)</td>
<td>107 (12%)</td>
<td>33 (23%)</td>
<td>.0002</td>
</tr>
<tr>
<td>Negative laparotomy after delayed exploration ‡</td>
<td>23 (29%)</td>
<td>17 (26%)</td>
<td>6 (40%)</td>
<td>.35</td>
</tr>
</tbody>
</table>

Percentages calculated on 1,144 patients who received a laparotomy (986 anterior AGSW and 158 posterior AGSW).
Percentages calculated on 1,064 patients who received immediate laparotomy (921 anterior AGSW and 143 posterior AGSW).
Percentages calculated on 80 patients who received delayed laparotomy (65 anterior AGSW and 15 posterior AGSW).

Selective Nonoperative management for Patients with abdominal GSWs: Results

### Table 2. IMMEDIATE OPERATION VS. NONOPERATIVE MANAGEMENT

<table>
<thead>
<tr>
<th></th>
<th>Immediate Operation (n = 1,064)</th>
<th>Nonoperative Management (n = 792)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>26 ± 10</td>
<td>25 ± 10</td>
<td>.59</td>
</tr>
<tr>
<td>Age ≥ 55 years</td>
<td>17 (2%)</td>
<td>8 (1%)</td>
<td>.31</td>
</tr>
<tr>
<td>Male gender</td>
<td>988 (93%)</td>
<td>722 (91%)</td>
<td>.18</td>
</tr>
<tr>
<td>ISS</td>
<td>15 ± 13</td>
<td>3 ± 5</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>ISS ≥ 16</td>
<td>493 (46%)</td>
<td>45 (6%)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Systolic BP (mm Hg)</td>
<td>114 ± 44</td>
<td>140 ± 23</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Systolic BP &lt; 100 mm Hg</td>
<td>287 (27%)</td>
<td>120 (14%)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Heart rate (beats/min)</td>
<td>93 ± 32</td>
<td>84 ± 34</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Heart rate ≥ 100 beats/min</td>
<td>385 (37%)</td>
<td>241 (32%)</td>
<td>.03</td>
</tr>
<tr>
<td>Emergent intubation</td>
<td>82 (8%)</td>
<td>2 (0.25%)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Anterior AGSW</td>
<td>921 (87%)</td>
<td>484 (61%)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Extraabdominal injury</td>
<td>368 (35%)</td>
<td>215 (27%)</td>
<td>.0006</td>
</tr>
<tr>
<td>Hospital days</td>
<td>14 ± 13</td>
<td>4 ± 4</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Charges</td>
<td>$50,169 ± 78,569</td>
<td>$10,637 ± 14,360</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Death</td>
<td>183 (17%)</td>
<td>1 (0.13%)</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

ISS, Injury Severity Score; BP, blood pressure on admission; AGSW, abdominal gunshot wound.

Selective Nonoperative management for Patients with abdominal GSWs: Results

**Table 3. PATIENTS WITH THERAPEUTIC DELAYED LAPAROTOMIES AND COMPLICATIONS POTENTIALLY ASSOCIATED WITH THE DELAY**

<table>
<thead>
<tr>
<th>Pt. No.</th>
<th>ISS</th>
<th>GSW Site</th>
<th>Time From Admission to OR (hr)</th>
<th>Intraabdominal Injuries</th>
<th>Extraabdominal Injuries</th>
<th>Surgical Procedure</th>
<th>Complications</th>
<th>Days in Hospital</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>Anterior</td>
<td>3</td>
<td>Colon</td>
<td>None</td>
<td>Primary repair</td>
<td>Psoas abscess intraabdominal abscess/pneumonia</td>
<td>18</td>
</tr>
<tr>
<td>2</td>
<td>14</td>
<td>Anterior</td>
<td>6</td>
<td>Colon</td>
<td>Lung</td>
<td>Primary colon repair</td>
<td>Intraabdominal abscess/pneumonia</td>
<td>24</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>Anterior</td>
<td>6.5</td>
<td>Small bowel/ureter</td>
<td>None</td>
<td>Primary repair</td>
<td>Intraabdominal abscess/pneumonia</td>
<td>29</td>
</tr>
<tr>
<td>4</td>
<td>16</td>
<td>Posterior</td>
<td>8</td>
<td>Iliac artery and vein</td>
<td>None</td>
<td>Repair of artery/vein</td>
<td>Postoperative ileus</td>
<td>12</td>
</tr>
<tr>
<td>5</td>
<td>14</td>
<td>Anterior</td>
<td>48</td>
<td>Liver, right kidney</td>
<td>Lung</td>
<td>Hepatorrhapsy, nephrectomy</td>
<td>ARDS/sepsis</td>
<td>39</td>
</tr>
</tbody>
</table>

ISS, Injury Severity Score; GSW, gunshot wound; OR, operating room; ARDS, acute respiratory distress syndrome.

Selective Nonoperative management for Patients with abdominal GSWs: Conclusions

- Compared with patients with nontherapeutic laparotomy, patient managed without surgery had shorter hospital stay and lower hospital charges.
- Of 1,856 patients with abdominal GSWs, 38% did not require an operation. The rate of unnecessary laparotomies was 14% with SNOM and would have been 47% with routine laparotomy.
- SNOM is a safe method for large level 1 trauma centers with in-house trauma team.

Selective Nonoperative Management of Abdominal GSW in low volume centers

- Retrospective study including 125 patients with abdominal GSW at low volume level 1 trauma center from 1999 to 2009 who were evaluated for SNOM
- 87 patients (70%) had immediate laparotomy for hemodynamic instability, peritonitis or inability to evaluate clinically
- 38 patients (30%) were managed nonoperatively, 7 had delayed laparotomy for worsening abdominal exam, often with suspicious CT findings

Selective Nonoperative Management of Abdominal
GSW in low volume centers

• 10 patients (8%) had nontherapeutic laparotomy (all immediate laparotomy patients)
• 30 patients were discharged without operation
• Patients without operation had fewer complications and shorter hospital stay
• SNOM is safe and effective for the management of abdominal GSWs in low volume centers

Table 3. Comparison of Patients Who Received an Operation During Their Hospital Stay With Those Who Were Successfully Managed Nonoperativelya

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Operated On (n = 95)</th>
<th>Successfully Managed Nonoperatively (n = 30)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>25 (7)</td>
<td>25 (8)</td>
<td>.66</td>
</tr>
<tr>
<td>Male sex, No. (%)</td>
<td>92 (97)</td>
<td>29 (97)</td>
<td>.96</td>
</tr>
<tr>
<td>Anterior AGSW, No. (% of category) (n = 99)</td>
<td>79 (83)</td>
<td>20 (67)</td>
<td>.05</td>
</tr>
<tr>
<td>Posterior AGSW, No. (% of category) (n = 26)</td>
<td>16 (17)</td>
<td>10 (33)</td>
<td></td>
</tr>
<tr>
<td>Abbreviated Injury Score abdomen</td>
<td>3 (1)</td>
<td>1 (1)</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Injury Severity Score</td>
<td>28 (11)</td>
<td>11 (10)</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Blood pressure on admission, mm Hg</td>
<td>132 (27)</td>
<td>143 (27)</td>
<td>.05</td>
</tr>
<tr>
<td>Heart rate on admission, beats/min</td>
<td>97 (22)</td>
<td>104 (23)</td>
<td>.18</td>
</tr>
<tr>
<td>Hematocrit</td>
<td>38 (5)</td>
<td>38 (7)</td>
<td>.32</td>
</tr>
<tr>
<td>Length of stay, d</td>
<td>11 (11)</td>
<td>6 (7)</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Complications, No. (%)</td>
<td>29 (31)</td>
<td>3 (10)</td>
<td>.03</td>
</tr>
<tr>
<td>Mortality, No. (%)</td>
<td>4 (4)</td>
<td>0</td>
<td>.25</td>
</tr>
</tbody>
</table>

aAbbreviation: AGSW, abdominal gunshot wound. Data are given as mean (SD) unless otherwise indicated.
Role of CT

- Prospective study including 104 hemodynamically stable patients without peritonitis with penetrating injuries to the torso from nipple line to upper third of the thigh over 17 months period at high volume level 1 trauma center
- 50 patients with SW, 54 patients with GSW
- Triple-contrast CT scans of the chest and abdomen/pelvis were performed on all patients

Shanmuganathan et al: Triple Contrast Helical CT in Penetrating Torso Trauma: A Prospective Study to Determine Peritoneal Violation and the Need for Laparotomy. AJR. 2001;177:1247-1256
Role of CT

• Positive findings on CT for peritoneal penetration:
  – Wound tract entering peritoneal cavity
  – Intraperitoneal free air, bullet fragments
  – Intraperitoneal organ, mesenteric or vascular injury (active bleeding, pseudoaneurysm)

• Positive findings on CT for diaphragmatic injury:
  – Wound tract adjacent to the diaphragm
  – Thickening of the diaphragm
  – Defect in the continuity of the normal diaphragm

• Positive findings on CT for bowel or mesenteric injuries:
  – Extravasation of oral or rectal contrast
  – Defect in bowel wall
  – Bowel wall thickening
  – Mesenteric bleeding, mesenteric hematoma
  – Wound tract extending up to the wall of hollow viscus
  – Free air or fluid was not considered a sign of hollow viscus injury

Shanmuganathan et al: Triple Contrast Helical CT in Penetrating Torso Trauma: A Prospective Study to Determine Peritoneal Violation and the Need for Laparotomy. AJR. 2001;177:1247-1256
Role of CT: Results

- 35 patients (34%) had positive findings on CT, 21 patients out of 35 underwent laparotomy, as well as 1 patient with negative CT.
- Laparotomy was therapeutic in 86%, nontherapeutic in 9% and negative in 5% (total 3 patients, all SW).
- Patient with negative CT had hematoma on sigmoidoscopy, no injury was identified on laparotomy.
- 69 patients (66%) had negative CT, 97% of those were treated nonoperatively without late complications from missed injuries.
- Sensitivity 100%, specificity 96%, negative predicting value 100%, positive predicting value 86% for the need for laparotomy in this study.

Shanmuganathan et al: Triple Contrast Helical CT in Penetrating Torso Trauma: A Prospective Study to Determine Peritoneal Violation and the Need for Laparotomy. AJR. 2001;177:1247-1256
### TABLE 2  Selective Treatment of Penetrating Injuries

<table>
<thead>
<tr>
<th>Study</th>
<th>Mechanism</th>
<th>Method</th>
<th>Unnecessary Laparotomy</th>
<th>Missed Injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demetriades et al. [4]</td>
<td>Gunshot wound, stab wound</td>
<td>Clinical examination</td>
<td>9% (9/106)</td>
<td>5% (5/106)</td>
</tr>
<tr>
<td>Demetriades and Rabinowitz [10]</td>
<td>Stab wound</td>
<td>Clinical examination</td>
<td>5% (15/306)</td>
<td>3.6% (11/306)</td>
</tr>
<tr>
<td>Feliciano et al. [12]</td>
<td>Stab wound</td>
<td>Diagnostic peritoneal lavage, local wound exploration</td>
<td>2% (10/500)</td>
<td>1.4% (7/500)</td>
</tr>
<tr>
<td>Ivatery et al. [14]</td>
<td>Gunshot wound</td>
<td>Laparoscopy</td>
<td>Not mentioned</td>
<td>7% (7/100)</td>
</tr>
<tr>
<td>Keleman et al. [35]</td>
<td>Gunshot wound</td>
<td>Diagnostic peritoneal lavage</td>
<td>18% (8/44)</td>
<td>9% (4/44)</td>
</tr>
<tr>
<td>This study</td>
<td>Gunshot wound, stab wound</td>
<td>CT</td>
<td>3% (3/105)</td>
<td>0</td>
</tr>
</tbody>
</table>

Shanmuganathan et al: Triple Contrast Helical CT in Penetrating Torso Trauma: A Prospective Study to Determine Peritoneal Violation and the Need for Laparotomy. AJR. 2001;177:1247-1256
Role of CT: Conclusion

• Triple contrast CT is accurate in excluding peritoneal violation in hemodynamically stable patient with penetrating torso trauma

• Among patients with peritoneal violation, CT was accurate in verifying isolated liver injury and permitting nonoperative treatment for patients with penetrating trauma to the right upper quadrant

• Accuracy of diaphragmatic or bowel injuries should be determined with further studies

Shanmuganathan et al: Triple Contrast Helical CT in Penetrating Torso Trauma: A Prospective Study to Determine Peritoneal Violation and the Need for Laparotomy. AJR. 2001;177:1247-1256
Role of CT

- Prospective study including 103 patients with nontangential abdominal GSWs selected for NOM admitted during 2 year period (2002-2004) to level 1 trauma center who underwent single contrast (IV only) CT scan
- 26 patients underwent laparotomy, which was nontherapeutic in 5 (19%)
- 74 patients did not undergo laparotomy, 11 of those patients had isolated solid organ injuries that were managed nonoperatively
- 2 CT scans were false-negative (missed hollow viscus injury), 3 CT scans were false-positive (suspicion of colon injury based on bullet trajectory, no injury on laparotomy)
- Overall, sensitivity was 90.5% and specificity 96%
- CT scan was found to be a useful tool in conjunction with serial abdominal exams to follow patients selected for nonoperative management of abdominal gunshot wounds

Velmahos et al: Abdominal computer tomographic scan for patients with gunshot wounds to the abdomen selected for non-operative management. J Trauma. 2005;59:1155-1160
Role of DPL

• DPL for penetrating trauma was described starting in the 1960s, with thresholds for positive lavage ranging from 1000 to 100,000 RBC/mm³
• With the concept of SNOM, noninvasive tools like CT and FAST became more popular adjuncts for hemodynamically stable patients
• DPL now is more often reserved for unstable patients requiring rapid diagnosis

Role of laparoscopy: Evaluation of the diaphragm

- Prospective case series of 34 hemodynamically stable patients with thoracoabdominal penetrating trauma
- All patients underwent laparoscopy and subsequent laparotomy (30) or thoracoscopy (4)
- 1 patient had false-negative laparoscopy due to hemoperitoneum and splenic injury obscuring the diaphragm
- Sensitivity 87%, specificity 100% for laparoscopy to identify diaphragmatic injuries

Friese et al: Laparoscopy is sufficient to exclude occult diaphragmatic injury after penetrating abdominal trauma. J Trauma. 2005;58:789-792
Summary

• Selective nonoperative management is well established for abdominal SWs in stable patients without peritoneal signs and is practiced in some high volume trauma centers for abdominal GSWs

• Nonoperative management of GSW to the right upper quadrant resulting in isolated liver injuries is more widespread and practiced safely at many institutions

• With mandatory laparotomy, the rate of nontherapeutic laparotomy is 25-42% for SWs and 5-27% for GSWs, with SNOM and use of CT its is 14% for GSWs

• The complication rate for nontherapeutic laparotomies is 2.5 % (only major complications) to 42% (including minor complications), LOS 4-5 days

• The complication rate for delayed laparotomy is low

• Abdominal CT scan is a useful adjunct for SNOM, with sensitivity >90% and specificity >95% for peritoneal violation and need for laparotomy

• Diagnostic laparoscopy should be strongly considered in patients with penetrating trauma to the left thoracoabdominal area to rule out and to potentially repair diaphragmatic injuries
References

- Shanmuganathan et al: Triple Contrast Helical CT in Penetrating Torso Trauma: A Prospective Study to Determine Peritoneal Violation and the Need for Laparotomy. AJR. 2001;177:1247-1256
- Friese et al: Laparoscopy is sufficient to exclude occult diaphragmatic injury after penetrating abdominal trauma. J Trauma. 2005;58:789-792
- Velmahos et al: Abdominal computer tomographic scan for patients with gunshot wounds to the abdomen selected for non-operative management. J Trauma. 2005;59:1155-1160