

# **Practice Management Guidelines for Nonoperative Management of Penetrating Abdominal Trauma**

Eastern Association for the Surgery of Trauma:

Practice Management Guideline Committee

John J. Como, MD

Faran Bokhari, MD

William C. Chiu, MD

Therese M. Duane, MD

Michele R. Holevar, MD

Margaret A. Tandoh, MD

April 11, 2007

Study Group:

Chairman

John J. Como, MD  
MetroHealth Medical Center  
Case School of Medicine  
Cleveland, OH

Vice-Chairman

Faran Bokhari, MD  
Stroger Hospital of Cook County  
Rush Medical College  
Chicago, IL

Committee Members

William C. Chiu, MD  
R Adams Cowley Shock Trauma Center  
University of Maryland School of Medicine  
Baltimore, MD

Therese M. Duane, MD  
Virginia Commonwealth University Medical Center  
Medical College of Virginia  
Richmond, VA

Michele R. Holevar, MD  
Mount Sinai Hospital  
Chicago Medical School  
Chicago, IL

Margaret A. Tandoh, MD  
Upstate Medical Center  
SUNY Upstate Medical University  
Syracuse, NY

## **I. STATEMENT OF THE PROBLEM**

Until the late 19th century, penetrating abdominal trauma was managed expectantly, with high mortality rates.<sup>1</sup> In World War I, operative management replaced expectant management and became the accepted standard for penetrating wounds to the abdomen.<sup>2</sup> It has since been realized that not all penetrating abdominal wounds require operation. As early as 1960, Shaftan advocated “observant and expectant treatment” rather than mandatory laparotomy in the management of penetrating abdominal injury.<sup>3</sup> This was reinforced in 1969 by Nance and Cohn for the management of abdominal stab wounds.<sup>2</sup> Since that time, selective nonoperative management of stab wounds to the anterior abdomen has become common. Gunshot wounds (GSWs) to the abdomen, however, are still commonly treated with mandatory exploration. The reason for this is there is thought to be a high incidence of intra-abdominal injuries and a low rate of complications if laparotomy is negative.

Reports on the incidence of unnecessary laparotomy range from 23 to 53% for patients with stab wounds and 5.3 to 27% for patients with GSWs.<sup>4</sup> Complications develop in 2.5 to 41% of all trauma patients undergoing unnecessary laparotomy, and small bowel obstruction, pneumothorax, ileus, wound infection, myocardial infarction, visceral injury, and even death have been reported secondary to unnecessary laparotomy.<sup>2,4</sup> Unnecessary laparotomy may also lead to greater lengths of stay and increased cost.

Mandatory celiotomy for penetrating abdominal trauma results in a high rate of unnecessary operations. There is associated morbidity and increased cost. There is a risk of transmission of blood-borne diseases to healthcare providers. Complication rates from unnecessary laparotomy must, however, be weighed against the mortality and morbidity of a missed injury. The goal of the trauma surgeon is to avoid unnecessary laparotomy while minimizing missed injuries. The surgeon deciding whether or not a laparotomy for trauma is indicated must know the risks and benefits associated with either course of action.

## **II. PROCESS**

### **a. IDENTIFICATION OF REFERENCES**

A computerized search of the National Library of Medicine and the National Institutes of Health MEDLINE database was undertaken using the Entrez PubMed ([www.pubmed.gov](http://www.pubmed.gov)) interface. The primary search strategy was developed to retrieve English language articles focusing on nonoperative management of penetrating abdominal trauma starting in 1990 and continuing through 2005; review articles, letters to the editor, editorials, other items of general commentary, and case reports were excluded from the search. These articles were then reviewed for relevance by the committee chair, and the final reference list of 51 citations was distributed to the remainder of the study group for review.

We would like to acknowledge Steven J. Grove, MA, MLS of the Brittingham Memorial Library at MetroHealth Medical Center for his assistance in this portion of the project.

### **b. QUALITY OF THE REFERENCES**

Articles were classified as Class I, II or III according to the following definitions:

**Class I:** Prospective, randomized clinical trials (1 reference).

**Class II:** Clinical studies in which data was collected prospectively or retrospective analyses based on clearly reliable data (26 references).

**Class III:** Studies based on retrospectively collected data (24 references).

Recommendations were classified as Level 1, 2, or 3 according to the following definitions:

**Level 1:** The recommendation is convincingly justifiable based on the available scientific information alone. This recommendation is usually based on Class I data, however, strong Class II evidence may form the basis for a level 1 recommendation, especially if the issue does not lend itself to testing in a randomized format. Conversely, low quality or contradictory Class I data may not be able to support a level 1 recommendation.

**Level 2:** The recommendation is reasonably justifiable by available scientific evidence and strongly supported by expert opinion. This recommendation is usually supported by Class II data or a preponderance of Class III evidence.

**Level 3:** The recommendation is supported by available data but adequate scientific evidence is lacking. This recommendation is generally supported by Class III data. This type of recommendation is useful for educational purposes and in guiding future clinical research.

### **III. RECOMMENDATIONS:**

**a. Level 1**

There is insufficient data to support a Level 1 recommendation on this topic

**b. Level 2**

- i.** Patients who are hemodynamically unstable or who have diffuse abdominal tenderness after penetrating abdominal trauma should be taken emergently for laparotomy.
- ii.** Patients with an unreliable clinical examination (i.e., severe head injury, spinal cord injury, severe intoxication, or need for sedation or intubation) should be explored or further investigation done to determine if there is intraperitoneal injury.
- iii.** Others may be selected for initial observation. In these patients:
  1. Triple-contrast (oral, intravenous, and rectal contrast) abdominopelvic computed tomography (CT) should be strongly considered as a diagnostic tool to facilitate initial management decisions as this test can accurately predict the need for laparotomy.
  2. Serial examinations should be performed, as physical examination is reliable in detecting significant injuries after penetrating trauma to the abdomen. Patients requiring delayed laparotomy will develop abdominal signs.

3. If signs of peritonitis develop, laparotomy should be performed.
4. If there is an unexplained drop in blood pressure or hematocrit, further investigation is warranted.

**c. Level 3**

- i.** The vast majority of patients with penetrating abdominal trauma managed nonoperatively may be discharged after twenty-four hours of observation in the presence of a reliable abdominal examination and minimal to no abdominal tenderness.
- ii.** Patients with penetrating injury to the right upper quadrant of the abdomen with injury to the right lung, right diaphragm, and liver may be safely observed in the presence of stable vital signs, reliable examination and minimal to no abdominal tenderness.
- iii.** Angiography and investigation for and treatment of diaphragm injury may be necessary as adjuncts to initial nonoperative management of penetrating abdominal trauma.
- iv.** Mandatory exploration for all penetrating renal trauma is not necessary.

#### IV. SCIENTIFIC FOUNDATIONS

##### **Indications for laparotomy:**

*Patients who are hemodynamically unstable or who have diffuse abdominal tenderness after penetrating abdominal trauma should be taken emergently for laparotomy. Patients with an unreliable clinical examination (i.e., severe head injury, spinal cord injury, severe intoxication, or need for sedation or intubation) should be explored or further investigation done to determine if there is intraperitoneal injury. If signs of peritonitis develop, laparotomy should be performed. If there is an unexplained drop in blood pressure or hematocrit, further investigation is warranted. These recommendations are reasonably justifiable by available scientific evidence is strongly supported by expert opinion; therefore a Level 2 recommendation is appropriate. In general, patients fitting the above profile were excluded from nonoperative management and were not included in the studies evaluated by this committee.*

##### **Physical examination:**

*In patients selected for nonoperative management, serial examinations should be performed, as physical examination is reliable in detecting significant injuries after penetrating trauma to the abdomen. Patients requiring delayed laparotomy will develop abdominal signs. A number of Class II articles support this recommendation.*

Demetriades and colleagues published a prospective series of 41 patients with minimal or equivocal abdominal signs after GSW to the abdomen managed nonoperatively.<sup>5</sup> Seven

required delayed laparotomy within 4 hours to 4 days (3 colon injuries, 3 small bowel injuries, 1 liver injury); of these, two developed wound infection, one with abdominal dehiscence. There was no mortality or serious morbidity. The authors concluded that carefully selected patients with abdominal GSW can be safely managed nonoperatively.

A prospective study on GSW to the anterior abdomen using observation if the patient was stable, without peritonitis, and without severe head or spinal cord injury was published by Demetriades et al in 1997.<sup>6</sup> One hundred six patients were in this group, with 14 undergoing delayed operation (13 for increasing tenderness and one for continued bleeding) of which 5 were therapeutic. Four of these patients had colon injuries managed by primary repair. Only one of these had a subsequent complication: a psoas abscess that required percutaneous drainage. One patient was observed for 48 hours in violation of the protocol and developed abdominal compartment syndrome and acute respiratory distress syndrome. The sensitivity of the initial negative physical examination was 97.1%. The mean hospital stay in the group with nontherapeutic operations was 6.4 days, and the complication rate was 27.6%. Of the total of 309 patients in the series, 92 (29.8%) were successfully managed nonoperatively.

Velmahos and coworkers, in 1997, published a prospective series of 230 consecutive patients with GSW to the back.<sup>7</sup> Patients with hemodynamic instability or peritonitis underwent urgent operation. Of the remaining 188 patients, 58 (31%) underwent laparotomy (56 therapeutic, 2 negative) and 130 (69%) were initially observed due to negative clinical exam. 4/130 (3%) underwent delayed laparotomy after developing abdominal tenderness; all of these laparotomies were nontherapeutic. The authors also

note a diaphragm injury that presented with no clinical signs. The sensitivity and specificity of initial clinical exam in detecting significant intraabdominal injuries were 100% and 95% respectively.

In the same year, Velmahos et al reported 59 consecutive patients with GSW to the buttocks.<sup>8</sup> Unstable patients underwent immediate laparotomy. Stable patients with peritoneal signs underwent surgery. Patients with gross hematuria or blood on rectal exam underwent cystography and/or rigid sigmoidoscopy. Patients without clinical signs of significant injury underwent "appropriate" diagnostic tests, including rigid sigmoidoscopy, and were admitted for serial clinical examinations. Nineteen (32.2%) underwent surgery based on clinical findings, with significant intraabdominal injuries in 17 (28.8%). The remaining 40 (67.8%) were successfully observed. There were no missed injuries or delays in diagnosis. Sensitivity and specificity of clinical exam for identifying significant intra-abdominal injury was 100% and 95.3% respectively.

A review of 37 patients with transpelvic GSW was published in 1998 by Velmahos and colleagues.<sup>9</sup> Patients with peritoneal signs, hemodynamic instability, gross hematuria, or rectal bleeding underwent immediate operation. Eighteen were initially managed nonoperatively. Three of these subsequently underwent exploration for the development of abdominal tenderness. All 3 were nontherapeutic. The sensitivity of clinical examination was 100% in detecting the need for laparotomy.

A retrospective review of 792 patients with abdominal GSW treated with selective nonoperative management was published by Velmahos et al in 2001.<sup>10</sup> During observation 80 (10%) patients developed symptoms and required a delayed laparotomy. Fifty-seven (72%) of laparotomies were therapeutic. Five (6.3%) suffered complications potentially related to the delay in laparotomy, which were managed successfully. Seven hundred twelve (90%) were successfully managed nonoperatively. If patients had been managed by routine laparotomy, the unnecessary laparotomy rate would have been 47% (39% for anterior and 74% for posterior abdominal GSW). Patients without surgery had significantly shorter hospital LOS and lower hospital charges.

**Use of computed tomography:**

*Triple-contrast (oral, intravenous, and rectal contrast) abdominopelvic computed tomography (CT) should be strongly considered as a diagnostic tool to facilitate initial management decisions as this test can accurately predict the need for laparotomy. This recommendation is also supported by a number of Class II articles.*

Himmelman et al found that a negative triple contrast CT has 100% sensitivity for retroperitoneal injury after penetrating trauma to the back and flank.<sup>11</sup> Eighty-eight patients were enrolled prospectively. Five of nine high-risk scans had laparotomy, and two had injuries. Seventy-seven patients with non-high-risk scans were observed without complication.

Kirton and colleagues performed a registry review on back and flank stab wounds who were evaluated with CT with contrast enema.<sup>12</sup> None of the 92 low-risk patients required surgery or had sequelae. Six of the 53 patients with high-risk scans had laparotomy (two due to CT findings and four due to evolving signs). CT predicted all surgical findings in all six.

A prospective study of 104 stable patients without peritonitis receiving triple-contrast CT after penetrating torso trauma was published by Shanmuganathan et al in 2001.<sup>13</sup> A positive CT was defined as evidence of peritoneal penetration or injury to the retroperitoneal colon, major vessel, or urinary tract. Patients with a positive CT, except for patients with isolated liver injury or free fluid, underwent laparotomy. Nine patients with isolated hepatic injuries were successfully treated without laparotomy. Patients with a negative finding on CT were initially observed. Among patients with a negative CT, 67 (97%) of 69 were successfully observed. The negative predictive value of triple-contrast CT was 100% (69/69). The authors concluded that triple-contrast CT accurately predicts the need for laparotomy (97% accuracy) and excludes peritoneal violation in penetrating torso trauma.

A prospective study of 75 consecutive stable patients with penetrating injury to the torso (lower chest, abdomen or pelvis) without definite indication for laparotomy who underwent triple contrast CT interpreted by blinded radiologists was published by Chiu and coworkers in 2002.<sup>14</sup> In patients with a positive CT, 18 (69%) had laparotomy, two nontherapeutic and one negative. The remainder was successfully managed

nonoperatively. Of the patients with negative CT, 47/49 (96%) were successfully managed nonoperatively and one received a negative laparotomy. The false-negative CT injury was a left diaphragm injury discovered at laparotomy. CT accurately predicted whether laparotomy was needed in 71/75 (95%) patients. The authors note that adjunctive angiography and investigation for diaphragm injury may be prudent.

Munera et al performed a prospective study of 47 patients with abdominal GSW who received a triple-contrast helical CT.<sup>15</sup> Twenty patients had a negative CT scan. These patients were treated nonoperatively. One injury was missed at CT (a cecal wall contusion that was repaired). It was concluded that in stable patients with gunshot wounds to the abdomen in whom there is no indication for immediate surgery, triple-contrast helical CT can help reduce the number of cases of unnecessary or nontherapeutic laparotomy (accuracy of 96%).

Another prospective study of triple-contrast helical CT in 200 patients with penetrating torso trauma was published by Shanmuganathan et al in 2004.<sup>16</sup> Two patients with negative CT findings failed to improve with observation and underwent therapeutic laparotomy. In one, an actively bleeding left upper quadrant mesenteric hematoma and a left diaphragm injury were found; in the other, a left diaphragm injury was found. Twenty-one of 23 patients with isolated liver injury had successful nonsurgical management. Angioembolization was performed on four of these patients. None of the six patients with renal injury required surgery. CT had 97% sensitivity (66 of 68 patients), 98% specificity (130 of 132 patients), and 98% accuracy (196 of 200 patients)

for peritoneal violation. The authors concluded that triple-contrast helical CT accurately demonstrates peritoneal violation and visceral injury in patients with penetrating torso wounds. The accuracy of CT for diagnosis of left diaphragm injuries requires further study.

**Morbidity of nontherapeutic laparotomy:**

Mandatory laparotomy for penetrating abdominal trauma detects some unexpected injuries earlier and more accurately, but results in a higher nontherapeutic laparotomy rate, longer hospital stays, and increased hospital costs. Nontherapeutic laparotomies for penetrating abdominal trauma carry morbidity. These statements are supported by Class I and Class II evidence.

A prospective series of 372 operations performed on 368 patients with penetrating injuries to the abdomen, chest, neck and extremities was reported by Demetriades and colleagues.<sup>17</sup> There were 46 negative or non-therapeutic operations. Eleven percent of patients with nontherapeutic operations developed major complications due to anesthesia or operation (pancreatitis, aspiration pneumonia, wound infection, DVT, pneumonia). Hospital LOS was 4.1 days for those with uncomplicated nontherapeutic operations and 21.2 days for those with complications. The authors conclude that nontherapeutic operations for penetrating trauma carry a significant morbidity rate and they advocate a policy of selective conservatism.

Hasaniya and coworkers performed a retrospective study to look at complications of non-therapeutic laparotomies.<sup>18</sup> Two hundred thirty of these were identified. The incidence of significant complications directly related to the anesthesia or operation was 8.2%. One patient with a major thoracic injury died secondary to complications of a nontherapeutic laparotomy. The average hospital stay for uncomplicated nontherapeutic operations was 5.1 days, and for patients with complications 11.9 days.

Renz and Feliciano, in 1995, reported a prospective case series of 254 patients with unnecessary laparotomies for trauma.<sup>4</sup> Complications occurred in 41.3% of patients and included atelectasis (15.7%), postoperative hypertension that required medical treatment (11.0%), pleural effusion (9.8%), pneumothorax (5.1%), prolonged ileus (4.3%), pneumonia (3.9%), surgical wound infection (3.2%), small bowel obstruction (2.4%), urinary tract infection (1.9%), and others. The mortality rate for the entire series was 0.8% and was unrelated to unnecessary laparotomy.

In 1995, Leppaniemi et al reported a retrospective study of 172 patients undergoing mandatory explorative laparotomy for truncal stab wounds.<sup>19</sup> It was concluded that mandatory laparotomy for truncal stab wounds leads to an unnecessary operation in about 40% of cases, with a 20% morbidity rate associated with the laparotomy itself.

In 1996, the same group published a prospective, randomized (not blinded) trial on the safety and cost-effectiveness of selective non-operative management compared to mandatory laparotomy in patients with abdominal stab wounds not requiring immediate

laparotomy.<sup>20</sup> Fifty-one patients not requiring immediate laparotomy for hemodynamic instability, generalized peritonitis, or evisceration were randomly assigned to mandatory laparotomy or expectant, nonoperative management. The morbidity rate was 19% following mandatory laparotomy and 8% after observation. Four patients (17%) managed nonoperatively required delayed laparotomy. Suture repair of colon injuries was performed 6 and 18 hours after the injury in two patients; one patient underwent laparotomy for hemorrhage 44 hours after the injury, and was found to have a liver laceration that was not actively bleeding, but 1.4 L of blood in the abdomen; and a fourth patient was discharged home but represented 52 days later with empyema and was found to have a missed diaphragm injury through which the stomach had partially herniated and perforated. About \$2800 was saved for every patient who underwent successful nonoperative management. Mandatory laparotomy detects some unexpected organ injuries earlier and more accurately but results in a high non-therapeutic laparotomy rate.

In the same year, Renz and Feliciano performed a prospective case series and found that unnecessary laparotomies for trauma resulted in a significant length of stay.<sup>21</sup> Two hundred fifty-four patients had unnecessary laparotomy for trauma from 1988-1991. The mean length of stay for 81 patients with negative laparotomies and no associated injuries was 4.7 days. The presence of a complication or an associated injury significantly prolonged the length of stay.

### **Duration of observation:**

*Twenty-four hours of observation is adequate for the vast majority of patients with penetrating abdominal trauma managed nonoperatively.* A number of observations and studies support this recommendation.

Alzamel and Cohn published a chart review of 650 asymptomatic patients with abdominal stab wounds who were admitted for serial examination.<sup>22</sup> Fifteen of 650 left against medical advice within 6 hours of presentation. Sixty-eight of 635 underwent exploratory laparotomy. All patients who needed surgery were identified within 12 hours of presentation. Twenty-three (33%) underwent surgery within 2 hours; 26 (38%) between 2 to 4 hours; 9 (13%) between 4 & 6 hours; 9 (13%) between 6 & 10 hours; and 1 (1.4%) at 12 hours. The authors conclude that asymptomatic patients with abdominal stab wounds may be discharged after 12 hours of observation with little likelihood of missed injury.

Velmahos and coworkers, in their article about gunshot wounds to the buttocks, found that observation of patients for more than 24 hours was unnecessary if they are stable, are able to tolerate a regular diet, and complain of no symptoms.<sup>8</sup> In an article on the nonoperative management of 1856 patients with abdominal GSW, Velmahos et al observed that of 80 patients who required delayed laparotomy, only one required it after 24 hours of observation, and this patient was a policy guideline violation, in that a patient with a GSW to the liver and right kidney with a falling hematocrit was transfused instead of being taken to surgery.<sup>10</sup> In a subsequent study, again by Velmahos and colleagues, now using CT in addition to physical examination, it was found that laparotomy guided

by CT findings was performed within an average of 4.5 hours and a maximum of 13 hours.<sup>23</sup>

Ginzburg and colleagues published a retrospective study of 83 patients using triple contract computed tomography (CT) to rule out injury after a gunshot wound to abdomen or flank.<sup>24</sup> CT scans were classified as positive, equivocal or negative. The negative studies (53) were observed for 23 hours, with a 100% true negative rate. After this, patients were either discharged home or transferred to other services for treatment of associated injuries. No patient with a negative CT had a missed injury using this protocol.

#### **Visceral or omental evisceration:**

Visceral or omental evisceration through an abdominal stab wound in a patient with stable clinical signs and without evidence of peritonitis is a relative rather than absolute indication for exploratory laparotomy. This is supported by Class II and Class III evidence. We did not feel the data, however, was strong enough to support a recommendation on this topic.

McFarlane reported on a small series of patients (n=14) with anterior abdominal stab wounds and omental evisceration.<sup>25</sup> The article does not state whether data was collected prospectively or retrospectively. There were no late complications or missed visceral injuries requiring laparotomy. The author concludes that omental evisceration through an

abdominal stab wound in a patient with stable clinical signs and without evidence of peritonitis is not an absolute indication for exploratory laparotomy.

Arikan et al published a prospective, nonrandomized series of 52 hemodynamically stable patients with abdominal stab wounds and either visceral or omental evisceration, who were treated either with exploratory laparotomy or wound exploration/closure under local anesthesia.<sup>26</sup> Patients with obviously perforated hollow viscera or peritonitis were excluded. Seven of 31 patients treated selectively required delayed operation, of which 2 (6.5%) were negative. Of the 21 patients treated with a routine laparotomy, 7 (33%) were nontherapeutic. Of the routine laparotomy group, 19% (4/21) had complications, but only 1 patient with a nontherapeutic laparotomy had a complication (bleeding through the suture line controlled by simple suturing). The complication rate in the selective group was 3.2% (one case of small bowel obstruction managed nonoperatively). The mean length of stay was 137 hours in the routine exploration group vs. 81 hours in the selective group ( $p < 0.001$ ). The authors concluded that selective observation is safe and superior to routine laparotomy for the treatment of penetrating abdominal stab wounds with omental evisceration.

### **Right upper quadrant penetrating injury:**

*Patients with penetrating injury to the right upper quadrant of the abdomen with injury to the right lung, right diaphragm, and liver may be safely observed in the presence of stable vital signs, reliable examination and minimal to no abdominal tenderness. This is supported by Class II and Class III evidence, but the numbers of patients are small.*

Chmielewski and colleagues reported prospectively on 12 patients with a single GSW to the right upper quadrant, stable vital signs, reliable examination, and minimal or no abdominal tenderness.<sup>27</sup> All were successfully observed. One nontherapeutic laparotomy was done secondary to abdominal tenderness.

Demetriades and coworkers performed a retrospective review of GSW to the liver. Sixteen stable patients were selected for nonoperative management.<sup>28</sup> Five patients in the observed group underwent delayed laparotomy for peritonitis (four patients with liver injuries) and abdominal compartment syndrome (one patient who had received six units of blood in violation of the recommended policy). Except for a missed right diaphragm injury, there were no missed injuries in the 16 patients. One patient in the group with delayed laparotomy had multiple complications from abdominal compartment syndrome, and one patient in the nonoperative group developed a biloma, which was successfully drained percutaneously.

In 1994 Renz and Feliciano also reported on this subject.<sup>29</sup> A prospective study on stable patients with GSW to the right thoracoabdomen was performed. Thirteen patients were identified. All patients had a right hemothorax treated with a chest tube. Complications included atelectasis (n=four), a small persistent pneumothorax (n=two), and pneumonia (n=one). It was concluded that stable patients without peritonitis after sustaining a GSW to the right thoracoabdomen can be managed nonsurgically with a low incidence of minor intrathoracic complications.

### **Investigation for diaphragm injury:**

*Investigation for diaphragm injury may be necessary as an adjunct to initial nonoperative management of penetrating abdominal trauma.* A number of the aforementioned papers report missed diaphragm injuries.<sup>7,14,16,28</sup> Other investigative modes, such as laparoscopy, may be necessary to rule out diaphragmatic injuries in appropriate patients.<sup>30,31</sup> The discussion of operative procedures, such as laparoscopy, is beyond the scope of this manuscript.

### **Angiography:**

*Angiography may be necessary as an adjunct to initial nonoperative management of penetrating abdominal trauma.* Only a few reports have described the use of angiography in this setting.<sup>16,32</sup> Velmahos in 1999 described 40 patients undergoing angiography after penetrating abdominal trauma.<sup>32</sup> Six of these patients had angiography performed during nonoperative management; the rest had this done as an adjunct to surgery. Three of the six patients managed nonoperatively had successful angioembolization: one liver injury and two renal injuries. Shanmuganathan reported four patients with liver injuries who were managed with angioembolization but not with operation.<sup>16</sup> Further study is needed on the use of angiography and angioembolization in this patient population.

### **Penetrating renal trauma:**

*Mandatory exploration for all penetrating renal trauma is not necessary.* Heyns and Vollenhoven performed a retrospective review of 95 patients with renal stab wounds.<sup>33</sup> Patients with stab wounds and hematuria were selected for surgical exploration if they had signs of severe blood loss, an associated intra-abdominal laceration, or a major abnormality on an intravenous urogram. Sixty patients were in the nonoperative management group, and 35 were in the operative group. Only 4 patients underwent nontherapeutic laparotomy. Complications, however, developed in 12 of the 60 patients (20%) in the nonoperative group and consisted mainly of secondary hemorrhage caused by an arteriovenous fistula or pseudoaneurysm. Management consisted of embolization in 6, nephrectomy in 2, heminephrectomy in 1, open ligation of a fistula in 1, and spontaneous resolution in 2. The authors concluded by stating that certain groups should be more aggressively selected for surgery, and that angioembolization may be a useful adjunct to nonoperative management.

Velmahos and colleagues reviewed the records of 52 consecutive patients with renal GSW.<sup>34</sup> Renal injuries were explored only if they involved the hilum or were accompanied by signs of continued bleeding. Thirty-two patients underwent renal exploration and 17 of them required nephrectomy. In the remaining 20 patients, renal exploration was successfully avoided. No kidneys were lost unnecessarily as a result of this policy. One renal complication was identified in a patient managed nonoperatively. A patient developed hematuria one month after injury. CT revealed lack of upper pole perfusion on the injured side. The patient underwent a successful partial nephrectomy.

### **Diagnostic peritoneal lavage:**

There are a number of articles that have investigated diagnostic peritoneal lavage (DPL) as a means to assess the need for surgery after penetrating abdominal trauma.<sup>35-41</sup> There is large variability in the criteria for a positive study. Most of the studies regarding DPL are from the early to mid 1990s, with very few recent studies. DPL seems to have been supplanted by other diagnostic modalities, such as CT. Because of these factors, we did not feel we could make any recommendations regarding its use in this patient population.

### **Ultrasound:**

There are few papers on the use of ultrasound (US) in the nonoperative management of patients with penetrating abdominal trauma. Only one addresses the use of Focused Abdominal Sonography for Trauma (FAST), and the conclusion is that additional diagnostic studies need to be performed in the face of a negative FAST to rule out occult injury.<sup>42</sup> Of the two other studies investigating US, one described radiologist-interpreted US and the other described US to evaluate penetration of the abdominal wall.<sup>43-44</sup> There is not enough data to make a recommendation about the use of US in this patient population.

### **Local wound exploration:**

Although no studies address the issue of local wound exploration (LWE) in patients with abdominal stab wounds during the time period covered in this review, this technique was used in a number of series to rule out penetration of the anterior fascia.<sup>40,41,45</sup> Patients with abdominal stab wounds may have intraabdominal injury ruled out by a LWE

demonstrating that the anterior abdominal fascia has not been penetrated. If there is no other reason for hospital admission, these patients may then be sent home.

**Applicability:**

Prudent judgment should be exercised in deciding to apply nonoperative management of penetrating abdominal trauma in a particular institution, as the above recommendations are generally from large academic hospitals with in-house senior level clinicians with extensive experience in trauma, in which careful observation and close monitoring are possible. It may not be applicable to medical centers with fewer trauma resources. These patients need to be examined frequently, preferably by the same surgeon. Pain medications should be given with caution, if at all. If a patient should develop abdominal pain or hemodynamic instability, nonoperative management should be abandoned and the patient taken to surgery emergently.

## **V. FUTURE INVESTIGATIONS**

Prospective, randomized trials would be useful in investigating this topic further, but are unlikely to be practical since many patients would be subjected to unnecessary laparotomies for the purposes of the research. The role of CT in identifying diaphragmatic injuries needs to be investigated further. Although there is no debate about the necessity of repairing injuries to the left diaphragm, further study is required in deciding the necessity of repairing right-sided tears due to penetrating trauma. The role of interventional radiology in the nonoperative management of penetrating abdominal trauma needs to be elucidated further.

## VI. REFERENCES

- 1 Loria FL. Historical aspects of penetrating wounds of the abdomen. *Int Abstracts Surg* 1948;87:521-49.
- 2 Nance FC, Cohn I Jr. Surgical management in the management of stab wounds of the abdomen: a retrospective and prospective analysis based on a study of 600 stabbed patients. *Ann Surg* 1969;170:569-80.
- 3 Shaftan GW. Indications for operation in abdominal trauma. *Am J Surg* 1960;99:657-64.
- 4 Renz BM, Feliciano DV. Unnecessary laparotomies for trauma: a prospective study of morbidity. *J Trauma* 1995;38:350-6.
- 5 Demetriades D, Charalambides D, Lakhoo, et al. Gunshot wound of the abdomen: role of selective conservative management. *Br J Surg* 1991;78:220-2.
- 6 Demetriades D, Velmahos G, Cornwall E 3<sup>rd</sup>, et al. Selective nonoperative management of gunshot wounds of the anterior abdomen. *Arch Surg* 1997;132:178-83.

- 7 Velmahos GC, Demetriades D, Faianini E, et al. A selective approach to the management of gunshot wounds to the back. *Am J Surg* 1997;174:342-6.
- 8 Velmahos GC, Demetriades D, Cornwell EE, et al. Gunshot wounds to the buttocks: predicting the need for operation. *Dis Colon Rectum* 1997;40:307-11.
- 9 Velmahos GC, Demetriades D, Cornwell EE 3rd, et al. Transpelvic gunshot wounds: routine laparotomy or selective management? *World J Surg* 1998;22:1034-8.
- 10 Velmahos GC, Demetriades D, Toutouzas KG, et al. Selective nonoperative management in 1,856 patients with abdominal gunshot wounds: should routine laparotomy still be the standard of care? *Ann Surg* 2001;234:395-403.
- 11 Himmelman RG, Martin M, Gilkey S, et al. Triple contrast CT scans in penetrating back and flank trauma. *J Trauma* 1991;31:852-5.
- 12 Kirton OC, Wint D, Thrasher B, et al. Stab wounds to the back and flank in the hemodynamically stable patient: a decision algorithm based on contrast-enhanced computed tomography with colonic opacification. *Am J Surg* 1997;173:189-93.

- 13 Shanmuganathan K, Mirvis SE, Chiu WC, et al. Triple-contrast helical CT in penetrating torso trauma: a prospective study to determine peritoneal violation and the need for laparotomy. *AJR Am J Roentgenol* 2001;177:1247-56.
- 14 Chiu WC, Shanmuganathan K, Mirvis SE, et al. Determining the need for laparotomy in penetrating torso trauma: a prospective study using triple-contrast enhanced abdominopelvic computed tomography. *J Trauma* 2001;51:860-9.
- 15 Munera F, Morales C, Soto JA, et al. Gunshot wounds of the abdomen: evaluation of stable patients with triple-contrast helical CT. *Radiology* 2004;231:399-405.
- 16 Shanmuganathan K, Mirvis SE, Chiu WC, et al. Penetrating torso trauma: triple-contrast helical CT in peritoneal violation and organ injury—a prospective study in 200 patients. *Radiology* 2004;231:775-84.
- 17 Demetriades D, Vandebossche P, Ritz M, et al. Non-therapeutic operations for penetrating trauma: early morbidity and mortality. *Br J Surg* 1993;80:860-1.
- 18 Hasaniya N, Demetriades D, Stephens A, et al. Early morbidity and mortality of non-therapeutic operations for penetrating trauma. *Am Surg* 1994;60:744-7.

- 19 Leppaniemi A, Salo J, Haapiainen R. Complications of negative laparotomy for truncal stab wounds. *J Trauma* 1995;38:54-8.
- 20 Leppaniemi AK, Haapiainen RK. Selective nonoperative management of abdominal stab wounds: prospective, randomized study. *World J Surg* 1996;20:1101-5.
- 21 Renz BM, Feliciano DV. The length of hospital stay after an unnecessary laparotomy for trauma: a prospective study. *J Trauma* 1996;40:187-90.
- 22 Alzamel HA, Cohn SM. When is it safe to discharge asymptomatic patients with abdominal stab wounds? *J Trauma* 2005;58:523-5.
- 23 Velmahos GC, Constantinou C, Tillou A, et al. Abdominal computed tomographic scan for patients with gunshot wounds to the abdomen selected for nonoperative management. *J Trauma* 2005;59:1155-61.
- 24 Ginzburg E, Carrillo EH, Kopelman T, et al. The role of computed tomography in selective management of gunshot wounds to the abdomen and flank. *J Trauma* 1998;45:1005-9.
- 25 McFarlane ME. Non-operative management of stab wounds to the abdomen with omental evisceration. *J R Coll Surg Einb* 1996;41:239-40.

- 26 Arikan S, Kocakusak A, Yucel AF, et al. A prospective comparison of the selective observation and routine exploration methods for penetrating abdominal stab wounds with organ or omentum evisceration. *J Trauma* 2005;58:526-32.
- 27 Chmielewski GW, Nicholas JM, Dulchavsky SA, et al. Nonoperative management of gunshot wounds of the abdomen. *Am Surg* 1995;61:665-8.
- 28 Demetriades D, Gomez H, Chahwan S, et al. Gunshot injuries to the liver: the role of selective nonoperative management. *J Am Coll Surg* 1999;188:343-8.
- 29 Renz BM, Feliciano DV. Gunshot wounds of the right thoracoabdomen: a prospective study of nonoperative management. *J Trauma* 1994;37:737-44.
- 30 Friese RS, Coln CE, Gentilello LM. Laparoscopy is sufficient to exclude occult diaphragm injury after penetrating abdominal trauma. *J Trauma* 2005 58:789-92.
- 31 McQuay N Jr, Britt LD. Laparoscopy in the evaluation of penetrating thoracoabdominal trauma. *Am Surg* 2003;69:788-91.
- 32 Velmahos GC, Demetriades D, Chahwan S, et al. Angiographic embolization for arrest of bleeding after penetrating trauma to the abdomen. *Am J Surg* 1999;178:367-73.

- 33 Heyns CF, Van Vollenhoven P. Selective surgical management of renal stab wounds. *Br J Urol* 1992;69:351-7.
- 34 Velmahos GC, Demetriades D, Cornwell EE 3rd, et al. Selective management of renal gunshot wounds. *Br J Surg* 1998;85:1121-4.
- 35 Boyle EM Jr, Maier RV, Salazar JD, et al. Diagnosis of injuries after stab wounds to the flank and back. *J Trauma* 1997;42:260-5.
- 36 Chihombori A, Hoover EL, Phillips T, et al. Role of diagnostic techniques in the initial evaluation of stab wounds to the anterior abdomen, back, and flank. *J Natl Med Assoc* 1991;83:137-40.
- 37 Gonzalez RP, Turk B, Falimirski, et al. Abdominal stab wounds: diagnostic peritoneal lavage criteria for emergency room discharge. *J Trauma* 2001;51:939-43.
- 38 Keleman JJ 3<sup>rd</sup>, Martin RR, Obney JA, et al. Evaluation of diagnostic peritoneal lavage in stable patients with gunshot wounds to the abdomen. *Arch Surg* 1997;132:909-13.

- 39 Nagy KK, Krosner SM, Joseph KT, et al. A method of determining peritoneal penetration in gunshot wounds to the abdomen. *J Trauma* 1997;43:242-6.
- 40 Rosemurgy AS 2<sup>nd</sup>, Albrink MH, Olson SM, et al. Abdominal stab wound protocol: prospective study documents applicability for widespread use. *Am Surg* 1995;61:112-6.
- 41 Taviloglu K, Gunay K, Ertekin C, et al. Abdominal stab wounds: the role of selective management. *Eur J Surg* 1998;164:17-21.
- 42 Udobi KF, Rodriguez A, Chiu WC, et al. Role of ultrasonography in penetrating abdominal trauma: a prospective clinical study. *J Trauma* 2001;50:475-9.
- 43 Bokhari F, Nagy K, Roberts R, et al. The ultrasound screen for penetrating truncal trauma. *Am Surg* 2004;70:316-21.
- 44 Soto JA, Morales C, Munera F, et al. Penetrating stab wounds to the abdomen: use of serial US and contrast-enhanced CT in stable patients. *Radiology* 2001;220:365-71.
- 45 Conrad MF, Patton JH Jr, Parikshak M, et al. Selective management of penetrating truncal injuries: is emergency department discharge a reasonable goal? *Am Surg* 2003;69:266-73.

**Practice Management Guidelines for Nonoperative Management of Penetrating Abdominal Trauma  
1990 - Present**

Updated April 3, 2007

Article #	First Author	Year	Reference Title	Class	Comments
1	Albrecht RM	1999	Stab wounds to the back/flank in hemodynamically stable patients: evaluation using triple-contrast computed tomography.	III	This is a retrospective study with 79 hemodynamically stable patients who were stabbed in the flank or back. Triple contrast computed tomography was performed in 58 and was found to be 97.9% accurate in identifying significant injury with only clinical follow up, not operative. Patients with low-risk scans and no associated injuries were discharged immediately.
			<i>Am Surg</i> 1999;65:683-8.		
2	Alzamel HA	2005	When is it safe to discharge asymptomatic patients with abdominal stab wounds?	III	This is a chart review of 650 asymptomatic patients with abdominal stab wounds who were admitted for serial examination. Fifteen of 650 left against medical advice within 6 hours of presentation. Sixty-eight of 635 underwent exploratory laparotomy. All patients who needed surgery were identified within 12 hours of presentation. Twenty-three (33%) underwent surgery within 2 hours; 26 (38%) between 2 to 4 hours; 9 (13%) between 4 and 6 hours; 9 (13%) between 6 & 10 hours; and 1(1.4%) at 12 hours. The authors concluded that asymptomatic patients with abdominal stab wounds may be discharged after 12 hours of observation with little likelihood of missed injury.
			<i>J Trauma</i> 2005;58:523-5.		
3	Arikan S	2005	A prospective comparison of the selective observation and routine exploration methods for penetrating abdominal stab wounds with organ or omentum evisceration.	II	This is a prospective, nonrandomized series of 52 hemodynamically stable patients with abdominal stab wounds and either visceral or omental evisceration, who were treated either with exploratory laparotomy (21) or wound exploration/closure under local anesthesia (31). Patients with obviously perforated hollow viscera or peritonitis were excluded. Nineteen of 52 patients had significant injuries. Seven of 31 patients treated selectively required operation. Of the 21 patients treated with a routine laparotomy, 33% were nontherapeutic versus 6.45% in the selective group (p < 0.05). Of the routine laparotomy group, 19% had complications versus 3.2% in the selective group (p > 0.05). The only complication in the selective group was a case of small bowel obstruction managed nonoperatively. Mean length of stay was 137 hours in the routine exploration group versus 81 hours in the selective group (p < 0.001), and the mean LOS was 81 hours. The authors concluded that selective observation is safe and

				superior to routine laparotomy for the treatment of penetrating abdominal stab wounds with omental evisceration.	
4	Bokhari F	2004	The ultrasound screen for penetrating truncal trauma.	II	This is a prospective blinded pilot study of 49 patients with truncal stab wounds (SW) and gunshot wounds (GSW) evaluated by ultrasonic evaluation of the injured abdominal wall compared to the contralateral uninjured side. These were compared to diagnostic peritoneal lavages performed in all penetrating injuries to the anterior abdomen or thoracoabdomen; back and flank injuries were worked up with a triple-contrast computed tomography. A total of 58 injuries were evaluated: 37 SWs and 21 GSWs. There were 20 true positives, 20 false positive, and 18 true negatives. There were no false negatives. The sensitivity and negative predictive value of ultrasound in determining clinically significant truncal visceral injury was 100%; the specificity and positive predictive value were both approximately 50%. The authors concluded that ultrasonic exam of the injured abdominal walls in truncal penetrating trauma is an excellent screening tool.
			<i>Am Surg</i> 2004;70:316-21.		
5	Boyle EM Jr	1997	Diagnosis of injuries after stab wounds to the back and flank.	III	This is a retrospective review of 203 patients admitted for stab wounds to the back and flank. Group I patients were admitted prior to 1989 and had mandatory celiotomy. Group II patients were managed selectively. Selectively managed patients with hemodynamic instability, evisceration or acute abdominal symptoms had an IVP followed by immediate laparotomy (Group IIa). Stable patients without obvious signs suggesting internal injury had either observation alone (IIb), a DPL (IIc), a triple contrast computed tomography scan (CT) after a negative DPL (IId), or CT alone (IIe). The nontherapeutic laparotomy rate was 85% in Group I. None of the 34 patients in Group IIb underwent laparotomy, with no missed injuries. Eighteen of 32 Group IIc patients underwent laparotomy and 49% had a nontherapeutic laparotomy. Two of 37 patients in Group IIId underwent initial exploration with all procedures being therapeutic. Two of 37 scans were falsely negative. Two of 28 patients in Group IIe underwent initial exploration and both laparotomies were negative. One of 28 scans was falsely negative. The authors conclude that DPL should be the initial diagnostic study in stable patients; if the DPL is negative a triple contrast CT is indicated. We have a concern for how a DPL will alter CT findings with fluid and air. This study provides support at the very least for selective management since the

					therapeutic laparotomy rate increased from 15 to 80%.
			<i>J Trauma</i> 1997;42:260-5.		
<b>6</b>	Chihombori A	1991	Role of diagnostic techniques in the initial evaluation of stab wounds to the anterior abdomen, back, and flank.	III	This is a retrospective review of 162 patients with stab wounds, 103 with anterior abdominal wounds and 59 with back and flank wounds. Seventeen of 162 patients with shock, peritonitis, and evisceration were immediately explored. Most of the remainder underwent diagnostic peritoneal lavage (DPL). A total of 54 patients were explored with 6 negative laparotomies. Of 126 DPLs, none were false positive and 1 was false negative. Of 47 computed tomographic enema scans (CTEs), 3 were interpreted as an indication for angiography. The overall mortality was 4.3%. DPL was considered positive if red blood cells were > 2000/mm <sup>3</sup> , white blood cells were > 500/mm <sup>3</sup> or lavage fluid exited the urinary catheter or chest tube. The authors concluded that their algorithm can be safely applied to patients with penetrating trauma, as 108 of 162 patients were spared laparotomy.
			<i>J Natl Med Assoc</i> 1991;83:137-40.		
<b>7</b>	Chiu WC	2001	Determining the need for laparotomy in penetrating torso trauma: a prospective study using triple-contrast enhanced abdominopelvic computed tomography.	II	This is a prospective study of 75 consecutive hemodynamically stable patients with penetrating injury to the torso (lower chest, abdomen or pelvis) without definitive indication for laparotomy who underwent triple contrast computed tomography (CT) interpreted by blinded radiologists. A positive CT scan was defined as any evidence of peritoneal violation. In patients with a positive CT, 18 (69%) had laparotomy, two nontherapeutic and one negative. The remainder with positive CT was successfully managed nonoperatively. Of the patients with negative CT, 47/49 (96%) were successfully managed nonoperatively and one received a negative laparotomy. The false-negative CT injury was a left diaphragm injury discovered at laparotomy. CT accurately predicted whether laparotomy was needed in 71/75 (95%) patients. The authors note that adjunctive angiography and investigation for diaphragm injury may be prudent.
			<i>J Trauma</i> 2001;51:860-9.		

<b>8</b>	Chmielews ki GW	1995	Nonoperative management of gunshot wounds to the abdomen.	II	This is a prospective report on 12 patients with a single gunshot wound to the right upper quadrant, stable vital signs, reliable examination, and minimal or no abdominal tenderness. All were successfully observed. One nontherapeutic laparotomy was done secondary to abdominal tenderness.
			<i>Am Surg</i> 1995;61:665-8.		
<b>9</b>	Conrad MF	2003	Selective management of penetrating truncal injuries: is emergency department discharge a reasonable goal?	III	This is a retrospective review of 107 hemodynamically patients with penetrating truncal injuries who had "selective" emergency department (ED) workup consisting of local wound exploration for stab wounds to the anterior abdomen, a triple contrast computed tomography (CT) for penetrating injuries to the back/flank, or a triple contrast CT with sigmoidoscopy and/or cystography (depending on the trajectory) for penetrating wounds to the pelvis. Gunshot wounds to the anterior abdomen and left-sided thoracoabdominal injuries underwent operative intervention (laparoscopy or laparotomy). Of the patients who did not receive operative intervention, 62/107 (58%) were discharged home after negative CT in the ED, 18 were managed operatively (for positive CT scan), and 27 were managed nonoperatively. Two missed injuries were later identified (one hepatic and one small bowel injury) and managed in a delayed fashion without complications. Follow-up was available in 66% of ED workup patients. The authors concluded that certain patients having a negative ED workup can be safely discharged home.
			<i>Am Surg</i> 2003;69:266-73.		
<b>10</b>	Demetriade s D	1991	Gunshot wound of the abdomen: role of selective conservative management.	II	This is a prospective series of 41 patients with minimal or equivocal abdominal signs after a gunshot wound (GSW) to the abdomen who were observed nonoperatively. Seven of the 41 required delayed laparotomy within 4 hours to 4 days (3 colon injuries, 3 small bowel injuries, 1 liver injury); of these, two developed wound infection, one with abdominal dehiscence. The authors conclude that carefully selected patients with abdominal GSWs can be safely managed nonoperatively.
			<i>Br J Surg</i> 1991;78:220-2.		
<b>11</b>	Demetriade s D	1993	Non-therapeutic operations for penetrating trauma: early morbidity and mortality.	II	This is a prospective series of 372 operations performed on 368 patients with penetrating injuries to the abdomen, chest, neck and extremities. There were 46 negative or non-therapeutic operations. Eleven percent of patients with nontherapeutic operations developed major complications due to anesthesia or operation (pancreatitis, aspiration pneumonia, wound infection, DVT, pneumonia). Hospital length of stay was 4.1 days for those with uncomplicated nontherapeutic operations and 21.2 days for those with complications. The authors concluded that nontherapeutic operations for penetrating trauma carry a significant morbidity rate and they advocate a policy of selective conservatism.

<b>12</b>	Demetriade s D	1999	<i>Br J Surg</i> 1993;80:860-1.  Gunshot injuries to the liver: the role of selective nonoperative management.	III	This is a retrospective review of gunshot wounds to the liver. Sixteen stable patients were selected for nonoperative management. Five patients in the observed group underwent delayed laparotomy for peritonitis (four patients with liver injuries) and abdominal compartment syndrome (one patient who had received six units of blood in violation of the recommended policy). Except for a missed right diaphragm injury, there were no missed injuries in the 16 patients. One patient in the group with delayed laparotomy had multiple complications from abdominal compartment syndrome, and one patient in the nonoperative group developed a biloma, which was successfully drained percutaneously.
			<i>J Am Coll Surg</i> 1999;188:343-8.		
<b>13</b>	Demetriade s D	1997	Selective nonoperative management of gunshot wounds of the anterior abdomen.	II	This is a prospective study on gunshot wounds to the anterior abdomen using observation if the patient was stable, without peritonitis, and without severe head or spinal cord injury. One hundred six patients were in this group, with 14 undergoing delayed operation (13 for increasing tenderness and one for continued bleeding) of which five were therapeutic. Four of these patients had colon injuries managed by primary repair. Only one of these had a subsequent complication: a psoas abscess that required percutaneous drainage. One patient was observed for 48 hours in violation of the protocol and developed abdominal compartment syndrome and acute respiratory distress syndrome. The sensitivity of the initial negative physical examination was 97.1%. The mean hospital stay in the group with nontherapeutic operations was 6.4 days, and the complication rate was 27.6%. Of the total of 309 patients in the series, 92 (29.8%) were successfully managed nonoperatively.
			<i>Arch Surg</i> 1997;132:178-83.		
<b>14</b>	Easter DW	1991	A prospective, randomized comparison of computed tomography with conventional diagnostic methods in the evaluation of penetrating injuries to the back and flank.	II	Sixty-one patients with penetrating back and flank injuries were randomized into conventional testing or computed tomography (CT) testing, if they did not need immediate operation. Specificities were 96% for CT and 93% for conventional testing. The false positive rate for laparotomy based on physical exam was 43%. The numbers in this study are small and conventional diagnostic modalities were compared to outdated ones including cystogram and barium enema. The conclusion is that CT may be a good way to work up patient, but there are not a lot of patients to support this. Like the Demetriades studies, those who avoided surgery accrued lower costs.
			<i>Arch Surg</i> 1991;126:1115-9.		

<b>15</b>	Ertekin C	2005	Unnecessary laparotomy by using physical examination and different diagnostic modalities for penetrating abdominal stab wounds.	II	This study evaluated primarily anterior stab wounds in a prospective fashion. There was a significantly decreased negative laparotomy rate with selective management with multiple diagnostics including local wound exploration, echocardiography, colonoscopy, computed tomography, diagnostic peritoneal lavage, diagnostic laparoscopy, and intravenous pyelogram. Clinical examination, however, was the primary tool used to differentiate those patients requiring operation. Seventy-nine percent were successfully managed nonoperatively, but too many adjunctive studies are included. There was no change in mortality but a higher morbidity in delayed laparotomies (more than 8 hours later) versus early laparotomies (36% vs 27%).
<b>16</b>	Ginzburg E	1998	The role of computed tomography in selective management of gunshot wounds to the abdomen and flank.	III	This is a retrospective study of 83 patients using triple contrast computed tomography (CT) to rule out injury after a gunshot wound to abdomen or flank. CT scans were classified as positive, equivocal or negative. Positive studies (15) received laparotomy, except for four right upper quadrant wounds treated nonoperatively. Negative studies (53) were observed for 23 hours, with a 100% true negative rate. Equivocal studies (15) received cavity endoscopy (11), laparotomy (2), local wound exploration (1), or observation (1). Only one patient (the observed patient in the equivocal group) had a missed colon injury when using this protocol, which was repaired primarily.
<b>17</b>	Gonzalez RP	2001	Abdominal stab wounds: diagnostic peritoneal lavage criteria for emergency room discharge.	II	This is a prospective study of 90 patients investigating stab wounds only. If diagnostic peritoneal lavage (DPL) showed less than 1000 red blood cells/mm3 (44 patients), patients were sent home or admitted for reasons unrelated to the abdominal wound. Thirty-four were discharged immediately and had no complications with 85% follow up. One of four patients with evisceration required operation. This study provides good evidence for a threshold of 1000 RBC/mm3 as lower limit for DPL. There were no complications in patients immediately discharged, and 21% (8/38) of those observed needed surgery, of which 63% (5/8) were therapeutic.
<b>18</b>	Grossman MD	1998	Determining anatomic injury with computed tomography in selected torso gunshot wounds	III	This is a retrospective chart review. Computed tomography (CT) was used to look at trajectories through chest or abdomen or pelvis. Twenty of 37 abdominopelvic CTs were negative without subsequent complication. Eight of the remaining 17 needed therapeutic laparotomies, and the rest were observed. There were no complications or missed injuries.

<b>19</b>	Hasaniya N	1994	Early morbidity and mortality of non-therapeutic operations for penetrating trauma.	III	This was a retrospective study to look at complications of non-therapeutic laparotomies (n=230; 21.7%) after penetrating trauma. The rate was significant at 8.2% and those with complications had longer stays than those without. One patient with a major thoracic injury died secondary to complications related to a nontherapeutic laparotomy. The conclusion is to attempt to avoid these surgeries by selective management.
			<i>Am Surg</i> 1994;60:744-7.		
<b>20</b>	Heyns CF	1992	Selective surgical management of renal stab wounds.	III	This is a retrospective review of 95 patients with renal stab wounds. Patients with stab wounds and hematuria were selected for surgical exploration if they had signs of severe blood loss, an associated intra-abdominal laceration, or a major abnormality on an intravenous urogram. Sixty patients were in the nonoperative management group, and 35 were in the operative group. Only 4 patients underwent nontherapeutic laparotomy. Complications, however, developed in 12 of the 60 patients (20%) in the nonoperative group and consisted mainly of secondary hemorrhage caused by an arteriovenous fistula or pseudoaneurysm. Management consisted of embolization in 6, nephrectomy in 2, heminephrectomy in 1, open ligation of a fistula in 1, and spontaneous resolution in 2. The authors concluded by stating that certain groups should be more aggressively selected for surgery, and that angioembolization may be a useful adjunct to nonoperative management.
			<i>Br J Urol</i> 1992;69:351-7.		
<b>21</b>	Himmelma n RG	1991	Triple-contrast CT scans in penetrating back and flank trauma.	II	A negative triple contrast computed tomography scan has 100% sensitivity for retroperitoneal injury. Eighty-eight patients were enrolled. Five of nine high-risk scans went to surgery; two had injuries. None of the 77 non-high risk scans had complications.
			<i>J Trauma</i> 1991;31:852-5.		
<b>22</b>	Kelemen JJ 3rd	1997	Evaluation of diagnostic peritoneal lavage in stable patients with gunshot wounds to the abdomen.	II	This was a prospective clinical trial to assess physical exam and diagnostic peritoneal lavage (DPL) in stable patients with gunshot wounds to the abdomen. Forty of 44 received laparotomy. Physical examination was 82% sensitive and DPL 91%; the latter missed 3 small bowel injuries. The conclusion is that DPL augments physical examination to help triage abdominal gunshot wound patients.
			<i>Arch Surg</i> 1997;132:909-13.		
<b>23</b>	Kirton OC	1997	Stab wounds to the back and flank in the hemodynamically stable patient: a decision algorithm based on contrast-enhanced computed tomography with colonic opacification.	III	Computed tomography (CT) was performed on back and flank injuries in stab wound victims. None of 92 low-risk (without penetration of the deep muscle fascia) patients had injuries or complications, and six of 53 high-risk (penetration beyond the deep muscle fascia) scans went to surgery (two due to scan and four due to evolving signs). CT predicted all surgical findings in all six, with no additional injuries identified intraoperatively. Patients with low-risk CTs may be discharged immediately.

24	Leppaniemi A	1995	<i>Am J Surg</i> 1997;173:189-93. Complications of negative laparotomy for truncal stab wounds.	III	This is a retrospective study of 459 patients undergoing mandatory explorative laparotomy for truncal stab wounds. Of these, 172 (37%) were negative. It was concluded that mandatory laparotomy for truncal stab wounds leads to an unnecessary operation in about 40% of cases, with a 20% morbidity rate associated with the laparotomy itself.
			<i>J Trauma</i> 1995;38:54-8.		
25	Leppaniemi AK	1996	Selective nonoperative management of abdominal stab wounds: prospective, randomized study.	I	This is a prospective, randomized (not blinded) trial on the safety and cost-effectiveness of selective non-operative management compared to mandatory laparotomy in patients with abdominal stab wounds not requiring immediate laparotomy. Fifty-one patients not requiring immediate laparotomy for hemodynamic instability, generalized peritonitis, or evisceration were randomly assigned to mandatory laparotomy or expectant, nonoperative management. The morbidity rate was 19% following mandatory laparotomy and 8% after observation. Four patients (17%) managed nonoperatively required delayed laparotomy. Suture repair of colon injuries was performed 6 and 18 hours after the injury in two patients; one patient underwent laparotomy for hemorrhage 44 hours after the injury, and was found to have a liver laceration that was not actively bleeding, but 1.4 L of blood in the abdomen; and a fourth patient was discharged home but represented 52 days later with empyema and was found to have a missed diaphragm injury through which the stomach had partially herniated and perforated. About \$2800 was saved for every patient who underwent successful nonoperative management. Mandatory laparotomy detects some unexpected organ injuries earlier and more accurately but results in a high non-therapeutic laparotomy rate.
			<i>World J Surg</i> 1996;20:1101-6.		
26	Martin RR	1991	Outcome for delayed operation of penetrating colon injuries.	III	This is a records review of patients with penetrating injuries to the colon. Seven hundred sixty-nine patients were treated within 6 hours of the injury, and 137 were treated more than 6 hours after admission. The mortality for the immediate group was 4.0% vs. 1.5% for the delayed group. Colon-related infectious complications, defined as abscess or colon suture-line failure, occurred in 10% of the immediate group and 4.4% of the delayed group. There was no mortality for 128 patients with colon injuries only operated on within 12 hours of injury, and the colon-related infectious morbidity was 3%. Eleven patients with colon injuries only were treated after 12 hours with a mortality of 9% and a colon-related infectious morbidity of 18%. The authors concluded that even patients with fecal contamination can have operative repair delayed for up to 12 hours without undue morbidity related to infection.
			<i>J Trauma</i> 1991;31:1591-5.		

<b>27</b>	McFarlane M	1995	Management of penetrating abdominal injuries.	III	This is a review of data retrieved from notes and operative records. Clinical criteria are used to determine the need for laparotomy in the management of patients with penetrating abdominal trauma (n=112), and mandatory laparotomy is recommended for all patients with gunshot wounds. Selective management is advocated for stab wounds.
			<i>West Indian Med J</i> 1995;44:140-2.		
<b>28</b>	McFarlane ME	1996	Non-operative management of stab wounds to the abdomen with omental evisceration.	III	This is a report of 14 patients with omental evisceration without signs of peritonitis managed nonoperatively that had no complications. Thus omental evisceration is not a definitive indication for laparotomy. This study is limited by size, and the conclusion might be not supported at higher numbers of patients.
			<i>JR Coll Surg Edinb</i> 1996;41:239-40.		
<b>29</b>	Morrison JE	1996	Complications after negative laparotomy for trauma: long-term follow-up in a health maintenance organization.	III	This is a retrospective cohort study. The incidence of long-term complications after negative or nontherapeutic laparotomy is low. Negative or nontherapeutic laparotomies have a high 40% short-term complication rate (pneumonia, etc.) and low long-term complications (i.e., no small bowel obstructions). There was only a 63% follow-up. Seventy-nine percent were blunt patients, thus no visceral mobilization was needed.
			<i>J Trauma</i> 1996;41:509-13.		
<b>30</b>	Muckart DJ	1990	Selective conservative management of abdominal gunshot wounds: a prospective study.	II	This is a prospective study of 111 patients with low velocity gunshot wounds of the abdomen followed with repeated physical examination. Twenty-two (20%) underwent nonoperative management, and none required delayed laparotomy. The authors concluded that selective conservative management may be applied safely to a limited group of patients with gunshot wounds of the abdomen. All the mortality was in the laparotomy group.
			<i>Br J Surg</i> 1990;77:652-5.		
<b>31</b>	Munera F	2004	Gunshot wounds of abdomen: evaluation of stable patients with triple-contrast helical CT.	II	This is a prospective study of 47 patients with abdominal gunshot wound who received a triple-contrast helical computed tomography (CT). Twenty patients had a negative CT scan. These patients were treated nonoperatively. One injury was missed at CT (a cecal wall contusion that was repaired). It was concluded that in stable patients with gunshot wounds to the abdomen in whom there is no indication for immediate surgery, triple-contrast helical CT can help reduce the number of cases of unnecessary or nontherapeutic laparotomy (accuracy of 96%).
			<i>Radiology</i> 2004;231:399-405.		

<b>32</b>	Nagy KK	1997	A method of determining peritoneal penetration in gunshot wounds to the abdomen.	III	Information on all patients who had a diagnostic peritoneal lavage (DPL) performed for a gunshot wound was extracted from a database retrospectively. DPL was study of choice, and was defined as positive if > 10,000 red blood cells/mm3. There were 429 patients, 279 with a negative DPL, and 150 with a positive DPL. Two of 278 patients with a negative DPL required laparotomy and were found to have injuries. The authors concluded that for patients who sustain a gunshot wound in whom peritoneal penetration is unclear, DPL is a sensitive, specific, and accurate test to determine the need for laparotomy.
			<i>J Trauma</i> 1997;43:242-6.		
<b>33</b>	Renz BM	1995	Gunshot wounds to the liver. A prospective study of selective nonoperative management.	II	This is a prospective study regarding nonoperative management of gunshot wounds (GSW) to the liver. Seven patients had a GSW to liver; all were hemodynamically stable; there were no deaths and no complications. Chest tubes were placed in all patients. No patient required a laparotomy. The authors concluded that a hemodynamically stable patient without peritonitis after sustaining a GSW to the liver could be managed nonoperatively with a few minor intrathoracic complications.
			<i>J Med Assoc Ga</i> 1995;84:275-7.		
<b>34</b>	Renz BM	1994	Gunshot wounds to the right thoracoabdomen: a prospective study of nonoperative management.	II	This is a prospective study on hemodynamically stable patients with a gunshot wound (GSW) to right thoracoabdomen. Thirteen patients with a GSW to right thoracoabdomen were included. All were hemodynamically stable. None required surgery. All had chest tubes placed, with only minor lung complications. The authors concluded that hemodynamically stable patients without peritonitis after sustaining a GSW to the right thoracoabdomen could be managed nonsurgically with a low incidence of minor intrathoracic complications. They also note that thoracoabdominal computed tomographic scanning is a comprehensive means of diagnosis and follow-up when nonsurgical management is chosen.
			<i>J Trauma</i> 1994;37:737-44.		
<b>35</b>	Renz BM	1995	Unnecessary laparotomies for trauma: a prospective study of morbidity.	II	This is a prospective case series. There were 254 patients with unnecessary laparotomies after trauma. There was a 19.7% complication rate in those with no associated injuries, and a 41.3% overall complication rate, mostly atelectasis, pleural effusion and hypertension. Unnecessary laparotomies for trauma result in significant morbidity.
			<i>J Trauma</i> 1995;38:350-6.		
<b>36</b>	Renz BM	1996	The length of hospital stay after an unnecessary laparotomy for trauma: a prospective study.	II	This is a prospective case series. The length of stay for patients with unnecessary laparotomies was 4.7 days for 81 patients who had no associated injuries. Unnecessary laparotomies for trauma resulted in a significant length of stay. The presence of a complication or an associated injury significantly prolonged the length of stay.

<b>37</b>	Rosemurgy AS 2nd	1995	<i>J Trauma</i> 1996;40:187-90. Abdominal stab wound protocol: prospective study documents applicability for widespread use.	II	This is a prospective study examining a protocol using diagnostic peritoneal lavage (DPL) for abdominal stab wounds. A positive DPL was defined as one with greater than 50,000 red blood cells/mm <sup>3</sup> , more than 500 white blood cells/mm <sup>3</sup> , or the presence of food particles or bacteria on gram stain and microscopic viewing. There were 72 patients with fascial penetration. Fifty-seven underwent paracentesis or DPL. Those with a positive DPL (30) underwent exploration. More than one-third with fascial penetration, some with evisceration, avoided exploration. Only one patient underwent delayed celiotomy (primary repair of a cecal injury) and did so without detriment. The authors concluded that patients with abdominal stab wounds could be selectively managed safely.
<b>38</b>	Shannuga nathan K	2001	<i>Am Surg</i> 1995;61:112-6. Triple-contrast helical CT in penetrating torso trauma: a prospective study to determine peritoneal violation and the need for laparotomy.	II	This is a prospective evaluation regarding triple-contrast helical computed tomography (CT) in penetrating torso trauma. A positive CT was defined as evidence of peritoneal penetration or injury to the retroperitoneal colon, major vessel, or urinary tract. There were 104 stable patients without peritonitis, 69 with negative CT scans. Two patients with negative scans had laparotomy, but no injury was found. Patients with a positive CT, except patients with isolated liver injury or free fluid, underwent laparotomy. Thirty-five had a positive CT, of which 21 had positive findings at laparotomy. Nine patients with isolated hepatic injuries were successfully treated without laparotomy. The negative predictive value of triple-contrast CT was 100%. The authors concluded that triple-contrast helical CT can accurately predict the need for laparotomy (97% accuracy) and exclude peritoneal violation in penetrating torso trauma including tangential abdominal wounds.
			<i>AJR Am J Roentgenol</i> 2001;177:1247-56.		
<b>39</b>	Shannuga nathan K	2004	Penetrating torso trauma: triple-contrast helical CT in peritoneal violation and organ injury--a prospective study in 200 patients	II	This is a prospective study of triple-contrast helical computed tomography (CT) in peritoneal violation and organ injury. There were 200 hemodynamically stable patients, 132 with a negative CT, and 68 with a positive CT. Forty-one of these 68 were taken to surgery and two had negative laparotomies. Twenty-one of 23 patients with isolated liver injury had successful nonsurgical management. Angioembolization was performed on four of these patients. None of the six patients with renal injury required surgery. There were two false negative studies; both of these patients had left diaphragm injuries. The authors concluded that triple-contrast helical CT accurately demonstrates peritoneal violation (98% accuracy) and visceral injury in patients with penetrating torso wounds.
			<i>Radiology</i> 2004;231:775-84.		

<b>40</b>	Sirinek KR	1990	Is exploratory celiotomy necessary for all patients with truncal stab wounds?	III	This study is a review of mandatory celiotomy in patients with truncal stab wounds. There were 1241 patients, all stab wound victims, who had a laparotomy. Thirty-eight percent had a negative laparotomy, and 3% had post-operative complications, and one patient died. The authors concluded that selective management protocols using observation, repeated physical examination, and special diagnostic procedures could be instituted for asymptomatic hemodynamically stable patients with truncal stab wounds.
<b>41</b>	Soto JA	2001	Penetrating stab wounds to the abdomen: use of serial US and contrast-enhanced CT in stable patients.	II	This is a prospective series of 32 patients with a stab wound to the abdomen who were examined with ultrasound (US) at admission and 12 hours later as well as a triple contrast computed tomography (CT). US was interpreted by the radiologist who performed the exam, and the CT was interpreted by two other radiologists. US demonstrated abnormalities in 14 (43.8% patients); 30/32 were successfully managed nonoperatively. CT demonstrated abnormalities in 21/32 (65.6%) of patients, primarily free fluid. Contrast extravasation was not demonstrated in any of the 32 patients. All abnormalities seen with US were also demonstrated with CT. In 12 patients, CT showed abnormalities not detected with US: free fluid in 10 and hepatic laceration in three. Bowel-wall hematomas were seen on CT in four but this finding was not specifically sought with US. The authors conclude that serial USG and CT help guide treatment for stable patients with a stab wound to the abdomen.
<b>42</b>	Taviloglu K	1998	Abdominal stab wounds: the role of selective management.	III	Three hundred eight-seven patients with abdominal stab wounds who did not have indications for immediate operation who were initially treated with wound exploration; 200 of 387 had peritoneal penetration and subsequently underwent open diagnostic peritoneal lavage (DPL). 142 were treated conservatively and 58 received an exploratory laparotomy. Twenty-five of 58 (43.1%) were operated on immediately after DPL; 33 (56.9%) were operated on after DPL and a period of observation. Of these 58, 48 had a true positive DPL; one had a true negative DPL; three had a false negative DPL; and six had a false positive DPL. False negative DPLs included diaphragmatic, colonic, and gastric injuries that were recognized after failed observation. Of the six false positive DPLs, four were due to abdominal wall bleeds, one from a liver injury and one from a splenic injury. The negative laparotomy rate was 7%, and the unnecessary laparotomy rate was 3%. The authors concluded that the selective approach might be applied in teaching hospitals to minimize the number of negative and unnecessary laparotomies.
			<i>Eur J Surg</i> 1998;164:17-21.		

<b>43</b>	Tsikiotis V	2004	Selective clinical management of anterior abdominal stab wounds.	III	<p>This is a retrospective review of 77 patients with an anterior abdominal stab wound. Twenty-five were taken directly to the operating room for hypotension, evisceration or peritonitis. Seventeen underwent diagnostic peritoneal lavage (DPL) for thoracoabdominal wounds and 5 had local wound exploration. Three of five patients with grossly positive DPLs had therapeutic laparotomies. One of three with positive DPL by red blood cell count had a therapeutic laparotomy. Four of five patients had negative local wound explorations; one of these was operated on for fascial closure but with an otherwise nontherapeutic laparotomy. The remaining 30 patients were managed with serial clinical assessments and did not require operation. The authors concluded that patients sustaining anterior abdominal stab wounds who present without hypotension, evisceration, or peritonitis might be managed safely under a protocol of serial clinical evaluations.</p>
<b>44</b>	Udobi KF	2001	Role of ultrasonography in penetrating abdominal trauma: a prospective clinical study.	II	<p>Seventy-five consecutive stable patients with penetrating trauma to the abdomen, flank or bank received Focused Assessment with Sonography for Trauma (FAST) as the initial diagnostic test. Twenty-one of 75 had a positive FAST. There were 2 false-positive studies. There were 19/21 true positive studies; all had peritoneal blood and injuries requiring repair at the time of laparotomy. Thirty-two of 54 had a true negative FAST; Thirteen of 54 had a false negative FAST with peritoneal blood and significant injury on further evaluation; thirteen of 54 had a false negative FAST without peritoneal blood but with abdominal injuries requiring operative repair. The overall sensitivity of FAST was 46% and the specificity was 94%. The positive predictive value was 90% and the negative predictive value was 60%. The authors concluded that while a positive FAST is a strong predictor of injury, additional diagnostic studies should be performed in the face of a negative FAST to rule out occult injury.</p>
<b>45</b>	van Haarst EP	1999	The efficacy of serial physical examination in penetrating abdominal trauma.	III	<p>This is a retrospective review of 370 patients with potentially penetrating abdominal wounds (48 gunshot wounds and 322 stab wounds). Initially diagnostic peritoneal lavage and local wound exploration were used, but these methods were later abandoned. The overall rate of laparotomies for stab wounds decreased while the rate of nontherapeutic laparotomies decreased. Delayed laparotomy did not increase morbidity or mortality. The authors conclude that abdominal stab wounds may be treated conservatively with repeated physical examination. They believe that peritoneal perforation and hemoperitoneum should not indicate a routine laparotomy.</p>
			<i>J Trauma</i> 2001;50:475-479.		
			<i>Injury</i> 1999;30:599-604.		

<b>46</b>	Velmahos GC	1997	A selective approach to the management of gunshot wounds to the back.	II	<p>This is a prospective study of 230 consecutive patients with gunshot wounds to the back. Patients with hemodynamic instability or peritonitis underwent urgent operation. Eleven patients were excluded from the study after receiving an emergency resuscitative thoracotomy. Four patients were operated on without abdominal findings due to spinal cord injuries in 2, inability to observe due to need for repair of another injury in 1, and participation in another protocol in 1. Of the remaining 188 patients, 58 (31%) underwent laparotomy (56 therapeutic, 2 negative) due to a positive physical examination (peritoneal signs, gross hematuria, rectal bleeding, or shock), and 130 (69%) were initially observed due to a negative clinical examination. Four of 130 (3%) underwent delayed laparotomy after developing abdominal tenderness; all of these laparotomies were nontherapeutic. The sensitivity and specificity of initial clinical exam in detecting significant intraabdominal injuries were 100% and 95% respectively. The authors also note a diaphragm injury that presented with no clinical signs. The authors concluded that clinical examination is a safe method of selectively managing patients with gunshot wounds to the back. They believe that an observation period of 24 hours is adequate for patients with no abdominal symptoms.</p>
<b>47</b>	Velmahos GC	1997	Gunshot wounds to the buttocks: predicting the need for operation.	II	<p>Hemodynamically unstable patients underwent immediate laparotomy. Hemodynamically stable patients with peritoneal signs had minimal preoperative diagnostic tests (hematocrit, plain radiographs, urinalysis) prior to operation. Rigid sigmoidoscopy was performed after intubation and prior to opening the abdomen in patients with potential pelvic trajectories. Patients with gross hematuria or blood on rectal exam underwent cystography and/or rigid sigmoidoscopy. Patients without clinical signs of significant injury underwent "appropriate" diagnostic tests, including rigid sigmoidoscopy and were admitted for serial clinical examinations. Nineteen (32.2%) were operated on based on clinical findings, with significant intraabdominal injuries in 17 (28.8%). The remaining 40 (67.8%) were successfully observed. There were no missed injuries or delays in diagnosis. Sensitivity and specificity of clinical exam for identifying significant intra-abdominal injury was 100% and 95.3% respectively. The authors conclude that clinical exam is a safe method for selectively managing patients with gunshot wounds to the buttocks.</p>
<b>48</b>	Velmahos GC	1998	Transpelvic gunshot wounds: routine laparotomy or selective management?	II	<p>This is a prospective case series of 37 patients with transpelvic gunshot wounds. Nineteen (51.4%) were operated on immediately for indications of peritonitis (11/19), peritonitis with hypotension (1/19), peritonitis with hematuria (5/19), peritonitis with hypotension and hematuria (1/19), hypotension with a pulseless lower extremity (1/19)</p>

				and tachycardia despite resuscitation (1/19). Of the patients operated on immediately, laparotomy was therapeutic in 16/19 (84.2%). Eighteen (48.6%) were initially observed. During observation, three patients developed clinical symptoms and were operated on; all three laparotomies were nontherapeutic. Of the patients initially observed, the authors performed 5 intravenous pyelograms, 13 rigid sigmoidoscopies, 2 cystograms and 1 abdominal computed tomography. None of these tests altered therapeutic decisions that had been made on the basis of the clinical exam. The clinical exam was 100% sensitive and 71.4% specific for detecting significant intraabdominal injuries, for a positive predictive value of 72.7% and a negative predictive value of 100%. The authors concluded that a policy of selective management is safe and clinical exam is the main method of selecting patients for operative or nonoperative treatment.	
			<i>World J Surg</i> 1998;22:1034-8.		
49	Velmahos GC	1998	Selective Management of Renal Gunshot Wounds.	III	This is a retrospective review of 52 consecutive patients with renal gunshot wounds who were managed by a protocol of selective exploration. Renal injuries were explored only if they involved the hilum or were accompanied by signs of continued bleeding. Three of 52 died from associated injuries shortly after admission. Fifteen of 52 suffered complications of which two were directly associated with the renal injury. Thirty-two underwent renal exploration; 17 required nephrectomy for major renovascular or parenchymal trauma. Renal exploration was successfully avoided in the remaining 20 patients. A total of only four patients did not undergo laparotomy. The authors concluded that mandatory exploration of all renal gunshot wounds is unnecessary; injuries that produce stable peripheral hematomas do not require exploration.
			<i>Br J Surg</i> 1998;85:1121-4.		
50	Velhamos GC	2001	Selective nonoperative management in 1,856 patients with abdominal gunshot wounds: should routine laparotomy still be the standard of care?	III	This is a retrospective review of 792 patients with abdominal gunshot wounds (GSWs) treated with selective nonoperative management. During observation 80 (4%) patients developed symptoms and required a delayed laparotomy; 57/80 laparotomies were therapeutic. Five (0.3%) suffered complications potentially related to the delay in laparotomy, which were managed successfully. Seven hundred twelve (38%) were successfully managed nonoperatively. The rate of unnecessary laparotomy was 14% among operated patients or 9% among all patients. If patients were managed by routine laparotomy, the unnecessary laparotomy rate would have been 47% (39% for anterior and 74% for posterior abdominal GSWs). Patients without surgery had significantly shorter hospital length of stay and lower hospital charges. The authors concluded that selective nonoperative management is safe for managing patients with abdominal GSWs in a Level I Trauma Center with an in-house trauma team. A policy of

					selective nonoperative management significantly reduces the unnecessary laparotomy rate and hospital charges.
			<i>Ann Surg</i> 2001;234:395-403.		
<b>51</b>	Velhamos GC	2005	Abdominal computed tomography scan for patients with gunshot wounds to the abdomen selected for nonoperative management.	II	This study is a prospective series of 100 stable patients with a nontangential abdominal gunshot wound (GSW) and no generalized abdominal tenderness who were evaluated with a single-contrast (IV) computed tomographic (CT) scan. Twenty-six underwent laparotomy, which was nontherapeutic in five (19%). Three of these five patients underwent operation on the basis of CT findings and two on the basis of clinical findings. Two CT scans were false negative, missing hollow visceral injuries. The sensitivity of CT scanning was 90.5% and the specificity was 96%. The authors concluded that abdominal CT scanning is a safe method for selecting patients with abdominal GSWs for nonoperative management.
			<i>J Trauma</i> 2005;59:1155-61.		