PRACTICE MANAGEMENT GUIDELINES FOR THE EVALUATION
OF BLUNT ABDOMINAL TRAUMA

EAST Practice Management Guidelines Work Group

William S. Hoff, MD, 1 Michelle Holevar, MD, 2 Kimberly K. Nagy, MD, 3 Lisa Patterson, MD, 4 Jeffrey S. Young, MD, 5 Abenamar Arrillaga, MD, 6 Michael P. Najarian, DO, 7 Carl P. Valenziano, MD 8

1Brandywine Hospital, Coatesville, PA
2Mount Sinai Hospital, Chicago, IL
3Cook County Hospital and Rush University, Chicago, IL
4Wright State University, Dayton, OH
5University of Virginia Health System, Charlottesville, VA
6Greenville Memorial Hospital, Greenville, SC
7Lehigh Valley Hospital, Allentown, PA
8Morristown Memorial Hospital, Morristown, NJ

Address for Correspondence:

William S. Hoff, MD, FACS
Brandywine Hospital - Department of Traumatology
201 Reeceville Road
Coatesville, PA 19320
Phone: (610) 383-8099 / Fax: (610) 383-8352
E-mail: bill.hoff@uphs.upenn.edu

© 2001 Eastern Association for the Surgery of Trauma
PRACTICE MANAGEMENT GUIDELINES FOR THE EVALUATION OF BLUNT ABDOMINAL TRAUMA

I. Statement of the problem

Evaluation of patients who have sustained blunt abdominal trauma (BAT) may pose a significant diagnostic challenge to the most seasoned trauma surgeon. Blunt trauma produces a spectrum of injury from minor, single-system injury to devastating, multi-system trauma. Trauma surgeons must have the ability to detect the presence of intra-abdominal injuries across this entire spectrum. While a carefully performed physical examination remains the most important method to determine the need for exploratory laparotomy, there is little Level I evidence to support this tenet. In fact, several studies have highlighted the inaccuracies of the physical examination in BAT.1, 2

The effect of altered level of consciousness as a result of neurologic injury, alcohol or drugs, is another major confounding factor in assessing BAT.

Due to the recognized inadequacies of physical examination, trauma surgeons have come to rely on a number of diagnostic adjuncts. Commonly used modalities include diagnostic peritoneal lavage (DPL) and computed tomography (CT). Although not available universally, focused abdominal sonography for trauma (FAST) has recently been included in the diagnostic armamentarium. Diagnostic algorithms outlining appropriate use of each of these modalities individually have been established. Several factors influence the selection of diagnostic testing: (1) type of hospital - i.e., trauma center vs. “non-trauma” hospital; (2) access to a particular technology at the surgeon’s institution; (3) the surgeon’s individual experience with a given diagnostic modality. As facilities evolve, technologies mature and surgeons gain new experience, it is important that any diagnostic strategy constructed be dynamic.

The primary purpose of this study was to develop an evidence-based, systematic diagnostic approach to BAT utilizing the three major diagnostic modalities: i.e., DPL, CT and FAST. This diagnostic regimen would be designed such that it could be reasonably applied by all general surgeons performing an initial evaluation of BAT.

II. Process

A. Identification of references

A MEDLINE search was performed using the key words “abdominal injuries” and the subheading “diagnosis”. This search was limited further to (1) clinical research, (2) published in English, (3) publication dates January 1978 through February 1998. The initial search yielded 742 citations. Case reviews, review articles, meta-analyses, editorials, letters to the editor, technologic reports, pediatric series and studies involving a significant number of penetrating abdominal injuries were excluded prior to formal review. Additional references, selected by the individual subcommittee members, were then included to compile the master reference list of 197 citations.

B. Quality of the references
Articles were distributed among subcommittee members for formal review. A review data sheet was completed for each article reviewed which summarized the main conclusions of the study, and identified any deficiencies in the study. Further, reviewers classified each reference by the methodology established by the Agency for Health Care Policy and Research (AHCPR) of the U.S. Department of Health and Human Services as follows:

- **Class I**: Prospective, randomized, double-blinded study
- **Class II**: Prospective, randomized, non-blinded trial
- **Class III**: Retrospective series, meta-analysis

Following review by the subcommittee, references were excluded based on poor design or invalid conclusions. An evidentiary table was constructed using the remaining 101 references: Class I (20); Class II (32); Class III (49). Recommendations were based on studies included in the evidentiary table.

**III. Recommendations**

**A. Level I**
1. Exploratory laparotomy is indicated for patients with a positive DPL.
2. CT is recommended for the evaluation of hemodynamically stable patients with equivocal findings on physical examination, associated neurologic injury, or multiple extra-abdominal injuries. Under these circumstances, patients with a negative CT should be admitted for observation.
3. CT is the diagnostic modality of choice for nonoperative management of solid visceral injuries.
4. In hemodynamically stable patients, DPL and CT are complementary diagnostic modalities.

**B. Level II**
1. FAST may be considered as the initial diagnostic modality to exclude hemoperitoneum. In the presence of a negative or indeterminate FAST result, DPL and CT have complementary roles.
2. When DPL is used, clinical decisions should be based on the presence of gross blood on initial aspiration (i.e., 10 ml) or microscopic analysis of lavage effluent.
3. In hemodynamically stable patients with a positive DPL, follow-up CT scan should be considered, especially in the presence of pelvic fracture or suspected injuries to the genitourinary tract, diaphragm or pancreas.
4. Exploratory laparotomy is indicated in hemodynamically unstable patients with a positive FAST. In hemodynamically stable patients with a positive FAST, follow-up CT permits nonoperative management of select injuries.
5. Surveillance studies (i.e., DPL, CT, repeat FAST) are required in hemodynamically stable patients with indeterminate FAST results.

**C. Level III**
1. Objective diagnostic testing (i.e., FAST, DPL, CT) is indicated for patient with abnormal mentation, equivocal findings on physical examination, multiple injuries, concomitant chest injury or hematuria.
2. Patients with seatbelt sign (SBS) should be admitted for observation and serial physical examination. Detection of intraperitoneal fluid by FAST or CT in a patient with SBS mandates either DPL to determine the nature of the fluid or exploratory laparotomy.

3. CT is indicated for the evaluation of suspected renal injuries.

4. A negative FAST should prompt follow-up CT for patients at high risk for intraabdominal injuries (e.g., multiple orthopedic injuries, severe chest wall trauma, neurologic impairment).

5. Splanchnic angiography may be considered in patients who require angiography for the evaluation of other injuries (e.g., thoracic aortic injury, pelvic fracture).

IV. Scientific Foundation

A. Diagnostic Peritoneal Lavage (DPL)

DPL was introduced by Root in 1965 as a rapid and accurate method to identify the presence of intra-abdominal hemorrhage following trauma. Subsequent studies have confirmed the efficacy of DPL in diagnosing abdominal hemorrhage as well as its superiority over physical examination alone. The accuracy of DPL has been reported between 92% and 98%. The high sensitivity of DPL is due to the significant false positive rate of the technique. Several authors have highlighted the importance of interpreting DPL results in the context of the overall clinical condition of the patient. A positive DPL does not necessarily mandate immediate laparotomy in the hemodynamically stable patient. DPL has been shown to be more efficient than CT scan in identifying patients that require surgical exploration.

The complication rate associated with DPL is quite low. The incidence of complications is lower for open DPL compared with to the closed technique. However, closed DPL can be performed more rapidly. Studies designed to examine the ability of physicians to estimate the red blood cell (RBC) count in DPL fluid have demonstrated the poor sensitivity of visual inspection. A positive DPL, based on microscopic analysis of lavage fluid, has been defined as > 10^5 RBC/mm^3. It has been recommended that patients with RBC counts in the equivocal range (i.e., 25,000 – 75,000 RBC/mm3) undergo additional diagnostic testing, such as CT scanning.

The false positive rate for DPL is increased in patients with pelvic fractures. In order to avoid sampling the retroperitoneal hematoma, a suprpub-umbilical approach has been recommended, theoretically reducing the chances of a false positive result.

The advantages of DPL for detection of hollow visceral injuries have been clearly demonstrated. Two studies which advocate analysis of DPL fluid for amylase and alkaline phosphatase consistent with enteric injuries have been disputed. Similarly, the utility of the DPL white blood cell (WBC) count has been questioned. DPL is sensitive for mesenteric injury and, in fact, has been shown to be superior to CT for the diagnosis of this injury.

Thus, DPL is a safe, rapid and accurate method for determining the presence of intraperitoneal blood in victims of BAT. It is more accurate than CT for the early diagnosis of hollow visceral and mesenteric injuries, but it does not reliably exclude
significant injuries to retroperitoneal structures. False positive results may occur in the presence of pelvis fractures. Hemodynamically stable patients with equivocal results are best managed by additional diagnostic testing to avoid unnecessary laparotomies.

B. Computed Tomography (CT)

Routine use of CT for the evaluation of BAT was not initially viewed with overwhelming enthusiasm. CT requires a cooperative, hemodynamically stable patient. In addition, the patient must be transported out of the trauma resuscitation area to the radiographic suite. Specialized technicians and the availability of a radiologist for interpretation were also viewed as factors which limited the utility of CT for trauma patients. CT scanners are now available in most trauma centers and, with the advent of helical scanners, scan time has been significantly reduced. As a result, CT has become an accepted part of the traumatologist’s armamentarium.

The accuracy of CT in hemodynamically stable blunt trauma patients has been well established. Sensitivity between 92% and 97.6% and specificity as high as 98.7% has been reported in patients subjected to emergency CT. Most authors recommend admission and observation following a negative CT scan. In a recent study of 2774 patients, the authors concluded that the negative predictive value (99.63%) of CT was sufficiently high to permit safe discharge of BAT patients following a negative CT scan.

CT is notoriously inadequate for the diagnosis of mesenteric injuries and may also miss hollow visceral injuries. In patients at risk for mesenteric or hollow visceral injury, DPL is generally felt to be a more appropriate test. A negative CT scan in such a patient cannot reliably exclude intra-abdominal injuries.

CT has the unique ability to detect clinically unsuspected injuries. In a series of 444 patients in whom CT was performed to evaluate renal injuries, 525 concomitant abdominal and/or retroperitoneal injuries were diagnosed. Another advantage of CT scanning over other diagnostic modalities is its ability to evaluate the retroperitoneal structures. Kane performed CT in 44 hemodynamically stable blunt trauma patients following DPL. In 16 patients, CT revealed significant intra-abdominal or retroperitoneal injuries not diagnosed by DPL. Moreover, the findings on CT resulted in a modification to the original treatment plan in 58% of the patients.

C. Focused Abdominal Sonography for Trauma (FAST)

In recent years, focused abdominal sonography for trauma (FAST) has emerged as a useful diagnostic test in the evaluation of BAT. The advantages of the FAST examination have been clearly established. FAST is noninvasive, may be easily performed and can be done concurrently with resuscitation. In addition, the technology is portable and may be easily repeated if necessary. In most cases, FAST may be completed within 3 or 4 minutes. The test is especially useful for detecting intra-abdominal hemorrhage in the multiply injured or pregnant patient.

A noted drawback to the FAST examination is the fact that a positive examination relies on the presence of free intraperitoneal fluid. In the hands of most operators, ultrasound will detect a minimum of 200 mL of fluid. Injuries not associated with hemoperitoneum may not be detected by this modality. Thus, ultrasound is not a reliable method for excluding hollow visceral injury. In addition,
the FAST examination cannot be used to reliably grade solid organ injuries. Therefore, in the hemodynamically stable patient, a follow-up CT scan should be obtained if nonoperative management is contemplated.59

FAST compares favorably with more traditionally utilized diagnostic tests. In the hemodynamically stable patient with BAT, FAST offers a viable alternative to DPL.60 DPL may also be used as a complementary examination in the hemodynamically stable patient in the presence of an equivocal or negative ultrasound with strong clinical suspicion of visceral injury.61, 62 FAST has demonstrated utility in hemodynamically stable patients with BAT.58, 60, 63 In addition, ultrasound has been shown to be more cost-effective when compared to DPL or CT.45, 47, 60

Overall, FAST has a sensitivity between 73% and 88%, a specificity between 98% and 100% and is 96% to 98% accurate.46, 50, 57, 58, 64, 65 This level of accuracy is independent of the practitioner performing the study. Surgeons, emergency medicine physicians, ultrasound technicians and radiologists have equivalent results.46, 53, 64, 65, 66

D. Other Diagnostic Modalities

As interest in laparoscopic procedures has increased among general surgeons, there has been speculation regarding the role of diagnostic laparoscopy (DL) in the evaluation of BAT. One of the potential benefits postulated is the reduction of nontherapeutic laparotomies. With modification of the technique to include smaller instruments, portable equipment and local anesthesia, DL may be a useful tool in the initial evaluation of BAT. Although there are no randomized, controlled studies comparing DL to more commonly utilized modalities, experience at one institution using minilaparoscopy demonstrated a 25% incidence of positive findings on DL, which were successfully managed nonoperatively and would have resulted in nontherapeutic laparotomies.67

Although its ultimate role remains unclear, another modality to be considered in the diagnostic evaluation of BAT is visceral angiography. This modality may have diagnostic value when employed in conjunction with angiography of the pelvis or chest, or when other diagnostic studies are inconclusive.68

V. Summary

Injury to intra-abdominal viscera must be excluded in all victims of BAT. Physical examination remains the initial step in diagnosis but has limited utility under select circumstances. Thus, various diagnostic modalities have evolved to assist the trauma surgeon in the identification of abdominal injuries. The specific tests selected are based on the clinical stability of the patient, the ability to obtain a reliable physical examination and the provider’s access to a particular modality. It is important to emphasize that many of the diagnostic tests utilized are complementary rather than exclusionary.

Based on the above recommendations, a reasonable diagnostic approach to BAT is summarized in Figures 1 and 2. In hemodynamically stable patients with a reliable physical examination, clinical findings may be used to select patients who may be safely observed. In the absence of a reliable physical examination, the main
diagnostic choice is between CT or FAST (with CT in a complementary role). Hemodynamically unstable patients may be initially evaluated with FAST or DPL.

VI. Future Investigation

Recent literature is replete with studies that emphasize the many advantages of ultrasound in the valuation of BAT. Although this technology is becoming more available to trauma surgeons, for a variety of reasons, it has not become universally available in all centers. Continued research addressing the utility of FAST, with emphasis on its advantages specific to resource utilization, is suggested. In addition, studies should be designed to more closely evaluate the feasibility of FAST as the sole diagnostic test in hemodynamically stable patients. Perhaps safe strategies for nonoperative management of solid visceral injuries could be developed which rely on FAST alone, such that the number of CT scans could be reduced.
VII. References


### PRACTICE MANAGEMENT GUIDELINES FOR THE EVALUATION OF BLUNT ABDOMINAL TRAUMA

<table>
<thead>
<tr>
<th>First Author</th>
<th>Year</th>
<th>Reference Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wilson WR</td>
<td>1987</td>
<td>A prospective randomized trial of the open versus closed peritoneal lavage with particular attention to time, accuracy, and cost. Am Surg 53: 518-520</td>
</tr>
<tr>
<td>Howdieshell TR</td>
<td>1990</td>
<td>Open versus closed peritoneal lavage with particular attention to time, accuracy, and cost. Am Surg 56: 204-208</td>
</tr>
</tbody>
</table>

**Conclusions**

- Closed DPL is faster, safer and equally accurate as open DPL.
- The use of serum amylase and lipase in evaluating and managing blunt abdominal trauma is of no benefit.
- Diagnostic exploratory celiotomy is no longer recommended based on elevated serum amylase and lipase and randomy elevated in BAT.
- Open DPL recommended for patients with (+) DPL. Due to increased false negatives and increased cost, diagnostic exploratory celiotomy in blunt abdominal trauma is no longer recommended. Exclusion criteria: Exclusion of patients with (+) DPL, due to increased false negatives at admission and increased cost. Diagnostic exploratory celiotomy is no longer recommended.
<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Journal</th>
<th>Title</th>
<th>Key Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kimura A</td>
<td>1991</td>
<td>J Trauma</td>
<td>Emergency center ultrasonography in the evaluation of hemoperitoneum: a prospective study.</td>
<td>Overall sensitivity of US 66.7%, specificity of US 100%. Recommended US as a screening modality for detection of hemoperitoneum (86.7% sensitivity, 100% specificity).</td>
</tr>
<tr>
<td>Troop B</td>
<td>1991</td>
<td>Ann Emerg Med</td>
<td>Randomized, prospective comparison of open and closed peritoneal lavage for abdominal trauma.</td>
<td>Closed DPL superior to open DPL. Open or semi-open technique recommended for patients in whom closed DPL is contraindicated.</td>
</tr>
<tr>
<td>Day AC</td>
<td>1992</td>
<td>J Trauma</td>
<td>Diagnostic peritoneal lavage: integration with clinical information to improve diagnostic performance.</td>
<td>Combination of clinical evaluation and DPL reduces rate of non-therapeutic laparotomies, but increases the number of missed injuries. The highest accuracy (95%) is obtained by combination of circulatory assessment and DPL.</td>
</tr>
<tr>
<td>Tso P</td>
<td>1992</td>
<td>J Trauma</td>
<td>Sonography in blunt abdominal trauma: a preliminary progress report.</td>
<td>US sensitive (91%) for detection of free fluid but less sensitive (69%) for identification of free fluid plus organ disruption. US does not rule out organ injury in the absence of hemoperitoneum.</td>
</tr>
<tr>
<td>Liu M</td>
<td>1993</td>
<td>J Trauma</td>
<td>Prospective comparison of diagnostic peritoneal lavage, computed tomographic scanning, and ultrasonography for the diagnosis of blunt abdominal trauma.</td>
<td>Sensitivity and specificity of US comparable to CT or DPL. False negatives identified using CT (1) and US (3) in the presence of intestinal perforations. Defined complementary roles of US, CT, and DPL in evaluation of BAT.</td>
</tr>
<tr>
<td>Rothlin MA</td>
<td>1993</td>
<td>J Trauma</td>
<td>Ultrasound in blunt abdominal and thoracic trauma.</td>
<td>US highly sensitive (98.1%) and specific (100%) for identification of intra-abdominal fluid. Specificity remains high (99.6%) but sensitivity decreases (43.6%) for diagnosis of specific organ lesions. Recommend 1) CT to identify specific organ injury, 2) serial US every 1-2 hrs for first 6 hrs, then every 12 hrs for 2 days.</td>
</tr>
<tr>
<td>Rozycki GS</td>
<td>1993</td>
<td>J Trauma</td>
<td>Prospective evaluation of surgeons’ use of ultrasound in the evaluation of trauma patients.</td>
<td>In mixed blunt (84%) / penetrating (16%) population, US has 79.0% sensitivity and 95.6% specificity. Adjusted sensitivity for blunt trauma is 84.0%. US indicated for 1) blunt thoracoabdominal injury; 2) suspected pericardial tamponade; 3) multi-system injury with unknown etiology of hypotension; 4) pregnant trauma patient.</td>
</tr>
<tr>
<td>Goletti O</td>
<td>1994</td>
<td>J Trauma</td>
<td>The role of ultrasonography in blunt abdominal trauma.</td>
<td>Overall sensitivity of US 86.7%. Intraperitoneal fluid volumes correlate with high unnecessary laparotomy rate when diagnosed by US; suggest 250 ml as threshold for non-operative management using US. US-guided parascentesis allows safe non-operative management in presence of small volume of fluid.</td>
</tr>
<tr>
<td>Huang M</td>
<td>1994</td>
<td>J Trauma</td>
<td>Ultrasound for the evaluation of hemoperitoneum during resuscitation: a simple scoring system.</td>
<td>Overall specificity of US 77.7%, sensitivity of US 86.7%. US score ≥ 3 corresponds to &gt;1000 ml blood with 84% sensitivity, 71% specificity, and 71% accuracy.</td>
</tr>
<tr>
<td>Gonzalez O</td>
<td>1993</td>
<td>J Trauma</td>
<td>Use of ultrasonography in blunt abdominal trauma.</td>
<td>Full abdominal trauma. Specificity decreases (49.6%) for diagnosis of specific organ lesions; sensitivity decreases (96.9%) for identification of specific organ injury; sensitivity decreases (96.9%) for diagnosis of specific organ lesions; sensitivity decreases (96.9%) for identification of specific organ injury; sensitivity decreases (96.9%) for identification of specific organ injury.</td>
</tr>
<tr>
<td>Article</td>
<td>Year</td>
<td>Summary</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------</td>
<td>------</td>
<td>---------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comparison of US with DPL, CT scan and exploratory laparotomy in 200 patients with BAT. US 83% sensitive, 100% specific and 97% accurate.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prospective study of US performed in patients following DPL with no aspiration of gross blood. US demonstrated 97% sensitivity and 98% specificity, with a mean fluid volume of 619 ml. US screen should be initial branch point in BAT algorithm.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assessment of surgeon-performed US in 371 patients (295 blunt / 76 penetrating). US is an accurate modality (81.5% sensitivity; 99.7% specificity) which may be performed by surgeons. Recommendations: If initial exam is negative, repeat US at 12-14 hrs.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>US examination performed in 300 patients by surgeons and trauma fellows with review of false-negative and false-positive cases. Demonstrated 81.0% sensitivity and 99.3% specificity. Accuracy plateaued after 100 examinations. Projected cost savings of $41,000.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prospective study of 112 FAST examinations performed and initially interpreted by surgeons with final interpretation by radiologist. No false negatives, 2 false positives recorded. Good agreement between interpretation by surgeons and radiologists (99%).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DPL 93.4% accurate in prediction of positive exploratory laparotomy and 96.6% accurate in prediction of negative exploratory laparotomy in patients with positive or equivocal clinical findings.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>US recommended for trauma patients who are unable to obey simple commands secondary to closed head injury to exclude occult intra-abdominal injury.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In blunt trauma, the highest level of accuracy is achieved with the following criteria: DPL-RBC &gt; 100/µL; DPL-WBC &gt; 500/µL.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Detection of amylase or endotoxin in DPL fluid is valuable in the detection of pancreatitis and gastrointestinal injury.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DPL examination is accurate and reliable in predicting the presence of peritoneal fluid in blunt trauma patients.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A prospective study of ultrasound performed in patients following DPL with no aspiration of gross blood. US demonstrated 97% sensitivity and 98% specificity, with a mean fluid volume of 619 ml. US screen should be initial branch point in BAT algorithm.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roycke GS 1995</td>
<td>1995</td>
<td>Prospective study of ultrasound performed in patients following DPL with no aspiration of gross blood. US demonstrated 97% sensitivity and 98% specificity, with a mean fluid volume of 619 ml. US screen should be initial branch point in BAT algorithm.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>US examination performed in 300 patients by surgeons and trauma fellows with review of false-negative and false-positive cases. Demonstrated 81.0% sensitivity and 99.3% specificity. Accuracy plateaued after 100 examinations. Projected cost savings of $41,000.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Davis RA 1985 The use of computerized axial tomography versus peritoneal lavage in the evaluation of blunt abdominal trauma. Surgery 98: 845-850

Peitzman AB 1986 Prospective study of computed tomography in initial management of blunt abdominal trauma. J Trauma 26: 585-592


Gruessner R 1989 Sonography versus peritoneal lavage in blunt abdominal trauma. J Trauma 29: 242-244


<table>
<thead>
<tr>
<th>Performance</th>
<th>Open DPL</th>
<th>Closed DPL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to perform</td>
<td>Longer</td>
<td>Easier</td>
</tr>
<tr>
<td>Patient tolerance</td>
<td>Better</td>
<td>Worse</td>
</tr>
<tr>
<td>Complications</td>
<td>Less</td>
<td>More</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>96%</td>
<td>95%</td>
</tr>
<tr>
<td>Specificity</td>
<td>96%</td>
<td>95%</td>
</tr>
<tr>
<td>Accuracy</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Indications</td>
<td>Hemodynamically unstable</td>
<td>Stable</td>
</tr>
<tr>
<td>Recommendations</td>
<td>Use closed DPL</td>
<td>Use open DPL</td>
</tr>
<tr>
<td>Results</td>
<td>Better diagnostic yield</td>
<td>Lower diagnostic yield</td>
</tr>
</tbody>
</table>

**References:**

- **Cue JI** 1990 A prospective, randomized comparison between open and closed peritoneal lavage techniques. *J Trauma* 30: 880-883
- **Hoffmann R** 1992 Blunt abdominal trauma in cases of multiple trauma evaluated by ultrasonography: a prospective analysis of 291 patients. *J Trauma* 32: 452-458
- **Forster R** 1993 Ultrasonography in blunt abdominal trauma: influence of the investigators’ experience. *J Trauma* 34: 264-269
- **Jaffin JH** 1993 Alkaline phosphatase levels in diagnostic peritoneal lavage fluid as a predictor of hollow visceral injury. *J Trauma* 34: 829-833
<table>
<thead>
<tr>
<th>Study</th>
<th>Title</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acad Emerg Med 2: 581-586</td>
<td>Comparison of single-view (right intercostal oblique) with multiple-view US, performed with DPL (94% sensitivity; 99% specificity). Results: decreased use of DPL and CT by 74% and 88% respectively.</td>
<td>1995</td>
</tr>
<tr>
<td>Nagy KK 1995</td>
<td>Aspiration of free blood from the peritoneal cavity does not mandate immediate laparotomy.</td>
<td>1995</td>
</tr>
<tr>
<td>Am Surg 63: 184-188</td>
<td>Comparison of aspiration of peritoneal fluid using single- vs multiple-view US, performed with DPL (94% sensitivity; 99% specificity). Results: decreased use of DPL and CT by 74% and 88% respectively.</td>
<td>1995</td>
</tr>
<tr>
<td>Healy MA 1996</td>
<td>A prospective evaluation of abdominal ultrasound in blunt trauma.</td>
<td>1996</td>
</tr>
<tr>
<td>Gow KW 1996</td>
<td>Validity of visual inspection of diagnostic peritoneal lavage fluid.</td>
<td>1996</td>
</tr>
<tr>
<td>J Trauma 40: 875-883</td>
<td>Evaluation of peritoneal fluid using visual inspection of DPL fluid for detection of intraperitoneal fluid. Visual inspection found to have good NPV (98.9%) but poor PPV (25%).</td>
<td>1996</td>
</tr>
<tr>
<td>Bougner BR 1995</td>
<td>Description of a screening test for blunt abdominal trauma: a prospective study of emergency abdominal sonography in blunt trauma.</td>
<td>1995</td>
</tr>
<tr>
<td>Boulanger BR 1996</td>
<td>A prospective study of emergency abdominal sonography after blunt trauma. Results: sensitivity of 90% and specificity of 75%.</td>
<td>1996</td>
</tr>
<tr>
<td>Boulanger SW 1997</td>
<td>Ultrasound-based key clinical examination in blunt abdominal trauma: a prospective study of emergency abdominal sonography after blunt trauma. Results: sensitivity of 90% and specificity of 75%.</td>
<td>1997</td>
</tr>
<tr>
<td>J Trauma 40: 587-594</td>
<td>Comparison of surgeon-performed US to CT and DPL in 82 patients with BAT. US found to be 88% sensitive, 98% specific, 96% accurate; NPV = 97%, PPV = 93%.</td>
<td>1997</td>
</tr>
<tr>
<td>J Trauma 40: 587-594</td>
<td>Comparison of surgeon-performed US to CT and DPL in 82 patients with BAT. US found to be 88% sensitive, 98% specific, 96% accurate; NPV = 97%, PPV = 93%.</td>
<td>1997</td>
</tr>
</tbody>
</table>
### 1. Introduction

**Title:** Speed and efficiency in the resuscitation of blunt trauma patients with multiple injuries: the advantage of diagnostic peritoneal lavage over abdominal computed tomography.

- **Authors:** J Trauma
- **Volume:** 44
- **Pages:** 287-290

**Abstract:** In addition, the clinical importance of peritoneal lavage (1) maximal fluid collection (2) multi-system trauma (3) unexplained hypotension (4) suspicious clinical examination, or abnormal findings on the abdominal computed tomography scan. When peritoneal lavage allows direct visualization of the extent and injury of abdominal and thoracic injuries, it is indicated.

### 2. Methods

- **Sensitivity and specificity of DPL similar to CT scan in patients with hemodynamic instability, severe TBI, or multiple injuries. DPL is more efficient, and less expensive than CT scan in patients with blunt abdominal trauma.**

### 3. Results

- **Accuracy of DPL documented for spleen (98.5%), liver (97.1%), small bowel (91.3%), intraperitoneal bladder (66.7%), and diaphragm (59.1%).** Compared with historical controls, DPL decreased rate of unnecessary laparotomy from 13% to 6% and decreased mortality from 46.4% to 30%. Decreased mortality presumed due to decreased incidence of missed injury with clinical observation alone.

### 4. Conclusion

- **Study and management of blunt abdominal trauma requires a comprehensive approach involving DPL and other diagnostic modalities.**
Alyono D 1982 Significance of repeating diagnostic peritoneal lavage. Surgery 91: 656-659

III Repeat DPL performed at 1-2 hrs has a high degree of sensitivity, specificity and accuracy in patients with indeterminate initial DPL (i.e. DPL-RBC = 50-100 K/mm$^3$; DPL-WBC = 100-500/mm$^3$).


III High degree of accuracy demonstrated with PE in patients capable of a reliable PE. DPL is very sensitive and is associated with a high non-therapeutic laparotomy rate.


III Laparoscopy safer, faster, and more accurate than DPL. Identification of intra-abdominal blood without an identified injury permits non-operative management and decreases the rate of unnecessary exploratory laparotomies.


III Accuracy of DPL not diminished by presence of coagulopathy. Exploratory laparotomy is indicated in patients with (+) DPL with post-traumatic coagulopathy.


III DPL diagnostic in 86 patients with splenic injury documented by exploratory laparotomy.


III DPL may be overly sensitive in evaluation of BAT. DPL reveals injuries which require surgery in 45% of BAT patients.

McLellan BA 1985 Analysis of peritoneal lavage parameters in blunt abdominal trauma. J Trauma 25: 393-399

III Based on significant number of therapeutic explorations, DPL RBC count > 20K/mm$^3$ recommended as indication for exploratory laparotomy.


Alvino D 1982 Significance of repeating diagnostic peritoneal lavage.

- False positive rate for peritoneal lavage higher than previously reported (sensitivity = 83%) resulting in 27% non-therapeutic laparotomy rate.

Kane NM 1987 Efficacy of CT following peritoneal lavage in abdominal trauma. *J Comp Asst Tomo* 11: 998-1002

- CT revealed substantial intra-abdominal or retroperitoneal injuries in 1/3 patients who underwent CT following DPL. CT recommended when clinical status equivocal regardless of DPL results.


- Based on high sensitivity (false negative rate = 1%) and low incidence of complications (0.9% vs 3.4%), semi-open DPL recommended for the evaluation of BAT.


- Demonstrated 84% sensitivity and 97% specificity for US in evaluation of BAT. US is a reliable, fast and repeatable diagnostic modality.


- Sensitivity of CT inadequate to reliably exclude mesenteric injury. DPL recommended as a more sensitive diagnostic modality.

D’Amelio LF 1990 A reassessment of the peritoneal lavage leukocyte count in blunt abdominal trauma. *J Trauma* 30: 1291-1293

- Elevated DPL fluid WBC count (> 500/mm$^3$) has diagnostic value in the early (< 4 hrs) post-injury period. Isolated elevation of DPL WBC count may be more useful in delayed setting or in the absence of equivocal PE.


- Significantly lower complication rate for DPL compared to CT scan (0.9% vs 3.4%) with no difference in preventable deaths.

Henneman PL 1990 Diagnostic peritoneal lavage: accuracy in predicting necessary laparotomy following blunt and penetrating trauma. *J Trauma* 30: 1345-1355

- Semi-open DPL 96% accurate for prediction of need for exploratory laparotomy in BAT and 92% accurate in the presence of pelvic fracture.


- Ease, safety (1% complication rate) and accuracy of DPL (97%) justify continued use in evaluation of BAT.


- Isolated elevation of DPL WBC count (> 500/mm$^3$) not specific for diagnosis of intra-abdominal injury. Specificity increases with repeat DPL.
<table>
<thead>
<tr>
<th>Year</th>
<th>Reference</th>
<th>Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>Lang EK</td>
<td>Intra-abdominal and retroperitoneal organ injuries diagnosed on dynamic computed tomograms obtained for assessment of renal trauma.</td>
</tr>
<tr>
<td>1990</td>
<td>Matsubara TK</td>
<td>Computed tomography of abdomen (CTA) in management of blunt abdominal trauma.</td>
</tr>
<tr>
<td>1990</td>
<td>Megison SM</td>
<td>The value of alkaline phosphatase in peritoneal lavage.</td>
</tr>
<tr>
<td>1990</td>
<td>Soyka JM</td>
<td>Diagnostic peritoneal lavage: is an isolated WBC count greater than or equal to 500/mm³ predictive of intra-abdominal injury requiring celiotomy in blunt trauma patients?</td>
</tr>
<tr>
<td>1991</td>
<td>Barba C</td>
<td>Is positive diagnostic peritoneal lavage an absolute indication for laparotomy in all patients with blunt trauma?</td>
</tr>
<tr>
<td>1991</td>
<td>Berci G</td>
<td>Diagnostic laparoscopy (DL) is a viable diagnostic modality in the evaluation of blunt trauma. DL lowers incidence of non-therapeutic exploratory laparotomies.</td>
</tr>
<tr>
<td>1991</td>
<td>Davis JW</td>
<td>Base deficit as an indicator of significant abdominal injury. Base deficit (BD) &lt; -6.0 is a sensitive indicator of intra-abdominal injury. DPL or CT recommended for patients with BD &lt; -6.0.</td>
</tr>
<tr>
<td>1991</td>
<td>DeMaria EJ</td>
<td>Management of patients with indeterminate diagnostic peritoneal lavage results following blunt trauma. Indeterminate DPL correlates with injuries that may be managed non-operatively. CT recommended following indeterminate DPL rather than repeat DPL.</td>
</tr>
<tr>
<td>1991</td>
<td>Fryer JP</td>
<td>Diagnostic peritoneal lavage as an indicator for therapeutic surgery. Sixty-five percent (65%) of patients who underwent exploratory laparotomy for (+) DPL had therapeutic laparotomies.</td>
</tr>
<tr>
<td>1991</td>
<td>Melendez TK</td>
<td>Complete laparotomy of blunt trauma (CTA) in management of blunt trauma. CT is a valuable diagnostic modality in hemodynamically stable patients with (+) CT.</td>
</tr>
<tr>
<td>Page</td>
<td>Title</td>
<td>Authors</td>
</tr>
<tr>
<td>------</td>
<td>-------</td>
<td>---------</td>
</tr>
<tr>
<td>Year</td>
<td>Author</td>
<td>Title</td>
</tr>
<tr>
<td>--------</td>
<td>-------------------------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>1993</td>
<td>Visvanathan R</td>
<td>blunt abdominal trauma - injury assessment in relation to early surgery</td>
</tr>
<tr>
<td>1995</td>
<td>Nolan BW</td>
<td>mesenteric injury from blunt abdominal trauma.</td>
</tr>
<tr>
<td>1994</td>
<td>Grieshop NA</td>
<td>selective use of computed tomography and diagnostic peritoneal lavage in blunt abdominal trauma.</td>
</tr>
<tr>
<td>1993</td>
<td>Nolan BW</td>
<td>mesenteric injury from blunt abdominal trauma.</td>
</tr>
<tr>
<td>1993</td>
<td>Nolan BW</td>
<td>mesenteric injury from blunt abdominal trauma.</td>
</tr>
<tr>
<td>1993</td>
<td>Nolan BW</td>
<td>mesenteric injury from blunt abdominal trauma.</td>
</tr>
</tbody>
</table>
Chandler CF 1997 Seatbelt sign following blunt trauma is associated with increased incidence of abdominal injury. Am Surgeon 63: 885-888

III Evaluation of seatbelt sign (SBS) as predictor of intra-abdominal injury in 8% of patients with paracetamol injury at presentation. SBS were positive in 75% (> 3 hrs post-injury) and 100% (≤ 3 hrs post-injury). Sensitivity of SBS was 52% for the diagnosis of blunt injury to the viscera.


III Evaluation of focused abdominal sonography for trauma (FAST) following PE in 518 patients (92.4% blunt / 7.6% penetrating). FAST examination 73.3% sensitive, 97.5% specific with 98.3% NPV and 96.1% PPV. Presence of fluid on CT scan warrants further investigation (i.e. DPL or exploratory laparotomy). Study: The value of physical examination in the diagnosis of blunt abdominal trauma: a retrospective study of physical examination (PE) in 204 patients with BAT. NPV of PE was 95.2% with no TBIs identified on PE. A repeat PE was performed in 1631 patients without controls. Sensitivity and specificity of US 93% and 90% respectively. US safe and cost-effective diagnostic modality in the evaluation of BAT. Use of ultrasound to determine need for laparotomy in trauma patients. Ann Emerg Med 29: 323-330

McKenney KL 1997 Cost reduction using ultrasound in blunt abdominal trauma. Emerg Radiology 4: 3-6

III Comparison of 626 patients (Group 1) evaluated with CT and DPL with 564 patients (Group 2). Use of DPL and CT decreased by 94% and 63% respectively in Group 2. Decreased cost/patient by $170. Recommend US as the initial diagnostic test of choice in BAT with unreliable PE. US replaces DPL and allows more efficient use of CT scan. Cost reduction using ultrasound in blunt abdominal trauma. Ann Surgery 226: 70-76


III Serum amylase level on admission in the diagnosis of blunt injury to the pancreas. Sensitivity and specificity of serum amylase 95% and 93% respectively. Serum amylase elevated in 84% of patients with pancreatic injury at presentation; elevated in 76% (< 3 hrs post-injury) and 100% (> 3 hrs post-injury). Serum amylase elevated in 52% of patients with pancreatic injury at presentation. Serum amylase elevated in 84% of patients with pancreatic injury at presentation. Serum amylase elevated in 52% of patients with pancreatic injury at presentation. Serum amylase elevated in 84% of patients with pancreatic injury at presentation.
<table>
<thead>
<tr>
<th>Study</th>
<th>Year</th>
<th>Authors</th>
<th>Description</th>
</tr>
</thead>
</table>
| Buzzas GR 1998 | 1998 | Buzzas GR | A comparison of sonographic examinations for trauma performed by surgeons and radiologists.
| III | | | Sensitivity and specificity of FAST examination 73% and 98%.
| Arch Surg | 1998 | Smith SR | Institutional learning curve of ultrasound.-performed trauma examination.
| | | | Sensitivity and specificity 73% and 98%.
| | | | Sensitivity improved with exclusion of hollow visceral injuries.
| | | | Modality unreliable for detection of hollow visceral injuries.
| | | | Sensitivity and specificity of FAST examination 73% and 98%.
| | | | Comparison of FAST performed by surgical residents (Group A) and US technicians/radiologists (Group B).
| | | | Sensitivity 73% and 79.5% for Group A and B respectively.
| | | | Specificity 97.5% and 99.3% for Group A and B respectively.
| | | | Sensitivity improved with exclusion of hollow visceral injuries.
| | | | Exclusion of hollow visceral injuries.
| | | | Sensitivity 79% for Group A and B respectively.
| | | | Sensitivity 97.5% and 99.3% for Group A and B respectively.
| | | | Sensitivity 93% and 99.3% for Group A and B respectively.
| | | | Sensitivity 73% and 98%.
| | | | Comparison of FAST performed by surgical residents (Group A) and US technicians/radiologists (Group B).
| | | | Sensitivity 73% and 98%.
| | | | Sensitivity and specificity 73% and 98%.
| | | | Sensitivity improved with exclusion of hollow visceral injuries.
| | | | Exclusion of hollow visceral injuries.
| | | | Sensitivity 79% for Group A and B respectively.
| | | | Sensitivity 97.5% and 99.3% for Group A and B respectively.
Evaluation of Blunt Abdominal Trauma: Unstable Patient

Hemodynamically Unstable?

- Repeat DPL
- Fluid identified?
  - Yes
    - Exploratory Laparotomy
    - Continue resuscitation
    - Evaluate other potential sources of shock
  - No
    - US
    - DPL
    - Repeat ultrasound
    - Evaluate other potential sources of shock
    - Continue resuscitation
    - Aspiration of gross blood
    - Aspiration of particulate matter
    - WBC > 500/mm³
    - RBC > 100K/mm³
    - No
      - Continue resuscitation
      - Evaluate other potential sources of shock
      - Repeat ultrasound
      - Fluid identified?
        - Yes
          - Exploratory Laparotomy
          - Continue resuscitation
          - Evaluate other potential sources of shock
        - No
          - US
          - DPL
          - Repeat ultrasound
          - Evaluate other potential sources of shock
          - Continue resuscitation
          - Aspiration of gross blood
          - Aspiration of particulate matter
          - WBC > 500/mm³
          - RBC > 100K/mm³
CT scan may be elected based on institutional experience or clinical suspicion of intra-abdominal injury.

**Evaluation of Blunt Abdominal Trauma: Stable Patient**

- Hemodynamically Stable
  - Reliable Pe? Yes
    - CT scan
    - Solid Visceral Injury?
      - Consider exploratory laparotomy
      - Consider non-operative management
    - US
    - Free fluid identified?
      - Yes
        - Solid Visceral Injury?
          - Consider exploratory laparotomy
          - Consider non-operative management
        - Hollow Visceral Injury?
          - Consider exploratory laparotomy
          - Repel US
      - No
        - Admit
- Reliable Pe? No
  - CT scan
  - Fluid identified?
    - Yes
      - Solid Visceral Injury?
        - Consider exploratory laparotomy
        - Consider non-operative management
      - Hollow Visceral Injury?
        - Consider exploratory laparotomy
        - Repel US
    - No
      - US
      - Free fluid identified?
        - Yes
          - Solid Visceral Injury?
            - Consider exploratory laparotomy
            - Consider non-operative management
          - Hollow Visceral Injury?
            - Consider exploratory laparotomy
            - Repel US
        - No
          - Admit