AMERICAN COLLEGE OF EMERGENCY PHYSICIANS
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Case Studies in Trauma Care: State of the Art

Managing the trauma patient in the emergency department is being transformed through the use of new diagnostic modalities and through increasing pressure to cut cost. With the use of case presentations, the lecturer will examine the indications for the use of diagnostic studies in multisystem trauma victims and the outpatient management of patients with myocardial contusion, blunt abdominal trauma, skull fractures, and penetrating trauma.

- Discuss how new imaging studies such as helical computed tomography scanning, bedside ultrasound, and magnetic resonance imaging can be used in the diagnostic evaluation of trauma patients.
- Describe the accuracy, risks, and cost effectiveness of the different diagnostic approaches to patients with trauma.
- Review the disposition of asymptomatic trauma patients at risk for occult injuries.

TH-210
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FACULTY

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Case Studies in Trauma: State of the Art

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CASE #1

28-year-old man wearing a helmet was in a high speed motorcycle accident and was thrown 50 feet. He was unresponsive at the scene. He has multiple facial lacerations, and the paramedics are unable to intubate him. Upon arrival his vital signs are: BP 140/74, HR 148, RR 6. His pupils are 4 mm on the right and 3 mm on the left. He has a mandibular symphysis deformity, equal breath sounds, a soft abdomen, a stable pelvis, normal rectal tone, and is unresponsive.

Course to be discussed.

BLUNT ABDOMINAL TRAUMA

Physical exam

- > 40% of patients with significant abdominal injuries have no initial complaints or external evidence of abdominal pathology.
- The accuracy of the physical exam is at best 65%.
- Abdominal tenderness/peritoneal irritation may be masked in up to 90% of head injured or intoxicated patients

Diagnostic Peritoneal Lavage (DPL)

Advantages

- 94%-96% sensitive, 96%-99% specific
- Rapid, sensitive (> 95%), inexpensive
- In combination with hypotension, positive predictive value for a surgically correctable injury changes from 87% to 98%
- Best test for diaphragmatic injuries
- Is there hemoperitoneum?

Disadvantages

- Invasive (but complication rate <1%)
- Too sensitive (nontherapeutic laparotomy rate of 6% - 25%)
- Detects small amounts of intraperitoneal blood
- Not specific for organ injury
- Does not evaluate retroperitoneum
- Does not determine the extent of hemoperitoneum, the severity of organ injury, or need for operation
- May miss pancreatic, bladder, colon, small bowel, and diaphragmatic injuries
- False positive results with pelvic fractures

Indication:
Unstable blunt trauma patient

Relative Contraindications
Morbid obesity. However, there is a weight limit on CT table.
Previous abdominal surgery
Pregnancy:
In the first trimester the radiation exposure from abdominal CT is significant
Use supraumbilical, open technique
No evidence that open, supraumbilical DPL increases complications or has decreased accuracy
Pelvic fractures:
DPL is accurate if supraumbilical, open technique is used
Dissection of retroperitoneal hematoma limited by rectus fascia at this point

Absolute Contraindication: Clear need for emergent laparotomy

Criteria for Positive Lavage:

Grossly positive: aspiration of 10 cc of blood
90% positive predictive value for intraperitoneal injury
Infuse 15 cc/kg of warm NS. Allow gravity return of at least 70%

Positive by cell count:
Blunt trauma: $\geq$ 100,000 RBCs/mm^3 (> 95% sensitivity)
WBC ($\geq$ 500/mm^3)
Amylase (>10-20 IU is sensitive for small bowel injury)
Alkaline Phosphatase ($\geq$ 3 IU/L: suggestive of small bowel injury)

Abdominal CT Scan

Advantages:
- Non-invasive
- Sensitive for retroperitoneal injury
- Defines the organ injured and the degree of injury
- Greater specificity than DPL: decreases the incidence of unnecessary laparotomy with DPL.

Disadvantages:
- Time consuming, expensive
- Difficult to resuscitate/monitor patient
- May have a nontherapeutic laparotomy rate of .8% to 19%
- May miss hollow viscus, pancreatic, small diaphragmatic injuries, and mesenteric injuries
- Complication rate of 3% (aspiration, contrast reaction)

Contraindication: Unstable patient

Technique:
- Double contrast (oral/IV) for routine trauma patients.

Is Oral Contrast Necessary for Abdominal CT?
- Small bowel and pancreatic injuries may be missed if oral contrast is not used
- Recent studies question the need for oral contrast
- Tsang, 1997
  - Retrospective with prospective validation
  - Oral contrast was not considered essential for the diagnosis of solid organ injury, mesenteric or bowel injury
  - oral contrast was considered essential to the diagnosis (this included one false positive pancreatic injury) in only 2/124 patients,
  - Average additional time in the ED was 144 minutes
  - The authors conclude that oral contrast is rarely essential for CT diagnosis
  - Oral contrast may improve sensitivity for pancreatic injury
- Stafford, 1999
  - Randomized controlled trial, 394 patients
  - Sensitivity for bowel injury: 86% for oral contrast (OC), 100% for the no OC group
  - Sensitivity for solid organ injury: 84.2% (OC) vs. 88.9% for no OC
  - Specificity for solid organ injury: 94% (OC) vs. 57% in the no OC group
  - Time to CT was longer in the OC group and the addition of OC was unnecessary

Ultrasound

Goals:
- Determine the need for further diagnostic studies and for laparotomy
- Decrease the time to laparotomy
- Is there hemoperitoneum?
- Part of the secondary survey

Advantages:

- Rapid (30 seconds - 2 min.)
- Performed at the bedside
- Serial examinations: to detect ongoing hemorrhage
- Triage tool: laparotomy, DPL, CT scan
- Confirm placement of DPL fluid
- Noninvasive, inexpensive, no harmful effects, rapid initial screening, easily repeated
- Can replace DPL
- Can be used in a clinical pathway to decrease CT utilization and hospital admissions.

Disadvantages:

- User-dependent
- Training required
- Does not define injury
- Not sensitive for solid organ, retroperitoneal, diaphragm, or hollow viscus injuries
- Not useful in identifying the source of bleeding or quantifying specific injuries

Accuracy:

Overall: sensitivity: 84%-99%, specificity: 85% - 98%

Intraperitoneal Fluid: 79% - 98% sensitivity; specificity 88-100%

- The accuracy depends on which views are used.
- Morison's pouch: 36-82% sensitivity, 94-100% specificity
- Spenorenal space: 58% sensitivity
- Cul-de-sac: 56% sensitivity
- Multiple views (Morison's pouch, paracolic gutters, splenorenal space, cul-de-sac): 87% sensitivity, 100% specificity [Ma, Ingeman]

Solid organ disruption

- 41%-44% sensitivity
- Splenic injury: 33-94% sensitivity
- (Rosen, 1998; Bennett, 1997; Nordenholz, 1997; Rothlin, 1993)

Fluid in Morison's Pouch:

- Overall sensitivity for 1 liter was 97%
- Only 10% of ultrasonographers able to detect fluid volumes of $\leq$ 400 cc
- 85% of sonographers detected fluid volume of 850 cc (Branney, 1995)

Limitations

- < 1% of patients with a negative US required laparotomy (Boulanger, 1996; prospective)
- Up to 29% of patients with intraperitoneal injury will not have hemoperitoneum by US (Chiu, 1997)
- 26% of patients with abdominal injury had a negative ultrasound (no hemoperitoneum)
    - Missed injuries were spleen, liver, kidney, mesentery (Sherbourne)
- A negative ultrasound does not rule out surgically correctable injury

Rozycki, Ann Surg 1998

- Prospective
- 1,227 blunt trauma patients and 313 penetrating trauma patients
- Blunt abdominal trauma: 75.7% sensitivity, 99.8% specificity (*normotensive*)
- Pericardial exams (penetrating chest wounds): 100% sensitivity, 99.3% specificity

Management Implications: (for blunt trauma)

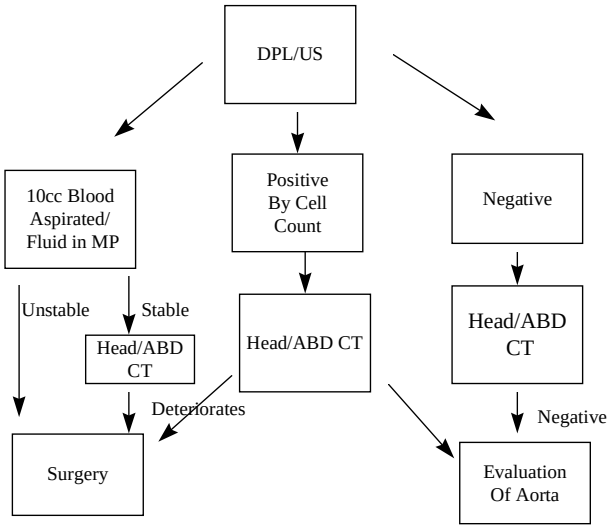
- May determine the need for laparotomy
    - Porter, 1997
        - 93% sensitivity, 90% specificity
    - There may be a correlation between the amount of hemoperitoneum and the likelihood that surgery is required (Akgur, 1993; Huang, 1994)
- In unstable patients:

- Wherrett, 1996
  - 3 views
  - 100% sensitivity, 94% specificity, NPV 100%, PPV 86%
  - Consider other bleeding sources if negative (retroperitoneal)
  - If US is positive, laparotomy is indicated
- Rozycki, Ann Surg 1998
  - 1,227 patients with blunt trauma
  - 30 hypotensive patients
  - 100% sensitivity and specificity

Other Uses of Ultrasound in Trauma

- Hemothorax
- Pericardial effusion
- Renal trauma (low sensitivity)

Evaluation of Blunt Multiple Trauma



CASE #2

A 22-year-old woman who was the unrestrained driver of a car that ran into a wall. The patient hit the steering wheel. There was no LOC. In the field: BP 130/p, HR 100, A&O x3, appropriate. She complains of a headache. In the ED her vital signs are BP 120/70, HR 70, RR 20. Her examination is notable for moderate frontal scalp tenderness, minimal midepigastric tenderness, and no ecchymosis. She is neurologically intact.

Course to be discussed.

Abdominal CT Scan

- A negative CT may be used to discharge patients from the ED.
  - In one recent study of 2,299 patients, CT missed 3 intestinal injuries. The negative predictive value was 99.6%. (Livingston)
  - In a retrospective study of 238 patients who were discharged from the ED based on a normal CT vs. admission for observation, $32,874 would have been saved yearly. There were no missed abdominal injuries. (Brasel, 1996)

Accuracy
- Splenic injury: > 95%
- Diaphragm: 61% sensitivity, 87% specificity (Murray, 1996)
- Less sensitive for bowel injury (84% sensitivity, 89% specificity, 89% negative predictive value) [Janzen, 1998]
- Improved with helical CT.

Key Clinical Pathway Utilizing Ultrasound
- US performed initially, then at 30 minutes and 4 hours.
- Observation for > 8 hours.
- Decreased utilization of CT from 56% to 26% and DPL from 17% to 4%.
- US was used exclusively in 65% of patients.
- Also decreased hospital admission rate. (Branney)

Duodenal Injuries
- Rare but extremely difficult injury to detect
- Delayed diagnosis in up to 20%
- Duodenal hematoma: Vague, insidious presentation-several days after trauma with vomiting, abdominal pain
- Blunt trauma: usually 2nd, 3rd portions
- Incidence of rupture after blunt trauma is .2% (Ballard)

Pathology:
- Contusion vs. perforation
- In duodenal perforation, signs are similar to duodenal ulcer perforation.
- Contusion requires only NG tube suction and observation.

Diagnosis:
- DPL sensitivity 50% - 85%
- CT may miss injury: may see retroperitoneal air, extravasation of contrast

Case #3

A 24-year-old man presents after a 25-feet fall. He did not have a loss of consciousness, and his only complaint is left flank pain. In the field: BP 90/60, HR 110, RR 20. He received 500 cc NS. Upon arrival to the ED his vital signs are BP 102/80, HR 70, RR 16. His physical examination is unremarkable.

Course to be discussed.

TRAUMATIC AORTIC INJURY

Introduction

- The most common cause of sudden death after MVC or fall from a height.
- Mechanism of injury: MVA 81% (72% head-on, 24% side impact, 4% rear impact)
- Can also occur after a broadside motor vehicle impact.
- 12.7% of auto-pedestrian accident fatalities (Brundage, 1998)
- 80% to 90% die at the scene. 10% to 20% survive initially due to tamponade by the aortic adventitia; 30% of the initial survivors will die within 6 hours; 40-50% will die within 24 hours if not promptly treated
- Suspect in patients with a deceleration mechanism, high speed side impact, fall from a height (> 30 ft), or steering wheel damage.

Clinical Findings

- Retrosternal or intrascapular pain (most common; 25-50% of patients)
- Dyspnea, hoarseness, dysphagia, hypertension
- Pseudocoarctation syndrome — hypertension in the upper extremities and weak pulses or hypotension in the lower extremities. (up to 1/3rd of patients)
- Hypotension (50%)
- Harsh systolic murmur over the precordium or posterior interscapular area (aortic insufficiency; 30% of patients)

- Lower extremity pulse deficit; lower extremity paralysis
- Multiple rib fractures, sternal fracture, scapula fracture
- Up to 50% of patients will have no external signs of chest trauma.

Chest x-ray

Initial screening test. May be normal in up to 15-28% of patients.

Findings:

- Widened mediastinum (the most sensitive sign)
    - > 6 cm (erect PA film) or > 8 cm in the supine AP film
    - Sensitivity 54% to 92%; specificity 10%; positive predictive value 10-20%
    - Differential diagnosis: AP film, spinal fractures, venous bleeding from clavicle or sternal fractures; pulmonary contusions
    - Normal mediastinum in 5-7.3%.
    - Widened mediastinum and an obscured aortic knob are the most reliable signs of aortic rupture.
- Fractures of 1st and 2nd ribs (18%; not associated with an increased risk of aortic injury)
- Obliteration of aortic knob (24%)
- Tracheal deviation to the right (12%)
- Left apical pleural cap (19-54%)
- Elevation and rightward shift of the right mainstem bronchus
- Depression of the left mainstem bronchus (5%)
- Obliteration of the space between the pulmonary artery and the aorta
- Deviation of the NG tube to the right (11-25%)
- Left hemothorax (19-25%)
- Widened paratracheal stripe

Chest Computed Tomography

- Can reduce the need for aortography by 50%.

Disadvantages:

- Dye load, time loss, difficult in uncooperative/unstable patient, only circumstantial evidence of aortic tear.

Findings:

- Mediastinal hematoma (25-30% will have aortic injury by aortography)
- Direct evidence of vascular injury: intimal flap or vessel contour abnormalities
- False positives: atherosclerotic disease or prominent ductus diverticulum

Helical CT

- The most sensitive method for detecting mediastinal hematoma as an indication of aortic injury.
- Recommended for patients with high-speed deceleration mechanism
- Demetriades, 1998
    - Prospective study of 112 patients
    - 42 patients (37.5%) had a widened mediastinum; of these, 5 had an aortic injury (11.9%), 9 (21.4%) had spinal fractures
    - 4 of the 9 patients (44.4%) with an aortic injury had a normal mediastinum on the initial CXR

Recent CT Studies:

Study	**Number of patients**	**Accuracy**	**Comments**
Mirvis, 1998 (prospective)	1,104	100% sensitive, 99.7% specific, 89% positive and 100% negative predictive value, 99.7% accuracy	10.7% of all CTs performed had mediastinal hemorrhage. Direct evidence of injury was detected in 20.3% of patients with mediastinal hemorrhage and 2.2% of all

			patients undergoing CT.
Fabian, Ann Surg 1998 (prospective)	494	100% sensitivity; 83% specificity; 100% NPV	Helical CT was more sensitive, less specific than aortography
Biquet, 1996	28	sensitivity: 92%; specificity: 100%	1 false negative: left subclavian injury; 67% decrease in aortography use.
Mirvis, 1996	677	Aortic injury: sens 90%; spec 99% Mediastinal hematoma: sens 100%; spec 87%	Meta-analysis: Aortic injury: sens 97%; spec 100% Mediastinal hematoma: sens 100%; spec 87%

Cost Analysis:

Reliance on CT versus plain radiography to determine the need for angiography would have saved > $365,000 in one study (Mirvis, 1996)

In another study of dynamic chest CT versus CXR + immediate angiography for deciding when angio should be performed:

- For patients undergoing CT for other injuries, triage to angio based on CT yielded equivalent survival chances and cost less ($1468 versus $2508 per patient).
- For patients not undergoing CT for other injuries, immediate angio yielded highest survival chances but cost $2 million per life saved versus triage based on CT.
- Immediate angio has a high incremental cost-effectiveness ratio compared with triage by CT and is warranted only in patients not undergoing CT for evaluation of other injuries who have a prior probability of aortic rupture $\geq$ 5%.

Conclusions:

1. In stable patients in whom there is a low clinical suspicion, CT can exclude the diagnosis if it is negative.
2. If the CT of the aorta and mediastinum are normal and clinical suspicion is low, then no further testing is required.
3. If the CT reveals mediastinal hematoma or is indeterminate, then aortography is required.
4. If positive, aortography is usually indicated to further define the extent of the injury prior to surgery.
5. If there is strong clinical suspicion of an aortic injury, the patient should proceed directly to aortography.

Transesophageal Echocardiography (TEE)

Provides detailed images of transverse and descending aorta, and aortic isthmus.

Advantages:

Non-invasive, rapid, can be performed at the bedside, does not require contrast administration

Limitations:

- Requires operator expertise
- Contraindicated if there is esophageal injury or unstable c-spine injury
- Mid-ascending aorta poorly visualized (but this is a rare site of injury)
- Distal ascending aorta (1% of ruptures) and aortic arch branches (may occur in up to 19% of patients with aortic injury)
- 17% of studies were equivocal (Fabian)

Accuracy: Sensitivity 91-100%; specificity 98-100%

Findings: Aortic wall flap and periaortic hematoma

TEE Studies:

Study	**# of patients**	**Type of Study**	**Sensitivity**	**Specificity**	**Gold Standard**	**Comments**
Chirillo, 1996	134	prospective	93%	98%	Aortography in 25 patients	Time to surgery was shorter (30 v. 71 minutes)

Vignon, 1996	40	prospective	100%	88%	Aortography, clinical follow-up	
Vignon, 1995	32	prospective	91%	100%	Aortography, autopsy, surgery	One 2 mm medial tear was missed
Saletta, 1995	114	retrospective	63% 97% NPV	84% 23% PPV	Aortography or surgery	17 patients had indeterminate studies
Smith, 1995	93	prospective	100%	98%	Aortography, surgery, autopsy	TEE took 29 minutes
Buckmaster, 1994	126	prospective	100%	100%		3 studies (2.5%) were equivocal

Conclusions:

1. TEE may have higher sensitivity than aortography, and it can significantly decrease the time to surgery.
2. Operative repair may be performed without additional studies.
3. TEE will also detect other injuries such as pericardial effusions, pleural effusions, blunt myocardial injury, and valvular disruption.
4. Patients with negative TEE but high clinical suspicion, evidence of periaortic hematoma, or indeterminate findings should undergo aortography.

Aortography

The "gold standard." Only 10-20% of aortograms ordered will be positive.
Multiple tears occur in 15-20%; precise localization is possible with aortography. This avoids missing tears intraoperatively.

Accuracy:

- Sensitivity 94%; specificity 96%
- In recent studies of TEE v. aortography: sensitivity 67-100%, specificity 98-99% (Kearney, Buckmaster, Strum)

Indications:

- Widened mediastinum or other abnormalities on CXR in a patient with significant blunt chest trauma.
- High speed deceleration mechanism with suggestive clinical findings or abnormal radiographic findings
- CT scan that shows mediastinal hematoma but no aortic tear
- Equivocal TEE results

Findings:

- Pseudoaneurysm of the isthmus (most common finding)
- Lateral bulging of the aorta
- Linear filling defect caused by torn intima and media
- Detection of injuries to the great vessels that arise from the aortic arch (1-2% of patients; may be missed by CT)
- Detects distal ascending aortic injury (1% of patients); aortic arch branch injuries (19%). May be missed by TEE [Kamran]
- False Positives: atherosclerotic plaque or prominent ductus diverticulum

Summary

- Defines the anatomy for the surgeon
- Prevents unnecessary manipulation of a false aneurysm during surgery if the rupture site is difficult to determine intraoperatively
- Allows visualization of the coronary arteries in the case of rupture of the ascending aorta with involvement of the coronary ostia
- Determines the need for cardiopulmonary bypass for ascending aortic injuries.

- Aortography should be delayed in patients with intracranial hemorrhage, abdominal trauma, or major orthopedic injuries, so that these other injuries can be addressed first. In these patients, beta-blockers and nitroprusside should be considered for decreasing blood pressure.

Magnetic Resonance Imaging
- 100% accuracy
- Can be used to monitor and follow the aortic injury prior to delayed surgical repair

CASE #4

A 25-year-old male was the unrestrained driver of a car that ran into a pole, sustaining moderate damage to the front end. The steering wheel was bent. There was no LOC. In the field, he was awake and intoxicated. Field VS: 140/80, HR 90, RR 18. In the ED his vital signs are BP 190/90, HR 100, RR 22. He has a right forehead contusion, equal breath sounds, sternal tenderness, and a seatbelt abrasion. He has mild right upper quadrant tenderness.

Course to be discussed.

BLUNT MYOCARDIAL INJURY

- Seen at autopsy with immediate trauma deaths.
- 3-75% of patients with severe blunt chest trauma
- Morbidity and mortality in the immediate survivors is related to other injuries.

Diagnosis:

- Suspect in patients sustaining chest trauma with chest wall contusions, external evidence of trauma, or steering wheel damage.
- The importance of making the diagnosis lies in the recognition of potentially life-threatening complications.
- Controversy exists as to the importance of making this diagnosis in the hemodynamically stable patient since the vast majority of contusions do not cause clinically significant complications.
- No gold standard.
- It is difficult to predict the need for admission and the risk of lethal complications.
- The goal of diagnostic studies is to identify low risk patients who can be discharged from the ED.

Clinical Findings:

- Angina-like chest pain
- Tachycardia (most common sign; 70% of patients); arrhythmias; shock; CHF
- Associated injuries include pulmonary contusions, pneumothorax, hemothorax, sternal fractures, rib fractures, and aortic injury.
- 25% will not have external evidence of trauma.

ECG

- The best screening test
- Neither specific nor sensitive (nondiagnostic)
- False negatives may be due to the fact that right heart is usually injured (EKG is insensitive to right heart damage).
- Sinus tachycardia, PVCs, and PACs are the most common findings
- Nonspecific ST and T wave changes are also common.
- Right bundle branch (or left bundle branch block) may occur.
- Other dysrhythmias (atrial fibrillation, atrial flutter, ventricular tachycardia or fibrillation) are less common.
- Life-threatening dysrhythmias may occur up to 12 hours after injury, and dysrhythmias have been reported up to 72 hours after injury.
- The onset of ECG changes may be delayed up to 48 hours. ECG changes do not necessarily predict subsequent complications.
- Arrhythmias may result from other causes such as hypoxia, hypovolemia, electrolyte abnormalities, or intracranial hemorrhage.

ECG Studies

Reference	Type of Study	# of Patients	Results

Dowd, J Trauma, 1996	retrospective	184 (< 18 y.o.)	No complications for patients with normal ECG in ED; all with complications had arrhythmia or shock in ED.
Maenza AJEM, 1996	meta-analysis	2,210 (prospective) 2,471 (retrospective)	Abnormal ECG correlated with complications: odds ratios = 3.2 and 26.0 (prospective and retrospective data). Normal ECG correlated with the lack of complications.
Fildes Am Surg 1995	prospective	93	No complications for hemodynamically stable patients with a normal ECG, no history of cardiac disease, and without major associated injuries.
Biffl 1994	retrospective	359	17 (5%) had complications; 2/17 had a normal ECG; 3/17 had sinus tachycardia (occurred at 6-22 hrs).

Other earlier studies conclude that:

1. ECG findings do not correlate well with abnormal nuclear medicine studies or echo results.
2. Abnormal initial ECG predicts cardiac complications requiring treatment.
3. Complications are extremely rare in patients with a normal initial ED ECG.
   (Gunnar, Illig, Wisner, Helling)

CXR

- May show associated sternal fractures.
- The presence of sternal fractures does not predict myocardial injury.

CPK-MB

- > 5% used as a cutoff
- Most of the studies document that it is an unreliable test and does not correlate with outcome or other diagnostic tests such as ECG or Echo, and does not predict complications.
- Insensitive: the sensitivity may be as low as 70% in patients with documented contusion.
- Nonspecific. Elevated after major skeletal muscle injury.

CK-MB Studies

Reference	Type of Study	# of Patients	Results
Maenza AJEM 1996	meta-analysis of 41 articles	1,210 (prospective) 2,471 (retrospective)	Abnormal ECG & CK-MB correlated with complications; normal ECG and CK-MB correlated with the lack of complications. Complication rates: 4.5% (retrospective), 2.6% (prospective).
Biffl Am J Surg 1994	retrospective	359	16% of admitted patients developed complications requiring treatment (dysrhythmia or cardiogenic shock); all of these patients had an abnormal ECG, but only 41% had elevated CK-MB. Elevated CK-MB was never the sole predictor of a complication.

Troponin I and T

- Cardiac regulatory protein (found only in cardiac tissue, not in skeletal muscle)
- More specific than CK-MB for myocardial injury. Will not be elevated after skeletal muscle injury.
- Remains elevated for 4-7 days.
- In a small study of 44 patients, all six patients with myocardial injury diagnosed by echo had elevated CK-MB and troponin I. However, 26/37 patients without cardiac injury had elevated CK-MB; none had elevated troponin I. This is preliminary data. Available data does not suggest good correlation with complications. This study used Echo as the gold standard, and did not look at the ability of troponins to predict complications. (Adams, 1996)

Troponin Studies

Reference	Marker Studied	# of Patients	Results
Ognibene Clin Chem, 1998	troponin I	28	100% sensitivity and specificity for TEE-demonstrated contusion

Adams Amer Heart J, 1996	troponin I	44	100% sensitivity and specificity for echo-demonstrated injury
Ferjani Chest, 1997	troponin T	29	Sensitivity of troponin T better than CK-MB (31% vs. 9%)
Fulda J Trauma, 1997	troponin T	71	Sensitivity = 27% and specificity = 91% for predicting significant ECG abnormalities
Mair Injury, 1995	troponin T	32	ST elevation and dysrhythmia did not occur more frequently in patients with troponin or CK-MB elevation.

- Thus far, there does not appear to be a predictive value for determining which patients require monitoring or further evaluation, or which patients will develop complications.
- Troponin I may be helpful in predicting echocardiographic abnormalities.
- No association between troponin T elevation and ECG changes or dysrhythmia.

Echocardiography:

- Most common abnormality is right ventricular free wall dyskinesia or other wall motion abnormalities.
- Uninterpretable in 1/3 of patients due to technical limitations of bedside studies.
- Identifies wall motion abnormalities and acute valvular dysfunction.
- Echocardiographic abnormalities do not predict complications, and Echo results do not correlate with ECG or enzyme abnormalities.
- The routine use of echocardiography as a screening test for cardiac contusion is not supported. Only useful in the management of patients with myocardial decompensation to detect pericardial tamponade and cardiac rupture.
- Transesophageal Echo (TEE) is more sensitive, yet the clinical significance of pericardial effusions detected by TEE remains to be determined.

Technetium 99m, Gated radionuclide angiography (MUGA), Thallium myocardial scintigraphy, Single photon-emission CT Scan (SPECT):

- Findings do not correlate with ECG abnormalities or CK-MB elevations.
- Do not predict life-threatening dysrhythmias.
- Not useful in the ED

Summary: No single test is accurate. Most myocardial contusions are of no clinical significance.

Conclusions and Recommendations Based on the Literature:

1. Young patients (< 55-60) who are stable and asymptomatic without major injuries and with a normal EKG (or no new changes) can be discharged from the ED.
2. Young patients who are stable without major trauma, with an abnormal EKG are unlikely to develop complications, and at most need 24 hours of non-ICU monitoring.
3. Patients who are unstable and have major chest trauma require ICU admission and may benefit from additional studies (echo, RNA) to answer specific clinical questions.
4. The routine use of echocardiography and other studies such as radionuclide angiography is not warranted for young patients who are stable and do not have major thoracic or extrathoracic trauma.
5. Cardiac enzyme determinations have no role in the evaluation of these patients. None of these diagnostic studies predict morbidity or mortality.
6. Patients without life-threatening dysrhythmias or complications after 12 hours of cardiac monitoring do not require further observation.
7. Pediatric patients who are hemodynamically stable in the ED with a normal EKG are at low risk for developing cardiac arrhythmias, shock, or dying during hospitalization and therefore do not require ICU admission. Pediatric patients who present in shock or with serious arrhythmias or PVCs should be monitored in an ICU. There is not agreement among the different diagnostic modalities (echocardiography, CK-MB, and ECG) used to evaluate these patients. Patients with suspected cardiac injury should undergo echocardiography to evaluate chamber function and wall motion.

Admission Criteria:

- Based on mechanism alone is not reliable or cost effective

- Cardiogenic shock
- Persistent chest pain
- Abnormal EKG
- Patients with minimal chest tenderness and sinus tachycardia can be observed for 4 to 6 hours until the tachycardia resolves, then discharged.

CASE #5

50-year-old male who states he fell and hit his forehead. He denies HA. He admits to drinking alcohol, is unsure if he lost consciousness, and complains of jaw pain. In the ED his vital signs are BP 176/98, HR 76, RR 16. He is awake, vomiting, and he has a right forehead laceration (3 cm) with hematoma, and blood coming from his right ear. He has tenderness of the RT parasymphyseal area of jaw. His neck is nontender. He has slurred speech and a nonfocal neurologic exam.

Course to be discussed.

MINOR HEAD INJURY

- GCS > 13
- 3-41% have positive CT scan
- 0-4% require neurosurgery
- 17% of patients who undergo craniotomy have an initial GCS of 15

Skull Radiographs
- Accurate for detecting skull fractures but not intracranial pathology
- Replaced by head CT
- Fracture by x-ray increases the risk of intracranial injury
    - Risk of intracranial pathology 3X higher in patients with a skull fracture by x-ray. (Shackford, 1992)
    - 45% of patients with skull fractures had intracranial lesions (Stein, 1992)

    Indications:
    - Penetrating trauma for tracking bullets
    - Documentation of child abuse
    - Negative skull x-ray should not be used to discharge patients
        - In one study, 40% of patients who needed an operation for IC hemorrhage after minor head trauma had no skull fracture (Stein, 1992)

Computed Tomography
- Study of choice
- Identifies intracranial pathology and skull fractures

Indications for CT

High Risk Criteria	**Low Risk Criteria**
• Depressed/compound skull fracture • GCS < 15 • Focal neurologic findings • Age < 2 or > 60 • Coagulopathy • Seizure • Altered or deteriorating mental status • LOC • Progressive headache • Evidence of basal skull fracture • Profound amnesia • Penetrating skull injury • (Alcohol/drug intoxication)	• Asymptomatic • Mild headache • Injury > 24 hours ago • Dizziness • Scalp hematoma, abrasion, laceration, contusion
• CT recommended	• Discharge with head injury instruction sheet

(Masters, 1987)

- In Stein's study of 1538 patients (GCS ≥ 13, +LOC):
  - 17% (265 patients) had abnormal CT, 4% required neurosurgery.
  - Patients with a normal CT did not have neurologic deterioration.
  - Based on this, the authors recommend CT for minor head injury and LOC/amnesia.
  - A normal CT can be used to discharge a patient. (Stein, 1992)

- Jeret, 1993
  - Prospective, 712 patients, GCS of 15, 9.4% positive CT rate, 2 [.3% required neurosurgery]
  - Predictors were signs of basal skull fracture, mechanism (pedestrian struck, assault), age.

- Borczuk, 1995
  - Patients with GCS ≥ 13.
  - Abnormal CT scan in 8% (6% for GCS of 15)
  - Neurosurgical intervention required in .8% (.08% for GCS of 15) (Borczuk)

    High-risk Clinical Variables
    - Presence of cranial soft-tissue injury
    - Focal neurologic deficits
    - Signs of basilar skull fracture
    - Age > 60 years
    - Sensitivity of 92%, NPV of 98%

- The rate of abnormal CT scans in patients with LOC depends on the GCS
  - 27.2%-40.3% (GCS of 13)
  - 10.5%-24.2% (GCS of 14) [Cheung, 1999]
  - GCS of 15:
    - Abnormal CT rate: 2.5%-17.1% [Cheung, 1999]
    - Shackford, 1992
      - 14.8% abnormal CT rate for 2,166 patients
      - 3.2% required neurosurgery
    - If the results of studies are combined then the incidence of abnormal CT is approximately 6% and the incidence of injury requiring neurosurgery is less than 1%

- Recent prospective studies have looked at patients with LOC, GCS of 15:
  - If patients underwent CT for severe HA, nausea, vomiting, or skull depression (The Miller Criteria) on PE:
    - Sensitivity for abnormal head CT was 65% (specificity of 63%)
    - 100% sensitivity for patients requiring neurosurgical intervention
    - 61% reduction in the number of head CTs
    - Overall incidence of neurosurgical intervention was .2% (5 of 2,143 patients) [Miller, 1997]

  - In an earlier study of 1,382 patients by Miller, et al:
    - Overall incidence of 6.1% of abnormal CT and .2% of injury requiring neurosurgery
    - 3% incidence of abnormal head CT (2/789) in patients with LOC or amnesia but no signs/symptoms of a depressed skull fracture.
    - No patient in this group required surgery.
    - The authors conclude that CT in patients with LOC/amnesia but no signs/symptoms of depressed skull fracture is not warranted.
    - (Miller, 1996)

- Does the length of LOC make a difference?
  - Length of LOC increases the likelihood of intracranial lesions
  - Incidence of intracranial lesion for children was 3% vs. 13% for LOC < 1 min vs. > 1 min (Davis)
  - Incidence of intracranial lesion was 5.9% vs. 8.5% for LOC < 5 min vs. > 5 min (Miller, 1996)

- Are there clinical criteria that are useful?
  - Low risk criteria:

- Normal mental status, nonfocal exam, not intoxicated, no coagulopathy, no more than one episode of vomiting, no severe or progressive headache, no assault with blunt object, no history of repetitive head injury

- Intoxicated patients:
  - Prospective study, 107 intoxicated patients
  - 8.4% positive CT rate
  - 1.9% required neurosurgery
  - No clinical variables were predictive (GCS scores at presentation and 1 hour)
  - (Cook, 1994)

Summary:
- The literature suggests that patients with an LOC should be considered for CT. However, there are limitations to this approach:
  - The incidence of intracranial injury in patients without an LOC is not known
  - It is often unclear whether or not there was an LOC or how long the LOC was
  - There are limitations to using the GCS to identify patients with intracranial pathology
  - More prospective studies are needed

Magnetic Resonance Imaging
- Better for detecting contusions, diffuse axonal injury, isodense subdurals
- Not useful for acute bleeds or fractures
- May detect small hemorrhages missed by CT, but the clinical significance is unclear (Cheung, 1999)
- Takes longer than CT and less readily available
- In one study, MRI and CT had similar sensitivities for hemorrhagic lesions (CT=90%, MRI=87%); MRI was more sensitive for nonhemorrhagic lesions (CT=17%, MRI=93%); MRI was more sensitive for brain stem lesions (CT=9%, MRI=81%). [Gentry, 1988]

Cost Analysis
- Dacey prospectively studied 610 patients with a transient LOC or neurologic dysfunction, GCS $\geq$ 13: Only 11% underwent CT. Admitting all patients for observation-$1.48 million in charges; discharging patients with a GCS of 15 and a normal CT-$686,000 in charges. (Dacey, 1991)
- Obtaining a CT, and discharging if negative is more cost effective than admitting for observation. In one recent study, this strategy would have resulted in a 58% decrease in charges. (Shackford, 1992)

Admission Criteria
- Persistent vomiting or abnormal mental status
- Suspicion of non-accidental trauma
- (Linear skull fracture over the middle meningeal artery)
- Linear skull fractures without intracranial injury by CT may not require admission:
  - In Dietrich's study of 322 pediatric patients with head injury:
    - 35 (11%) had isolated skull fracture without intracranial lesion
    - None of the patients developed a delayed presentation of an intracranial lesion. (Dietrich, 1993)
  - Of 101 infants with isolated skull fractures:
    - None demonstrated clinical decline during hospitalization
    - The authors conclude that isolated skull fracture does not necessitate admission. (Greenes, 1997)
  - In children, some recommend admission for < 1 y.o. or if the fracture crosses the middle meningeal artery

- Basal skull fracture
  - Of 114 patients < 18 years with basal skull fracture and a normal neurologic examination, (GCS of 15) and normal head CT:
  - No cases of delayed intracranial bleed
  - One case of meningitis in a patient with a CSF leak
  - In these low risk patients, admission might not be necessary. (Kadish, 1995)

The Use of Antibiotics in Patients with Basilar Skull Fractures

- CSF leak can form a path for bacteria to enter into the CSF resulting in meningitis
- Antibiotics may select out resistant organisms
- Antibiotics do not appear to be beneficial in preventing meningitis
- Patients with isolated basal skull fracture without CSF leak may not require admission or antibiotics as an outpatient
- Rathore, 1991
  - Literature review
  - 519 received antibiotics (4% developed meningitis), 329 did not receive antibiotics (3% developed meningitis)
- Villalobos, 1998
  - Meta-analysis
  - 12 studies, 1,241 patients (719 patients received antibiotics, 522 did not)
  - Antibiotic prophylaxis did not decrease the risk of meningitis (odds ratio: 1.15)
  - Odds ratio was 1.34 for patients with CSF leak

Discharge Criteria

- GCS 15
- Normal mental status
- Normal head CT
- Low risk patients
- (Stein, 1990)

CASE # 6

A 30-year-old man is stabbed in the left flank with a knife. In the field: BP 120/70, HR 100, RR of 20. Upon arrival his vital signs are BP 100/p, HR 70, RR 26. He has no JVD and normal carotid pulses. He has equal breath sounds and a 2 cm SW in the left posterior axillary line just below the scapula tip. His abdomen is benign, and he has a nonfocal neurologic examination.

Course to be discussed.

PENETRATING ABDOMINAL AND FLANK TRAUMA

Stab Wounds: Risk of Intraperitoneal Injury

Location:

Anterior:
70% Intraperitoneal
30% Require laparotomy

Flank:
44% Intraperitoneal
14% Require laparotomy

Low Chest:
15% Intraperitoneal
15% Require operative intervention (diaphragm)

Indications For Laparotomy

- Unstable, peritoneal signs
- Upper abdomen/epigastrium (consider intrathoracic injury or pericardial tamponade)
- Blood from NG tube (stomach/duodenal injury)
- Evisceration (intraperitoneal injury in 2/3rds)
- Suspected diaphragm injury
- Free air
- Impaled object

Local wound exploration

- Is there violation of the peritoneal cavity?
- Determine if stab wound tract is anterior to the rectus fascia (anterior abdomen) or extends through the fascia or muscle (flank or back)
- Consider an inconclusive exploration to be positive
- Discharge patients with a negative wound exploration
- If exploration is positive then DPL, CT scan, laparoscopy, or observation (serial abdominal examinations)

Diagnostic Peritoneal Lavage

For detecting intraperitoneal and diaphragmatic injury

Criteria for Positive Lavage:

- SW to the abdomen: in a recent study, RBC of 50,000/mm^3 discriminated best those who required surgery from those who did not (Zappa, 1992)
- SW lower chest: $\geq$ 5,000 (maximizes the sensitivity for isolated diaphragm injury)
- For diaphragm injury: falsely negative in 25% to 34%. Lavage fluid may drain through chest tube.
- GSW: $\geq$ 5,000 RBCs/mm^3. One recent study used 10,000 RBCs/mm^3 as a cutoff to determine peritoneal penetration in patients with abdominal GSWs (sensitivity 99%, specificity 98%, accuracy 98%) [Nagy].

Abdominal CT Scan

- Triple contrast (oral/IV/rectal) for suspected colorectal injury
- CT scan with oral and IV contrast for retroperitoneal injury
- May miss diaphragmatic injuries

Laparoscopy

Advantages:

- Direct visualization of abdominal viscera (small bowel, diaphragm)
- Grading of spleen and liver injuries (difficult to visualize entire bowel)
- Useful for determining the need for laparotomy
- Low sensitivity for hollow viscus injuries
- Detects diaphragmatic injuries:
    - Can be used to detect occult injury to the diaphragm.
    - In one recent study, laparoscopy detected diaphragm injury in 26% of patients with penetrating trauma to the left thoracoabdominal region. (Murray)
- Useful for SWs to the back, flank, low chest or to determine if GSW is intraperitoneal
- Similar sensitivity to DPL for significant intraabdominal injury, and higher specificity

Nonoperative or Selective Management

- Negative laparotomy rate of 14-28% for patients with physical findings.
- 36% with intraperitoneal injuries have no physical findings.
- Stab wounds to the back can be assessed in the same way as anterior abdominal injuries
- Decision to operate based on clinical criteria
- Based on this strategy, 85% of patients in one study did not require an operation. The diagnosis was delayed in 5/230 patients (2.2%) with no serious complications. The initial physical examination was accurate in 95% of patients. (Demetriades, 1988)
- In a more recent prospective, randomized study of selective nonoperative management vs. mandatory laparotomy for 51 patients with abdominal stab wounds:
    - morbidity rates: 19% for laparotomy, 8% for observation (p=.26)
    - hospital stays were shorter in the observation group: median of 2 vs. 5 (p=.002)
    - $2800 saved per patient who underwent successful nonoperative management (Leppaniemi, 1996)
- One approach for stab wounds to the back or flank is DPL then triple contrast CT if the DPL is negative

Cost Analysis

- In a recent retrospective study of stable patients with penetrating abdominal trauma laparoscopy was compared with laparotomy. The negative laparotomy rate was 19%. 14 patients underwent negative laparoscopy, 19 patients underwent negative laparotomy, and 4 underwent conversion from laparoscopy to laparotomy. The mean length of stay was shorter for the laparoscopy group versus the other two (1.43 v. 4.26 [laparotomy] v. 5.0). The

overall total costs were lower in the laparotomy group. There was an overall savings of $1,059.44 per patient when laparoscopy was performed instead of laparotomy. (Marks, 1997)

- In another recent study of 106 stable patients with penetrating abdominal trauma, the charges were $82 75 $\pm$ 4692 vs. $3,762 $\pm$ 3786 for patients who had a negative laparotomy vs. laparoscopy only. For patients who did not require tube thoracostomy, the length of stay was 2.6 $\pm$ 1.7 days vs. 4.7 $\pm$ 1.6 days for laparoscopy only vs. negative laparotomy. Utilizing laparoscopy first yielded a therapeutic laparotomy rate of 50% vs. 18% had all patients underwent laparotomy. (Ditmars, 1996)

Diagnosis of Diaphragmatic Injury

- 10-80% incidence after penetrating trauma
- Delayed diagnosis in up to 31% of patients
- Murray's study of 119 patients: 32% incidence after stab wound to the left thoracoabdominal area. 15 patients undergoing laparoscopy (26%) had occult diaphragm injuries.
    - Of 45 patients with diaphragm injury: 31% had abdominal tenderness, 40% had normal CXR, 49% had a hemopneumothorax (Murray, 1997)
- In one recent study of 41 patients with lower left chest wounds, 21 patients underwent selective laparotomy: 2 patients (10%) had isolated diaphragm injuries. 18% of the patients not explored returned within 18 months with an incarcerated diaphragmatic hernia. 20 patients underwent routine laparotomy: 50% had isolated diaphragm injuries. Thus, routine laparotomy resulted in recognition of a five-fold greater number of isolated diaphragm injuries. (Stylianos, 1992)

Other Diagnostic Studies
CXR: low yield after penetrating trauma
Fiberoptic Thoracoscopy
Magnetic Resonance Imaging
Contrast Studies:
Upper GI series for stomach and small bowel. Displacement of viscera into chest.
Barium enema for colon herniation.

PENETRATING GENITOURINARY TRAUMA

Ureteral Injury

- 95% of injuries are iatrogenic
- Clinical findings may be subtle or nonexistent: abdominal pain/tenderness, flank mass/tenderness, fever
- 85% have associated abdominal injuries
- Diagnosis is delayed in 40%
- Nephroureterectomy rate rises to over 50% if the diagnosis is delayed
- Urinalysis is normal in 1/3rd of patients

Renal Trauma

- 5-15% of patients with penetrating abdominal trauma will have renal injuries
- 80-90% have associated injuries (liver, small bowel)
- > 60% have gross hematuria
- 20% have microscopic hematuria

Diagnosis

- Urinalysis is not helpful.
- There is no correlation between the degree of hematuria and the presence of significant renal trauma.
- Work-up should be performed based on proximity to the GU tract

IVP

- Abnormal in 96% of patients with ureteral injury
- Ureteral injury: extravasation with dilatation proximal to the injury site
- More sensitive for small areas of upper tract extravasation

One-shot Preoperative IVP

- Rarely helpful
- In a recent study, preoperative IVP influenced operative decisions in only 8% of patients with suspected renal injury (flank wound or gross hematuria) [Nagy, 1997]

Abdominal CT

- Diagnostic test of choice
- Increase sensitivity with delayed scans to detect contrast extravasation
- Initial screening test for wounds in close proximity to urinary tract

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