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AN EVIDENCE-BASED APPROACH TO EMERGENCY MEDICINE

Blunt Abdominal Trauma: Priorities, Procedures, And Pragmatic Thinking

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Author

John A. Marx, MD
Chair and Chief, Department of Emergency Medicine, Carolinas Medical Center, Charlotte, NC; Clinical Professor, Department of Emergency Medicine, University of North Carolina at Chapel Hill, Chapel Hill, NC.

Peer Reviewers

Carolyn J. Sachs, MD, MPH
Assistant Professor, UCLA Emergency Medicine Center, Los Angeles, CA.

Alan E. Jones, MD
Chief Resident, Carolinas Medical Center, Charlotte, NC.

CME Objectives

Upon completing this article, you should be able to:

1. name typical mechanisms of injury for solid and hollow visceral trauma;
2. explain the appropriate diagnostic approach based upon the clinical scenario;
3. describe which clinical and laboratory features are useful for patients with blunt abdominal trauma; and
4. adapt the management approach in the context of special patient and clinical circumstances.

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Four a.m.—things are just starting to calm down in the ED. Suddenly, a worried mom arrives with her 14-year-old son. It seems he was doing tricks on his scooter, and during a flip he rammed the handlebar into his upper abdomen. He wouldn't eat dinner and started vomiting around midnight. His belly is fairly benign except for a bruise just below his xiphoid. Oh, well—it's probably just another case of gastroenteritis.

"THE belly is benign" takes its place among other cringe-causing statements in the emergency medicine lexicon (such as "Remember that older gentleman you sent home last night?"). What should accompany such abominable proclamations is the trailing caveat "but he's intoxicated…is head injured…has a fractured femur…has a seat-belt mark…has a cervical cord injury…" and so forth. Worse, though, is the failure even to suspect that abdominal trauma is a possibility in the well-appearing victim.

The diagnostic approach to blunt abdominal injury has shifted in the past four decades. Prior to the advent of diagnostic peritoneal lavage (DPL) in 1964, clinical examination was the primary modality. However, its limited accuracy led to a considerable number of unneeded laparotomies and, more disturbingly, failure to operate in a timely manner on those in need. DPL was the mainstay from its inception until the 1980s, when computed tomography (CT) became routinely available. Over the past decade, ultrasound (US) has found its way into the mix, mostly as a noninvasive replacement for DPL to search for intraperitoneal blood. Today, these four tools are used in various combinations for differing clinical scenarios in EDs across the country.

Current practice emphasizes cost-effective and efficient approaches.

This may include a strategy of simply observing patients with reliable and negative examinations unless and until they develop indications for specific diagnostic studies.[1] Decision trees vary widely among institutions according to the reliability and availability of the various technologies as well as the experience and preference of emergency physicians, trauma surgeons, and radiologists at the respective sites.[2,3] What is clear is that pragmatic thinking, attention to detail, and effective clinical algorithms will help the emergency physician detect occult injury and manage the traumatized victim. This issue of *Emergency Medicine Practice* outlines just such an approach.

Epidemiology

Blunt abdominal trauma is responsible for 10% of all trauma deaths. Motor-vehicle crashes and auto/pedestrian accidents are responsible for half to three-quarters of blunt abdominal injury, while assaults and falls make up the majority of the remainder.[4] Importantly, the bulk of abdominal trauma cases present within the context of multi-system trauma. These are often patients involved in a high-speed crash who present with simultaneous closed-head injury, hemopneumothorax, multiple extremity fractures, and numerous lacerations.

Non-accidental trauma in children can be an especially elusive diagnosis. A history of child abuse is often difficult to secure based on the child's fear coupled with the parents' misdirection.[5] These small victims may also suffer less common injuries, such as duodenal hematoma or pancreatic injury. Likewise, domestic violence may result in occult abdominal trauma, especially in females and, more particularly, in pregnant women.

Iatrogenic injury can be induced by bag-mask ventilations, inadvertent esophageal intubation, external cardiac compressions, and the Heimlich maneuver.[6,7]

Pathophysiology

Three basic mechanisms cause intraabdominal injury.[8] First, an external force applied to the anterior wall and the posterior thoracic cage or vertebral column can crush those organs caught between. This is more likely to occur to solid organs (particularly the liver and spleen) and in those with lax abdominal walls (typical of the elderly as well as alcoholic patients). Second, abrupt and powerful external forces can suddenly increase intraabdominal pressure, and burst a hollow viscus. This is exemplified by lap-belt injuries.[9] Third, extreme acceleration-deceleration can shear the solid viscera as well as vascular pedicles.

The spleen is the most frequently damaged intraperitoneal organ, followed by the liver. The intestine is the most likely hollow viscus to sustain injury.

Differential Diagnosis

Sure, it's *possible* that a patient presenting with abdominal pain and tenderness following a major car crash is simply doubled over from pre-existent pelvic inflammatory disease, appendicitis, lead poisoning, or even acute intermittent porphyria.

Guess again. The traditional differential formula doesn't adapt well to abdominal trauma. With that in mind, though, there are three considerations that warrant mention:

1. **Single vs. Multi-System Trauma:** Major forces inflicted by vehicles at high speeds tend to produce multi-system trauma. It is ill-considered to suppose that a patient thrown 50 feet from the train that hit him has an isolated leg fracture. Suspect the abdomen in this scenario.
2. **Single- vs. Multiple-Organ Injury:** There has been considerable emphasis in the past 15 years on avoiding laparotomy when there is known or strongly suspected isolated solid organ (i.e., spleen, liver) injury. This is especially true in children.[10] Unfortunately, coincident hollow viscus rupture is not rare in these circumstances and can be very difficult to identify by clinical examination or certain diagnostic studies, such as CT.[11]
3. **Trauma vs. Medical:** Medical problems can precipitate or coexist with trauma, especially in the elderly. Metabolic, anaphylactic, cardiac, or neurologic emergencies may cause the fall or motor vehicle crash. What appears to be closed-head injury may simply be hypoglycemia.

   Patients with enlarged or abnormal intraperitoneal organs (e.g., the enlarged spleen of infectious mononucleosis) or coagulation disorders can have profound pathology subsequent to what seems to be the most trivial trauma.

Prehospital Care

Paramedics are the physicians' eyes and ears at the scene. They can transmit invaluable information on the mechanism of injury and can determine seat-belt use, starred windshields, bent steering wheels, and vehicular intrusion. They provide clues to severity of injury by reporting prehospital vital signs and neurologic status.

From a management perspective, the "scoop and run" strategy prevails. Procedures such as intravenous insertion and intubation can usually be carried out in the rig. Wherever possible, paramedics should notify receiving hospitals regarding high-acuity patients to allow preparation.[12] The appropriate receiving hospital is determined by a combination of triage scoring systems and paramedic judgment.[13]

Nearly all studies show that the pneumatic antishock garment (PASG), a device prematurely popularized in the 1970s, is ineffective in most patients who suffer blunt trauma.[14] However, in one retrospec-

tive, non-randomized study, severely hypotensive trauma victims (BP ≤ 50) seemed to benefit from the application of the PASG.[15]

However, it or an alternative pelvic stabilizing device is indicated to mitigate the massive retroperitoneal hemorrhage that can occur in patients with pelvic fracture.[16] While it appears reasonable that the PASG would assist hemorrhage control in unstable pelvic fractures, no large, randomized, controlled trials have evaluated this.

Finally, recent studies have elaborated potential risks of aggressive crystalloid resuscitation, especially in the victim of penetrating torso trauma.[17,18] This issue remains unresolved at this time, specifically for the blunt trauma patient. It is reasonable, then, to place lines in the field but to avoid overzealous fluid administration, particularly in those patients injured shortly before transport who have brief transport times. While the definition of "overzealous" remains a moving target, high-volume infusions are not indicated in those with relatively stable vital signs.

Emergency Department Evaluation

"I had...come to an entirely erroneous conclusion which shows, my dear Watson, how dangerous it always is to reason from insufficient data."
—Arthur Conan Doyle,
The Adventures of the Speckled Band, 1892.

History

Although not always available, the patient's history can be extremely valuable. The patient interview may be compromised or impossible due to severe head injury, alcohol or drug intoxication, or the unavailability of key and credible witnesses. Remote history of trauma may be forgotten or considered trivial.

The pre-hospital events can provide key insight and should include assessment of vital signs, physical assessment, and response to therapy. Consider asking the paramedics, "What was the highest pulse and lowest blood pressure?" Outside records, including x-rays, must be reviewed carefully.

Ask the scene personnel about the extent of damage to the vehicle, amount of passenger compartment intrusion, the condition of the steering wheel and windshield, whether seat belts were used, whether front or side airbags were deployed, and the speed and size of the striking vehicle.

Certain mechanisms portend particular pathology. Compressive forces, especially to the rib cage, are associated with liver and spleen fractures. Sudden high-energy forces over a small impact zone are known as "spearing" mechanisms (e.g., nose of a football, bike handlebars, and lap-belt-only restraint). These frequently result in hollow viscus injury. The organ "speared" can be predicted somewhat based on whether the trauma was centered in the epigastrium (duodenal hematoma or rupture, pancreatic contusion), mid-abdomen (jejunum, ileum), or lower abdomen (ilium, bladder). Finally, high-speed deceleration (e.g., a fall from four stories or 80 mph into a tree) can shear solid viscera from their vascular pedicles, most notably the kidney.

The condition of the patient at the scene may suggest that a medical concern precipitated the crash or fall. These underlying conditions may contribute to or be wholly responsible for the patient's status. Seizures, arrhythmias, and hypoglycemia are notable culprits.

Ask about loss of consciousness (LOC) in victims of blunt trauma. In one study, transient LOC in the field was significantly associated not only with head injuries but with extracranial injuries as well. In this series, nearly 20% of patients suffering loss of consciousness required surgery for life-threatening injuries; many needed laparotomies.[19]

The patient with abdominal trauma may have a variety of complaints. There are two main presentations. First is volume loss, which, depending on the rate and severity of bleeding, can produce thirst, orthostatic dizziness, lightheadedness, confusion, or obtundation. Second, irritation of the peritoneum incites pain and will result directly from hematic (e.g., bleeding from the liver, spleen, or great vessels), infectious (e.g., leaking bowel or colon), or enzymatic (e.g., pancreas, bowel, gallbladder) irritation. Pain may be present at the outset or lag by hours to days, particularly in the case of hollow viscus or pancreatic injury. Remember that the sensation of pain may be diminished or rendered absent by the presence of competing pain at another body site, altered sensorium, possible intoxication, or spinal cord injury.

Abdominal pain may be diffuse, as when it follows gross hemoperitoneum and septic peritonitis. Local pain can also occur; for instance, splenic injury can produce pain in the left upper quadrant or referred pain in either shoulder tip or the neck. This referred pain is probably due to intraperitoneal irritation of the diaphragm and can sometimes be elicited by placing the patient in the Trendelenburg position (Kehr's sign).[20] Shortness of breath may occur with diaphragmatic irritation or the herniation of intraabdominal structures into the chest through a diaphragmatic tear. Nausea and vomiting may accompany hypovolemia or peritoneal irritation. Persistent vomiting may be secondary to obstruction and is frequent with duodenal hematoma.[21]

Past Medical History

An understanding of the patient's co-morbid medical conditions such as cardiovascular disease and coagulation disorders or coagulopathic medications (e.g., warfarin) can be critical to the management schema, particularly fluid and blood component therapy. Patients on warfarin may develop life-threatening hemorrhage after relatively minor trauma.[22]

Physical Findings

Examine everything; then do it again…and again. The physician who fails to perform complete primary, secondary, and tertiary surveys will miss clues to shock and serious injury. This admonition certainly applies to the peritoneal cavity. While the abdomen should never be ignored, it cannot be the sole focus of the emergency physician.

It may not be easy to perform a careful abdominal examination in the midst of a critical resuscitation—both the patient and the physician may be distracted from the abdomen. However, abdominal tenderness, peritoneal irritation, gastrointestinal hemorrhage, and hypovolemia not attributable to extraabdominal causes should always suggest intraperitoneal injury. That's the good news. The bad news is that even in the alert and conscious patient, reliance on the abdominal examination can lead to false-positive and false-negative errors.[23,24] In some patients, the examination may be unremarkable despite intraperitoneal injury, while in others it suggests pathology when none exists. This situation is made worse by compromising factors—altered sensorium, distracting injury, and the like. Overall, the accuracy of a single physical examination in blunt abdominal trauma is 55%-65%.[2,25]

Vital Signs

Blood pressure and pulse should be considered in context. Frank hypotension, tachycardia, or both strongly suggest hemorrhage. However, these findings are not specific for abdominal injury. In addition, premorbid circumstances such as hypertension and the presence of various drugs and medications can alter or mask the response to blood loss. An elderly patient with preexisting hypertension who's taking a beta-blocker can be in profound shock despite a "perfect" blood pressure of 120/80 mmHg and a pulse of 80.

Even healthy adults may not develop tachycardia despite profound shock. In a study of over 10,000 major trauma patients, relative bradycardia (defined as a systolic pressure < 90 mmHg and a pulse rate < 90 beats per minute) occurred in nearly 30% of all hypotensive patients.[26]

Abdominal Examination

Inspection of the abdomen may reveal distension or ecchymoses. In the case of distension, likely culprits include pneumoperitoneum, gastric dilatation, or ileus. Distension produced by hemoperitoneum alone is extraordinarily ominous and is an *extremely* late finding. Since two liters of free blood in the abdominal cavity will distend the belly almost imperceptibly,[27] never wait for this sign to prompt laparotomy. Inspection of the bare trunk may also reveal telltale ecchymosis. Bruising of the flanks (Grey Turner's sign) or umbilicus (Cullen's sign)[28] represents hemorrhage in the retroperitoneal or peritoneal spaces, respectively. However, these signs are typically delayed by six hours to several days.

More valuable is the presence of a lap-belt sign. This finding suggests worrisome intraabdominal injury—notably, perforation of the small bowel. As many as one-third of patients with a lap-belt sign will have injury to the bowel or mesentary.[29] In one prospective study, 36% of patients with a seat-belt sign required operative intervention.[30]

Auscultation of the injured abdomen provides little information. Many experienced practitioners believe that the presence of bowel sounds does not rule out ileus or serious injury, and their absence in no way proves that injury exists. However, this premise has not been subjected to in-depth study.

Perhaps the most valuable physical finding in abdominal trauma comes from palpation. Local or generalized tenderness is found in approximately 90% of *alert* patients with intraabdominal visceral injury.[25,31] However, not all abdominal tenderness represents intraabdominal pathology. The presence of thoracoabdominal wall trauma (e.g., lower chest rib fractures) can make the patient wince in reaction to abdominal palpation that too closely approaches the injured chest. Likewise, severe contusions of the abdominal wall can cause tenderness and guarding. Carnett's sign is tenderness of the abdominal wall elicited by palpating the abdomen during contraction of the rectus muscles (as when the supine patient lifts his or her head or legs off the gurney).[32,33] If the abdomen is more tender with the rectus muscle tense and less tender with the muscles relaxed, this implies muscle as opposed to visceral injury. However, no prospective studies have validated this finding in the trauma patient.

Extraabdominal Examination

In addition to auscultation and inspection of the chest, palpate the lower chest for rib fractures. As many as 20% of patients with left lower rib fractures have splenic injury, while slightly fewer with right lower rib fractures suffer liver damage.[34] Assess the pelvis for tenderness and stability.

The rectal examination is rarely of value in acute blunt trauma. It may be valuable in the male with pelvic fracture who is at risk for urethral injury but who has no blood at the meatus. In such a patient, the discovery of a high-riding prostate will prompt the need for urologic studies. In addition, a sacral fracture resulting in sensory loss in the posteromedial thigh and buttocks (S2-S4) demands assessment of rectal tone. Finally, certain intrahepatic hematomas can "liquefy" and empty through the hepatobiliary tree into the duodenum and ultimately the colon. However, this takes place 2-3 weeks or more after the original trauma—a long time to wait with a hemoccult card in hand.

Pay special attention to palpating the lumbar spine in the patient with abdominal wall ecchymosis. Patients with a lap-belt sign may have sustained a

coincident burst fracture of the upper lumbar vertebrae (Chance fracture).[35] The combination of a lap-belt sign and lumbar fracture places the patient at very high risk for hollow viscus injury.[36,37]

Serial Examinations

Repeated examinations by the same examiner are helpful in alert patients—especially so in patients with an altered sensorium. Appropriate documentation should accompany these examinations.

Diagnostic Studies

Patients in whom the physical examination is reliable and normal often require nothing but serial examinations. In those with clinical evidence of hemodynamic compromise or clear thoracoabdominal injury, immediate testing is needed, including baseline hematocrit, type and hold/cross, and one or more of the big three: DPL, US, or CT. Likewise, patients with blunt multisystem trauma who cannot be adequately observed in the ED should undergo sufficient diagnostic evaluation to preclude life-threatening intraabdominal injury before a non-abdominal operation (e.g., craniotomy, thoracotomy) or diagnostic study (e.g., aortogram). Occasionally, the patient with overwhelming clinical indications for laparotomy may be taken to the operating room with no additional testing. Such patients might include those with isolated abdominal trauma who have a rigid abdomen, refractory hypotension, and no other possible sources of blood loss.

Laboratory Studies

> *"I have become deeply impressed with the general reliance on laboratory methods shown by practitioners recently out of college, and at the same time with their inability accurately to observe or appreciate the significance and value of symptoms as compared with the finding of the microscope or test tube."*
> *—Robert Hall Babcock, The Lancet Clinic, 1911*[38]

Overall, hematologic and chemical tests provide little assistance to the acute blunt trauma patient.[39] Instead of routine testing, laboratory investigation is best tailored to the clinical circumstances. In one prospective study, researchers divided trauma patients into two categories: Trauma Blue—severe injury likely (Glasgow Coma Score < 13; systolic blood pressure < 100 mmHg at any time; significant head, chest, abdominal, or proximal long bone injury; or clinical suspicion of need for operative or intensive care unit management) and Trauma Yellow—severe injury unlikely. The tests ordered for Trauma Blue included an arterial blood gas (including pH, PO_2, PCO_2, HCO_3, base deficit, hemoglobin, sodium, potassium, and ionized calcium), blood alcohol, type and screen or crossmatch, and urine dipstick. Tests for the Trauma Yellow group were limited to a venous blood gas and blood alcohol. In this study, no patient suffered delay in care due to lack of laboratory testing—and cost savings were $29.82 per patient (or $20,000 a year) at this institution.[40] However, this study did not examine the equally appealing hypothesis that *no* tests may be required in the patient in whom the physician does not suspect serious injury. Other studies have shown similar results.[41]

Hematology

The hematocrit is most useful as a baseline study or when significantly low when the patient arrives (< 30%). Remember that the hematocrit reflects some combination of a pre-trauma value, the lag from hemorrhage, as well as dilutional effects of exogenous fluid administration and endogenous plasma refill.[42] In patients with a 10%-20% blood loss, the endogenous plasma refill proceeds at a modest rate of 40 mL/h for the first 10 hours, continuing for 30-40 hours. However, in a very remarkable study of volunteer patients with blood loss of at least 40% of total blood volume (how much were these volunteers paid?), this rate could be as high as 1500 mL in the first 90 minutes following injury.[43]

While a low hemoglobin level observed after injury usually indicates serious hemorrhage (and occasionally underlying anemia), most trauma victims have an initial hemoglobin in the normal range, even despite significant blood loss.[44] Serial levels are often more informative. Recall, however, that one liter of intravenous fluids alone (without blood loss) may decrease the hemoglobin level by a point or more.[45]

Part of medical mythology holds that an elevated white count on the CBC suggests splenic injury. However, leukocytosis with a count of 12,000-20,000 and moderate left shift is a common occurrence within several hours of any major injury. It is entirely nonspecific and has no diagnostic significance.

Blood Type

Some suggest that the single most important laboratory test in the seriously injured patient is the type and crossmatch. A number of decision rules have been suggested to determine the need for blood typing in the trauma patient, none of which has been prospectively validated. A type and screen is probably adequate for most patients who are hemodynamically stable but who remain at risk for intraabdominal injury as determined by the initial evaluation.

Chemical

While often helpful, no chemical analysis needs to be routine. An increased base deficit or elevated serum lactate can be an early harbinger of hemorrhagic shock. Substantive abnormalities such as a base deficit of -6 or greater are strongly associated with the need for early transfusion, increased ICU and hospital stays, and shock-related complications.[46,47] However, measures of acidosis are superfluous in those in obvious shock. Conversely, the emergency physician should never be

reassured by a normal base deficit in the presence of deteriorating vital signs.

While it would be helpful to have laboratory tests that could identify specific organ injury, this is simply wishful thinking. While elevated serum transaminases may reflect hepatic injury, they can be falsely positive in cases of alcohol-induced liver damage. Additionally, because liver function tests are frequently negative despite hepatic trauma, they are as likely to mislead as assist in management.[48] The situation is no better when it comes to pancreatic trauma. Serum amylase, lipase, and amylase isoenzymes all lack sensitivity and specificity.[49] Elevated or rising levels may indicate damage, but in and of themselves are not conclusive.[50]

Urinalysis

A visual examination of the urine can be extremely helpful in cases of significant blunt trauma. The most consistent sign of serious renal injury is gross hematuria. All patients with gross hematuria require investigation of the genitourinary system, either before laparotomy in the stable patient, or after or during laparotomy for the patient with intractable shock. For the stable patient, if the urine is clear yellow on visual inspection, significant renal injury is exceedingly unlikely. While a visual appraisal alone is adequate for the hemodynamically stable patient, a dipstick or microscopic evaluation is indicated in adults with shock.[51,52] At least one study showed that a dipstick examination is adequate to exclude traumatic hematuria.[53] Children who suffer significant trauma should undergo dipstick or microscopic analysis of the urine, as visual examination alone is inadequate.[54,55]

A dipstick urinalysis or microscopic urinalysis may tip the diagnostic scales in the patient with abdominal tenderness, especially when the physician is not sure that the patient requires an abdominal CT. In one prospective study in adult victims of blunt trauma, the combination of a tender abdomen and microscopic hematuria was very specific for intraabdominal injury on CT (94%).[56] This combination, however, was only 64% sensitive.

Radiology

Studies should be obtained only if they are likely to assist management, *and* their benefits outweigh the risks. Chief among those risks is leaving the resuscitation area to languish in the dark and unfriendly confines of radiology. These dangers have earned the CT scanner the grim nickname, "the circle of death."

Plain Films

The most common films ordered for the multi-trauma patient consist of the chest x-ray, the anteroposterior pelvis film, and the three-view cervical spine series. The chest film can help distinguish pneumothorax, hemothorax, diaphragmatic rupture, and rib fractures as well as an abnormal mediastinal contour and other signs of potential aortic disruption.

A pelvic fracture can be a significant source of blood loss. While this study is often routine in the multi-trauma victim, certain clinical criteria can safely determine its need. These clinical criteria are:[41]

- Unstable vital signs
- Significantly altered mental status
- Ecchymosis, swelling, laceration to the pelvis and surrounding structures
- Blood at urethral meatus, gross hematuria
- Tender pelvis, sacrum, or lower lumbar spine
- Neurologic deficit in lower extremities
- Abnormal rectal exam (lax tone, bloody stools, abnormal prostate)
- Pain upon hip movement

Abdominal plain films have essentially no role in acute blunt trauma. Suggestion of significant hemoperitoneum can be seen on a supine AP of the abdomen, but the sensitivity pales in comparison with DPL, US, or CT. Small quantities of readily detectable free intraperitoneal air are present in most patients with gastric, duodenal bulb, and colonic perforations but in a minority of patients with jejunal and ileal perforation. These are more readily seen on CT than plain films.[57]

Computed Tomography

CT is supremely capable of defining injured organs. It is most accurate for solid visceral pathology. It is often able to distinguish the presence, source, and approximate quantity of intraperitoneal hemorrhage.[58]

Findings On CT

The major findings on CT relate to detection of organ injury and free intraperitoneal fluid. Free fluid alone (absent signs of organ injury) in the adult patient can be suggestive of serious disease. One retrospective study showed that exploratory laparotomy was therapeutic in 94% of patients with isolated intraperitoneal fluid on CT scan.[59] Other studies support this conclusion.[60]

The presence of intraabdominal free air on CT is not an indication for laparotomy. This is due to the fact that free intraperitoneal air can be generated by mediastinal or pulmonary injury as well as barotrauma, and thus is not pathognomonic of hollow viscus perforation.[57]

In contradistinction to DPL and US, CT scanning coincidentally evaluates the retroperitoneum and therefore can be helpful in the evaluation of hematuria.[61] If a hemodynamically stable patient has a hemoperitoneum demonstrated by DPL or ultrasound, a subsequent CT can evaluate organ injury and assist in the decision of whether nonoperative, expectant management is appropriate.[3] If CT is performed after DPL, inform the radiologist of this fact to avoid confusing residual lavage fluid with hemoperitoneum or succus.

Issues In Using CT

The value of the CT in trauma management depends on a number of variables. Patient factors include hemodynamic stability and cooperation (either voluntary or pharmacologic). Scanner issues relate to the distance the scanner is located from the ED and the generation of the machine. Helical (spiral) scanners provide faster examinations, with improved visualization of solid organs, and reduced CT artifacts.[62] Spiral CT may even demonstrate areas of active hemorrhage and can help predict the success (or failure) of non-operative management.[63,64] An important caveat is that the accuracy of abdominal CTs in trauma is very reader-dependent.[65]

The use of intravenous contrast allows better visualization of solid organs and sharpens the distinction between normal and injured tissue. However, oral contrast does not provide any significant benefit. Several studies prove that oral contrast rarely adds to diagnostic accuracy and causes considerable lengthening of the time required for study completion.[66,67] One retrospective study showed that 60% of patients given oral contrast had inadequate opacification of the gut.[68]

Disadvantages

The greatest hazard of CT follows from ill-advised or poorly supervised studies wherein the dynamics of illness cause stable patients to crash and unstable patients to die. In one large review of blunt trauma, the authors described two preventable deaths, both secondary to operative delay associated with obtaining an abdominal CT.[69]

Other disadvantages of CT include its modest sensitivity for injury of the pancreas, small bowel, and mesentery.[70,71] The latter two are of particular concern, as hollow viscus injury may occur in approximately 5% of patients with significant blunt abdominal trauma.[72]

Complications, albeit uncommon, can stem from reactions to intravenous or oral contrast.[73] In addition, oral contrast is associated with an increased likelihood of emesis, early aspiration, and pneumonia.[68]

The cost of CT scanning can be substantial, particularly when employed in an overly liberal fashion. In one prospective study, intraabdominal injuries were identified in only 11% of patients undergoing CT scans of the abdomen.[56]

Ultrasound

In the past decade, US has come to the forefront as a cornerstone study in the initial evaluation of the blunt trauma patient. Its primary role is in the detection of free intraperitoneal blood via scan of Morison's pouch (RUQ), the splenorenal recess (LUQ), and the pouch of Douglas (pelvis), all dependent portions of the intraperitoneal cavity where blood is likely to accumulate. (See the April 2001 issue of *Emergency Medicine Practice*, "Emergency Imaging For The 21st Century: Where Does Ultrasound Fit In?") The Focused Assessment with Sonography in Trauma (FAST) includes these three views plus a subxiphoid cardiac view for the purpose of determining hemopericardium.[74]

Novel positioning may increase the sensitivity of the FAST exam. One prospective observational study used increasing aliquots of lavage fluid in hemodynamically stable patients undergoing DPL. Trendelenburg positioning allowed recognition of only 400 cc of intraperitoneal fluid, compared to 700 cc in the supine position.[75]

Advantages

Ultrasound has many advantages. First of all, it's accurate. A recent study examined 2576 patients who underwent US for blunt abdominal trauma. Fewer than 2% had a false-negative examination. Overall, US had a sensitivity of 86%, a specificity of 98%, and an accuracy of 97% for detection of intraabdominal injuries.[76] One study showed that in the hypotensive patient with blunt abdominal trauma, ultrasound is 100% sensitive and specific.[77]

The instrument is portable, routinely housed in the trauma resuscitation room, and can accomplish the FAST exam in fewer than five minutes. Sensitivity for detection of as little as 100 mL, but more typically 500 mL, of intraperitoneal fluid ranges from 60%-95% with excellent specificity.[77]

US can replace DPL in rapidly answering the key question of whether hemoperitoneum is present. In contrast to DPL, US can also evaluate the mediastinum, is not invasive, and can be performed repeatedly by multiple individuals. In contrast to CT, it poses no radiation or contrast hazard, and usage is not restricted to radiologists. Accuracy of performance is correlated with length of training and experience, but competence can readily be acquired. In one study, physicians were able to detect hemoperitoneum more than 90% of the time after only two hours of training (one hour, theory; one hour, practical).[78] All in all, US provides a relatively accurate, rapid, safe, and less expensive diagnostic screening tool.[79]

Limitations

It's important to understand that, in the United States at least, US is not used to image solid parenchymal damage, the retroperitoneum, or the diaphragm. Technical difficulties can occur in obese patients, as well as those with a great deal of bowel gas or subcutaneous emphysema. In general, US is less sensitive than DPL for the presence of hemoperitoneum. Like DPL, US is insensitive when there is organ injury but no free intraperitoneal blood, as in subcapsular hematoma of the spleen. In one retrospective review, surgical or angiographic intervention (or both) was required in 26 patients (17%) without hemoperitoneum; such patients would be expected to have a negative FAST examination.[80]

As is often true for CT, US often fails to recognize bowel injury directly but relies instead on the visualization of small amounts of intraperitoneal fluid.

Studies show that the majority of patients with isolated bowel and mesenteric injury have a negative US of the abdomen.[81]

Miscellaneous

Angiography is an invasive and time-consuming procedure. Its use is generally restricted to two instances. Most often, it is employed as a diagnostic and therapeutic agent for bleeding pelvic vessels. Occasionally, in selected centers, it is used to detect and embolize actively bleeding intraparenchymal vessels (usually in the spleen).[83] In patients suspected of pancreatic injury, endoscopic retrograde cholangiopancreaticoduodenography (ERCP) is utilized to evaluate the ductal system.[83]

Special Procedures

Diagnostic Peritoneal Lavage

After nearly 40 years, DPL remains a valued tool in abdominal trauma. It entails two steps. First is the attempted aspiration of free intraperitoneal blood (known as peritoneal aspiration or peritoneal tap); second is the lavage portion, in which fluid is used to wash the peritoneal cavity, then is recovered by gravity drainage and subsequently analyzed.

Advantages

The signal virtue of DPL is in the multiple trauma patient with hemodynamic instability. DPL, like US, can promptly discover or refute the presence of intraperitoneal hemorrhage. It is sensitive to bowel perforations, where other diagnostic tests (CT, US) often fail. It's especially valuable in patients who are poor candidates for ongoing clinical evaluation, due to severe head injury, for example. (See **Table 1**.)

DPL And Pelvic Fractures

The incidence of false-positive peritoneal lavage in pelvic fracture is as high as 29%.[84] Therefore, authorities recommend an open supraumbilical approach in order to avoid transgressing a preperitoneal hematoma that has dissected out of the pelvis to the anterior abdominal wall. It is estimated that a lag of at least two hours is required before this dissection can occur, but the accuracy of this in humans is unknown. In the hemodynamically stable patient with a pelvic fracture, a positive DPL by red cell criteria should ordinarily prompt CT to better define the need for laparotomy.[85]

Techniques

DPL can be conducted by closed (Seldinger technique), semi-open, or open technique.[86] Relative contraindications to DPL include prior midline surgery, history of significant intraperitoneal infection, coagulopathy, obesity, or second- or third-trimester pregnancy. However, any of these can be overcome when necessary.

Table 1. Clinical Purpose Of Diagnostic Peritoneal Lavage Following Blunt Mechanism.

Purpose	Circumstance	Alternate or Complementary Study
Rapidly determine presence of intraperitoneal hemorrhage	Multiple blunt trauma, hemodynamically unstable	Ultrasound
Determine presence of intraperitoneal organ injury	Suspected or known blunt trauma with unreliable examination	CT
Determine presence of intraperitoneal hemorrhage or injury	Multiple trauma patients who require general anesthesia or lengthy diagnostic studies for other injuries	CT, ultrasound

Adapted from: Marx JA. Peritoneal procedures. In: Roberts JR, Hedges JR, eds. *Clinical Procedures in Emergency Medicine*, 3rd ed. Philadelphia: W.B. Saunders; 1997.

Table 2. Preferred Site Of Diagnostic Peritoneal Lavage.

Clinical Circumstance	Site	Method
Standard adult	Infraumbilical midline	Closed or semi-open
Standard pediatric	Infraumbilical midline	Closed or semi-open
Second- and third-trimester pregnancy	Supra-uterine	Fully open
Midline scarring	Left lower quadrant*	Fully open*
Pelvic fracture	Supra-umbilical*	Fully open*

*Empirical data to support these recommendations are limited.

Adapted from: Marx JA. Peritoneal procedures. In: Roberts JR, Hedges JR, eds. *Clinical Procedures in Emergency Medicine*, 3rd ed. Philadelphia: W.B. Saunders; 1997.

The open method is the most arduous and is reserved for circumstances in which the other techniques have failed or are deemed unsafe, as in the presence of pelvic fracture, pregnancy, obesity, and prior abdominal surgery. (See **Table 2** on page 8.) However, the reputed advantages of the open technique for some of these conditions may be overstated. In a retrospective review, the authors found that "the complication rate and accuracy of closed DPL in patients with previous abdominal surgery were similar to those for DPL performed in patients without previous abdominal surgery."[87] In a prospective study comparing the closed vs. open technique, the authors found that the closed peritoneal lavage was superior to open lavage in abdominal trauma; it was faster, easier to use, less expensive, and as safe as open lavage.[88] A recent meta-analysis examined all of the prospective, randomized, controlled trials comparing the closed and open technique of DPL. In this analysis, the closed DPL technique was as accurate and safe as the standard open DPL technique.[89]

Interpretation

The aspiration of at least 10 cc of blood has a positive predictive value of greater than 90% for intraperitoneal injury, typically solid visceral or vascular. This finding is responsible for approximately 80% of true positive DPLs in blunt trauma.[90] The RBC count threshold for lavage effluent is set at 100,000/cc.

Other laboratory parameters of DPL are less useful. A WBC count exceeding 500/cc can herald hollow viscus injury but tends to lag this by 3-6 hours and is often nonspecific.[91] Elevated lavage amylase and alkaline phosphatase, particularly the former, have been demonstrated in the immediate post-injury period following small intestinal injury.[92] Bile staining and Gram's staining of lavage fluid lack accuracy such that their routine use is proscribed.

The volume of returned lavage fluid may be important. One study showed that in patients suffering blunt abdominal trauma, the RBC count of DPL fluid regularly increases as more fluid is recovered. The authors suggest collecting at least 600 cc of effluent to avoid a false-negative lavage.[93]

Limitations

On the one hand, thanks to the exquisite sensitivity of DPL for blood, the threshold of 100,000 RBC/cc can produce unnecessary laparotomy for trivial injury, typically to the spleen or liver. On the other hand, injury to certain structures—notably the bowel and the diaphragm—produces limited hemorrhage, such that RBC counts of 20,000-100,000 RBC/cc should be considered carefully in clinical context and for an observation period of 12-24 hours.[94]

Laparoscopy

Laparoscopy has been most useful in assessing penetrating trauma;[95] however, very little experience has been acquired in the setting of blunt trauma.

Nasogastric Tube

Penetrating trauma to the epigastrium, left upper quadrant, or low chest may result in gastroduodenal hemorrhage and result in positive aspiration by nasogastric tube placement. In acute blunt trauma, gastric perforation from sudden and severe forces can occur but is very uncommon. This will result in free intraperitoneal air and possibly intragastric bleeding.[96] Otherwise, nasogastric tube placement may be useful for the evacuation of gastric air and contents in the supine patient, particularly one about to be intubated (although Sellick's maneuver should suffice).

Management

General

The real crux of abdominal trauma management lies first in the suspicion of injury, and then in the utilization of the best diagnostic tools. Appropriate and timely consultation of a surgeon, when necessary, is a vitally important ED intervention.

Unlike penetrating trauma, laparotomy for blunt mechanism is rarely mandated solely by clinical parameters. Relative clinical indications for laparotomy are found in **Table 3**. Blunt trauma patients typically have numerous potential sources of blood loss—both intra- and extraabdominal. This can complicate the decision to operate on the abdomen. Furthermore, reliance on physical examination alone can be precarious for many reasons, including altered mental status, paralysis, and altered sensation.

This conundrum is profound. Rushing a patient to what proves to be a nontherapeutic laparotomy leads

Table 3. Clinical Indications For Laparotomy Following Blunt Trauma.

Manifestation	Pitfall
Unstable vital signs with strongly suspected abdominal injury	Alternate sources shock
Unequivocal peritoneal irritation	Unreliable
Pneumoperitoneum	Insensitive and non-specific; may be due to cardiopulmonary source or invasive procedures (DPL, laparoscopy)
Evidence of diaphragmatic injury	Nonspecific
Significant gastrointestinal bleeding	Uncommon, unknown accuracy

to delay in more vital diagnostic and therapeutic undertakings. Alternatively, failure to determine the need for exigent laparotomy has even more grave consequences. Thus, in multi-system blunt abdominal trauma, diagnostic studies (DPL, US, CT) are frequently indicated. (See **Table 4**.)

Traditional indications for diagnostic tests include:[97]

- Suspected intraabdominal injury
- Equivocal abdominal examination
- Altered sensorium due to drugs, alcohol, or head trauma
- Distracting injury
- Spinal cord injury with abdominal anesthesia
- Unexplained hypotension.
- Multiple trauma patients who must undergo general anesthesia for orthopedic, neurosurgical, or other injuries

These criteria have not been subjected to rigorous prospective examination. Several retrospective studies suggest that repeated physical examination in the intoxicated patient with a relatively normal mental status is generally reliable. For instance, one study retrospectively examined a cohort of intoxicated but hemodynamically stable and alert patients to determine the need for abdominal testing (CT, US, or DPL) prior to emergent extraabdominal surgery. All patients had a Glasgow Coma Score (GCS) of 14 or greater and a negative abdominal physical examination. Only three intraperitoneal injuries (1.4%) were diagnosed in the study population; two were stable grade I liver injuries, and one was a missed diaphragmatic injury diagnosed the day after admission.[98]

Another retrospective investigation examined the utility of physical examination in detecting intraabdominal injury in intoxicated blunt trauma victims. All study patients had a blood alcohol level of 80 mg/dL or greater, a GCS score of 15, and an unremarkable abdominal examination. In only two patients (0.6%) did physical examination miss an injury requiring abdominal exploration. The authors found a significant association between major chest injury and abdominal injury and concluded that physical examination and attention to clinical risk factors allow accurate abdominal evaluation without CT.[99]

As both of the above-mentioned studies were retrospective, further evaluation of who needs abdominal evaluation is required.

Management Schemata

A small minority of patients undergo laparotomy based on clinical indicators alone. For the remainder, abdominal trauma can be categorized at the primary level by whether the patient is hemodynamically stable or unstable. (See Table 4.) Within these two possibilities is a second level of staging based on other urgent concerns or "special circumstances" that co-exist with the possibility of intraperitoneal pathology. (See "Clinical Pathway: Management Of Blunt Abdominal

Table 4. Diagnostic Studies In Blunt Abdominal Trauma.

Scenario	Study Purpose	Primary Study	Alternate/Compensatory
Hemodynamically unstable			
General	Intraperitoneal hemorrhage	DPL, US	—
Pelvic fracture	Intraperitoneal hemorrhage	DPL,* US	—
Hemodynamically stable			
General	Organ injury†	CT	DPL, US‡
Nonoperative management§	Organ injury	CT#	DPL,** US‡
Closed-head injury	Organ injury, hollow viscus injury	DPL,** CT#	US‡
Blunt aortic disruption	Intraperitoneal hemorrhage	DPL, US	CT‡‡

* Positive peritoneal aspirate mandates laparotomy; positive RBC count only warrants attention to pelvic fracture.

† Specific organ damage or fluid/blood suggesting injury.

‡ US for organ injury much less reliable than for intraperitoneal hemorrhage.

§ Institutional capability should be carefully considered.

CT less reliable for hollow viscus than for solid visceral injury.

** Complementary to CT if hollow viscus suspected.

‡‡ May be more appropriate if can be rapidly acquired or if CT primary study for blunt aortic disruption.

DPL: Diagnostic peritoneal lavage
US: Ultrasound
CT: Computed tomography

Trauma" on page 13.)

Hemodynamically Unstable

In the multiple blunt trauma patient in shock, three cavities—the thoracic, abdominal, and retroperitoneal—warrant immediate attention. Clinical examination and chest x-ray will identify blood in the thoracic space or suggest the presence of blunt aortic disruption. The pelvis film, if positive for significant disruption, can predict a retroperitoneal hemorrhage.

The third space, the peritoneal cavity, should be targeted by peritoneal aspiration or ultrasound in order to reveal or exclude the presence of blood. A positive study in a clinically unstable patient mandates laparotomy. *The unstable patient is not a candidate for CT scanning.*

The unstable patient with a hemoperitoneum needs to be moving—moving to the operating room or to another hospital for laparotomy (if local facilities are unavailable). While the patient is being "packaged for transport" to either of these locations, the emergency physician may treat the patient with fluids and blood.

Predictors of need for transfusion include:[46,100,101]

- Shock
- Hematocrit less than 30%
- Observed blood loss of at least 500 cc or grossly visible GI bleeding
- Emergency operation with anticipated blood loss
- Prehospital SBP less than 100 mmHg
- A base deficit more negative than -6

Hemodynamically Stable

In this circumstance, CT scanning is widely preferred as it can specify organ pathology, assess hemoperitoneum, and evaluate non-abdominal body regions. In a stable patient, positive findings on CT do not necessarily mandate laparotomy. Rather, expectant management can be accomplished in select patients with low-to-moderate grades of liver or spleen trauma. In such cases the host should be otherwise normal (e.g., absent coagulopathy), and the center should be able to provide adequate monitoring and support. The ideal candidate for CT would have normal sensorium and minor-to-intermediate severity of mechanism.

Cost-Effective Strategies For Managing Patients With Blunt Abdominal Trauma

1. Use your physical examination.

While this article has pointed out the weaknesses of physical examination, it is certainly not without value. Patients with low-to-moderate trauma mechanism can often be managed with clinical examination alone.

Risk-Management Caveat: Patients with distracting injuries, altered sensorium, and spinal cord injuries are likely to have unreliable examinations.

2. Avoid unnecessary laboratory studies.

Mandatory testing of any kind for blunt abdominal trauma is an obsolete notion, and deservedly so. Beyond that, certain tests have very limited value (e.g., serum amylase). Others add nothing to the equation. For example, in a patient with a blood pressure of 60 and a positive abdominal ultrasound, serum lactate and hepatic enzymes couldn't be more irrelevant.

Risk-Management Caveat: Certain tests in the severely injured patient are very important. These may include a type and screen or crossmatch, as well as serial hemoglobin levels. A visual examination of the urine is important in adults, as is a dipstick or microscopic examination in children.

3. Avoid unnecessary abdominal imaging.

CT is overutilized in many institutions, and a thoughtful clinical pathway, based on the respective center's resources, can curb some of the unnecessary enthusiasm.

Risk-Management Caveat: CT is a powerful tool in the right circumstances. It can grade organ injury and is an important modality in those with altered sensorium and suspicious abdominal examinations.

4. Employ ED ultrasound.

This wonderful tool can serve as an exceptional screening measure. From a strict cost (vs. charges) standpoint, abdominal ultrasounds are extremely cost-effective.

Risk-Management Caveat: Recognize the limitations of ED ultrasound. While it can detect 400 cc or more of intraperitoneal blood, it is insensitive to bowel and retroperitoneal injury and cannot reliably grade organ injury or routinely detect isolated subcapsular hematomas.

5. Document, document, document!

As with every aspect of medicine, adequate documentation keeps the plaintiff's lawyer away. Make it clear that you considered the possibility of abdominal trauma, and then clarify your thought processes, diagnostic pursuit, and disposition. A thorough initial evaluation, serial examinations, and a final comparison prior to disposition are essential. ▲

Treating pain is an important part of caring for the trauma victim. Some authorities suggest special caution when administering analgesics and sedative-hypnotics to patients being observed for intraperitoneal pathology. As there are no prospective data on the matter, these medications should be titrated to permit recognition of symptoms by the patient and signs by the care provider.

Caution should be exercised in the administration of analgesics and sedative-hypnotics to patients being observed for intraperitoneal pathology. As there are no prospective data on the matter, usage of these medications must be judicious to optimize recognition of symptoms by the patient and signs by the care provider.

There are pitfalls in expectant management. First, coincident hollow visceral injury that's not detected by CT can lead to disastrous consequences (see subsequent section).[11] Second, expectant management tends to lead to increased use of blood products. Finally, should this approach fail, the lag from injury to operation lengthens, with a resultant increase in morbidity, mortality, and the likelihood of organ resection.

The role of ultrasound in the hemodynamically stable patient is less clear. If the patient has a relatively benign abdominal examination, a normal initial ultrasound is likewise reassuring. Such a patient may be followed with serial physical examinations and possibly serial ultrasounds without the use of CT. This strategy is best suited to those who have suffered a mild-to-moderate mechanism of injury, have a normal sensorium, and who have no significant distracting injuries. The question then becomes, "Which stable patient deserves ED ultrasound?" (as opposed to simply undergoing serial physical examinations).

Suspected Bowel Injury

The patient with suspected bowel injury provides a significant diagnostic challenge. Delayed or missed diagnosis can result in considerable morbidity or mortality. In one series of patients with hollow viscus injury, delays in the diagnosis were directly responsible for almost half of the deaths. Even delays as little as eight hours result in significant morbidity and mortality.[102]

There is also great debate as to the study of choice in patients likely to have hollow viscus injury, especially those with a seat-belt sign. In one prospective study, 36% of patients with a seat-belt sign required operative intervention, most of whom had small bowel perforation. In this series, DPL was 100% sensitive for the diagnosis of intestinal perforation (5 of 5 patients), while the initial CT scan was only 33% sensitive.[30] In another study examining the prospective CT diagnosis of bowel injury, CT had a sensitivity of 64%, an accuracy of 82%, and a specificity of 97%.[103] These and other articles have led some to suggest that patients with a seat-belt sign need a study other than CT to rule out intestinal injury.

However, a recent review regarding the use of CT in

Continued on page 17

Key Concepts In Blunt Abdominal Trauma

1. Physical Examination

The accuracy of the physical examination is not perfect and is rendered less so by distracting injury, head trauma, alcohol or drug intoxication, and spinal cord injury.

2. Diagnostic Tests

The selection of major diagnostic studies for abdominal trauma should be based upon the clinical setting, the timely availability of the study, and the trustworthiness of that study in the respective center.

3. Clinical Indications for Laparotomy

These are quite helpful in penetrating trauma. However, in blunt multi-system trauma, these are less dependable and are very uncommonly the sole reason a patient proceeds to laparotomy.

4. The Unstable Patient

The critical determinant in this patient is the rapid determination of the presence or absence of hemoperitoneum. DPL is a very sensitive but invasive method of accomplishing this. Ultrasound is noninvasive and slightly less sensitive, but it can simultaneously evaluate for blood in the pericardial space.

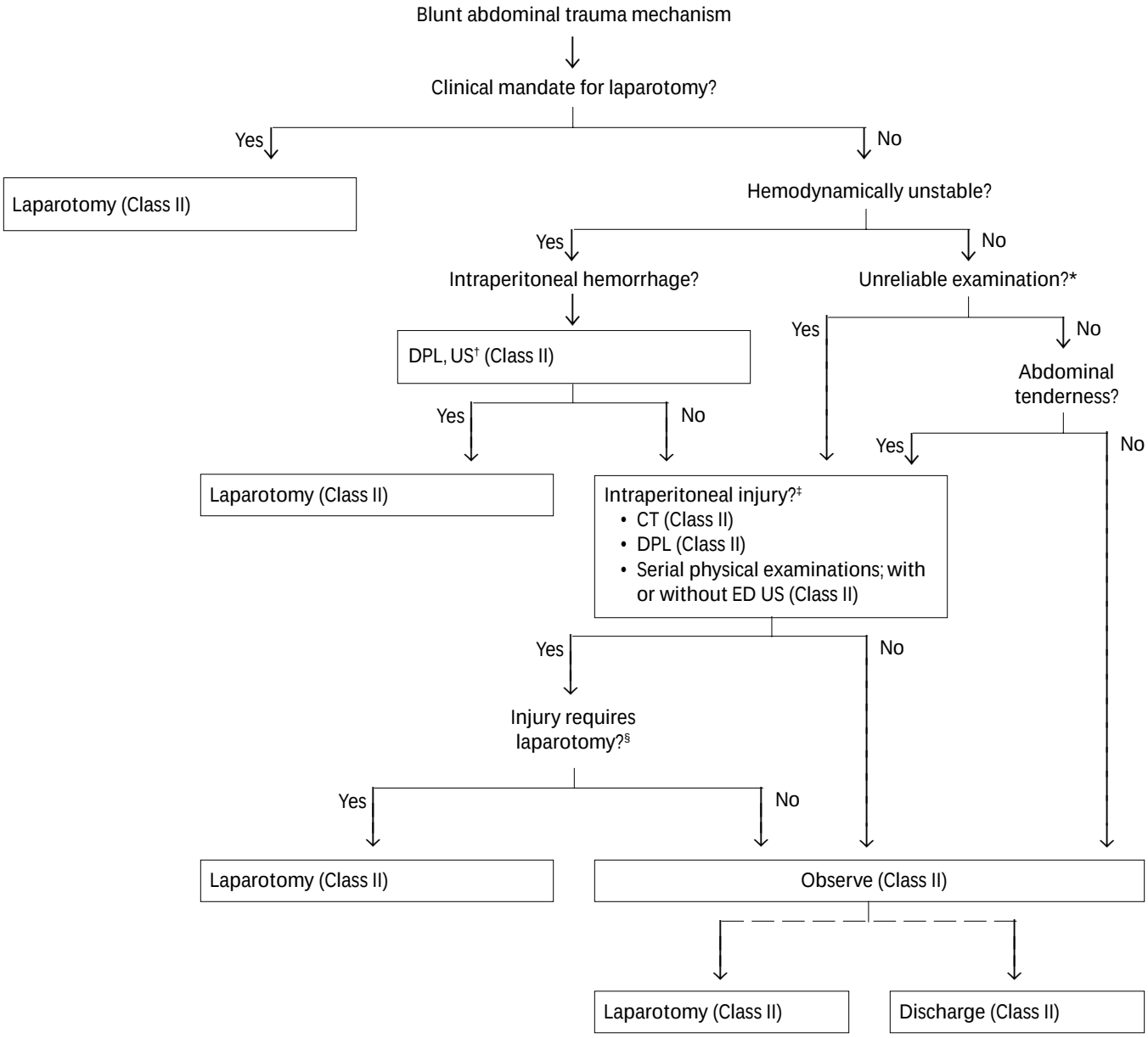
5. Pelvic Fracture

In the unstable, blunt, multi-system trauma patient with pelvic fracture, immediate ultrasound or peritoneal aspiration can determine the need for urgent laparotomy. If these studies are unequivocally negative, attention can be turned to other sources of hemorrhage, notably the pelvic vessels.

6. Special Circumstances

The preferred human qualities in managing critical blunt trauma patients are common sense and quick reflexes. An algorithm can't cover all of the permutations in the patient with some complex combination of head, chest, mediastinal, intraperitoneal, and pelvic trauma. The organ system that takes precedence is the one that is most immediately life-threatening. Then, simply do your best contending with the others until the most imminent disaster is managed. ▲

Clinical Pathway: Management Of Blunt Abdominal Trauma

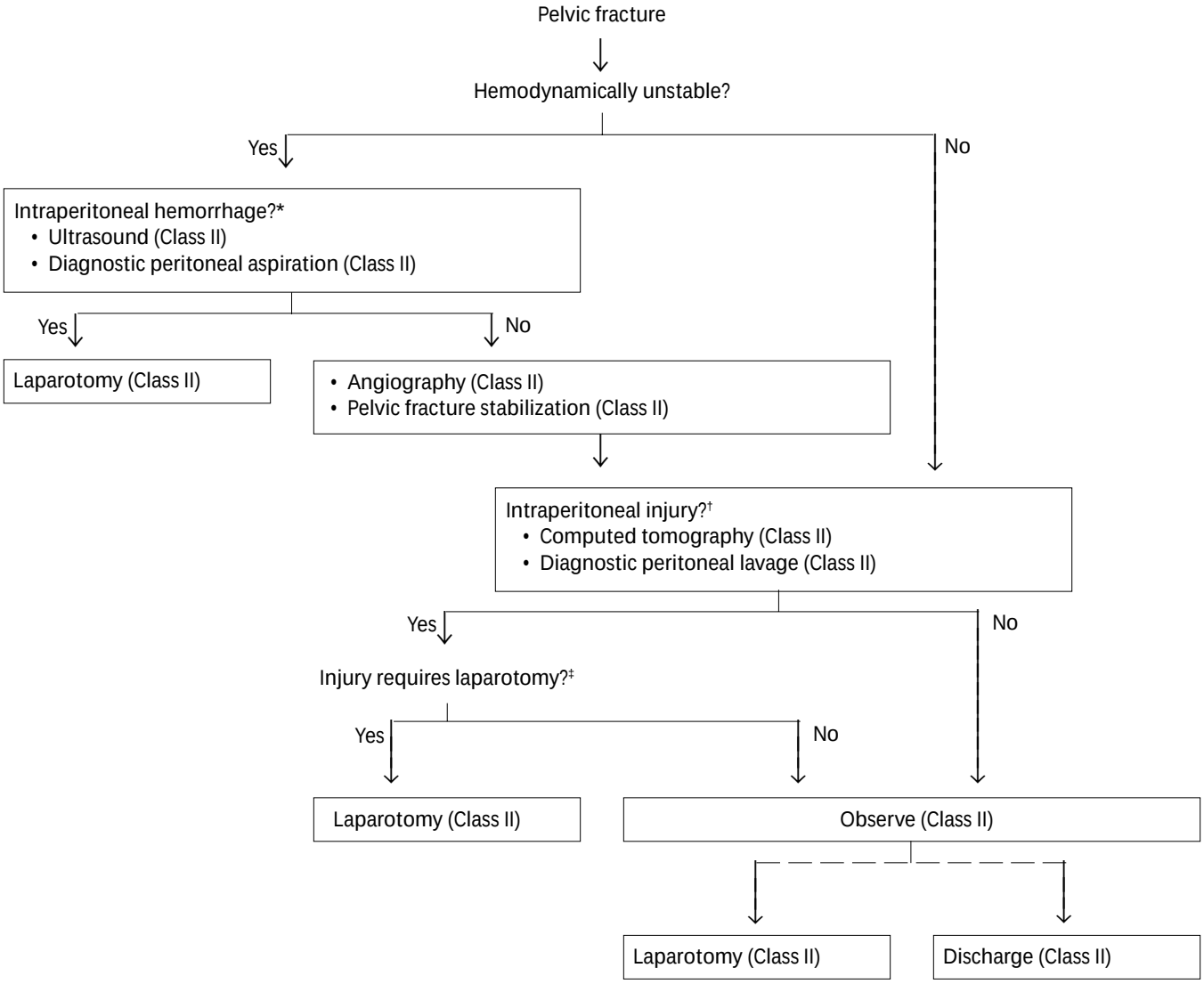


* Can be unreliable because of closed-head injury, intoxicants, distracting injury, or spinal cord injury.
† Determined by unequivocal free intraperitoneal fluid on ultrasound or positive peritoneal aspiration on DPL.
‡ One or more studies may be indicated.
§ Need for laparotomy is based on clinical scenario, diagnostic studies, and institutional resources.

The **evidence for recommendations** is graded using the following scale. For complete definitions, see back page. **Class I:** Definitely recommended. Definitive, excellent evidence provides support. **Class II:** Acceptable and useful. Good evidence provides support. **Class III:** May be acceptable, possibly useful. Fair-to-good evidence provides support. **Indeterminate:** Continuing area of research.

This clinical pathway is intended to supplement, rather than substitute, professional judgment and may be changed depending upon a patient's individual needs. Failure to comply with this pathway does not represent a breach of the standard of care.

Clinical Pathway: Management Of Combined Pelvic Fracture And Abdominal Trauma

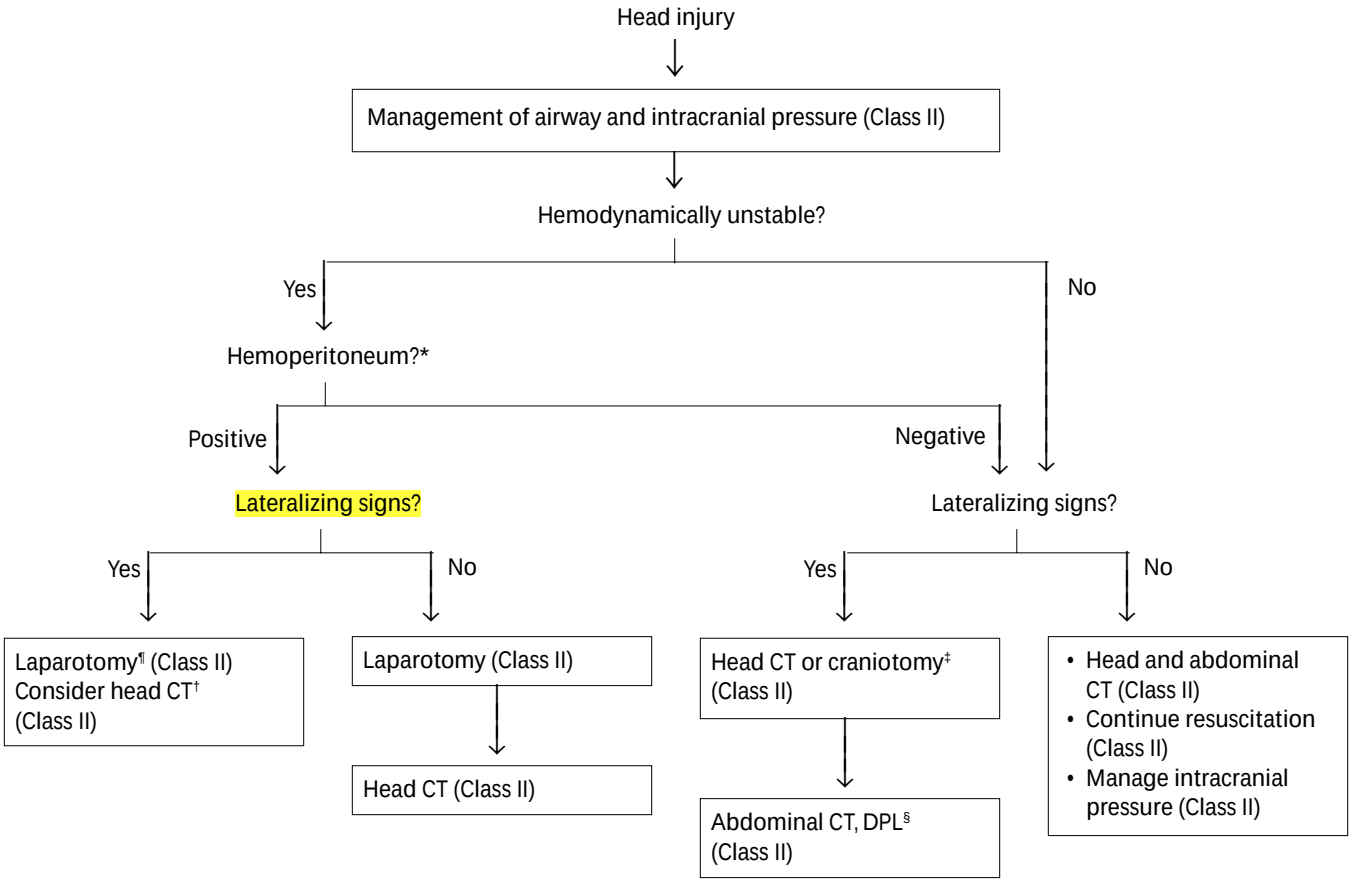


* Determined by unequivocal free intraperitoneal fluid on ultrasound or positive peritoneal aspiration on DPL.
† One or more studies may be indicated.
‡ Need for laparotomy is based on clinical scenario, diagnostic studies, and institutional resources.

The **evidence for recommendations** is graded using the following scale. For complete definitions, see back page. **Class I:** Definitely recommended. Definitive, excellent evidence provides support. **Class II:** Acceptable and useful. Good evidence provides support. **Class III:** May be acceptable, possibly useful. Fair-to-good evidence provides support. **Indeterminate:** Continuing area of research.

This clinical pathway is intended to supplement, rather than substitute, professional judgment and may be changed depending upon a patient's individual needs. Failure to comply with this pathway does not represent a breach of the standard of care.

Clinical Pathway: Management Of Combined Head And Abdominal Trauma

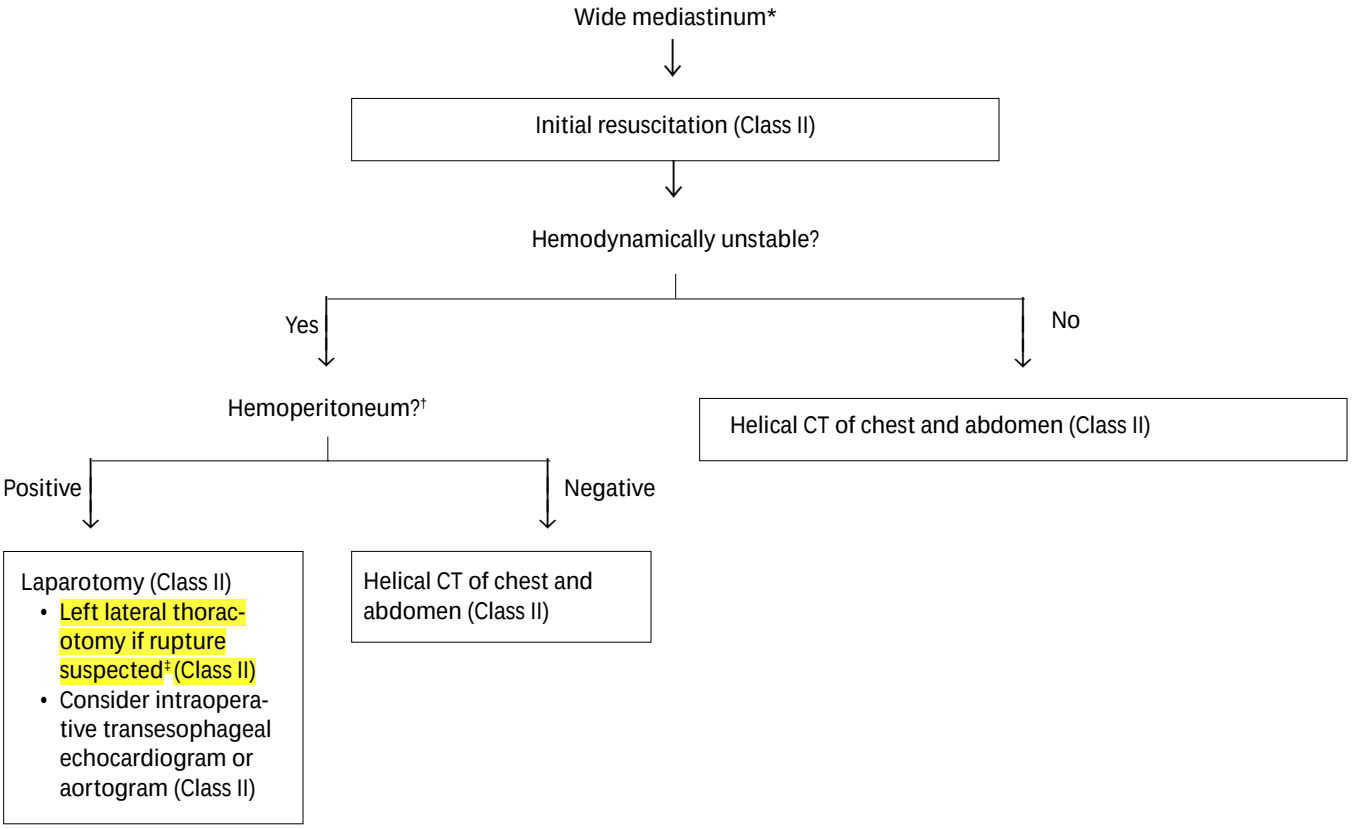


* Based on ultrasound, diagnostic peritoneal aspiration or both.
† Consider pre-LAP head CT based on clinical picture and availability of CT.
‡ Burr holes or craniotomy based on clinical picture and availability of CT.
§ DPL can be complementary to CT in determining hollow viscus injury.
¶ Consider burr holes or craniotomy simultaneous with laparotomy.

The **evidence for recommendations** is graded using the following scale. For complete definitions, see back page. **Class I:** Definitely recommended. Definitive, excellent evidence provides support. **Class II:** Acceptable and useful. Good evidence provides support. **Class III:** May be acceptable, possibly useful. Fair-to-good evidence provides support. **Indeterminate:** Continuing area of research.

This clinical pathway is intended to supplement, rather than substitute, professional judgment and may be changed depending upon a patient's individual needs. Failure to comply with this pathway does not represent a breach of the standard of care.

Clinical Pathway: Management Of Combined Wide Mediastinum And Abdominal Trauma



* Preferably based on upright PA film and mechanism of injury.
† Based on ultrasound, diagnostic peritoneal aspirate or both.
‡ Allows surgical access to majority of disruption sites.

The **evidence for recommendations** is graded using the following scale. For complete definitions, see back page. **Class I:** Definitely recommended. Definitive, excellent evidence provides support. **Class II:** Acceptable and useful. Good evidence provides support. **Class III:** May be acceptable, possibly useful. Fair-to-good evidence provides support. **Indeterminate:** Continuing area of research.

This clinical pathway is intended to supplement, rather than substitute, professional judgment and may be changed depending upon a patient's individual needs. Failure to comply with this pathway does not represent a breach of the standard of care.

Continued from page 12

this situation is more sanguine. In this review, the authors searched MEDLINE between 1980 and 1998 to evaluate the performance of DPL and CT in detecting blunt gastrointestinal tract injuries. They state that when expert interpretation is available, CT is accurate in detecting hollow viscus injury—*as long as unexplained free fluid, bowel wall thickening or enhancement, mesenteric fat streaking, and bowel dilatation are assumed to represent injury*. If the scan quality is suboptimal or expert interpretation is unavailable, the authors recommend DPL.[104]

Special Circumstances

Missed Injuries

Missed injury is common in trauma management. As many as 25% of seriously injured trauma patients have at least one injury that is overlooked during the initial evaluation.[105,106] Missed injuries are most common in patients who have altered mental status, those who are intubated, and those who need an immediate operation.[107,108]

While the most *frequently missed* injuries are orthopedic,[109-111] missed abdominal injury is far more lethal. In fact, missed intraabdominal injury is the most common preventable cause of trauma deaths.[112]

Distracting injury is so called as the patient, the physician, or both are…well…distracted. Distracting injury is one of those concepts all of us understand but none of us can quantify. However, it must be appreciated, as it is well known to cause missed abdominal as well as cervical spine pathology. In a recent prospective study, 7% of patients with no abdominal pain or tenderness but with distracting extraabdominal injury were found to have intraabdominal injury.[113]

Patients with altered mental status are also at high risk for undetected/unsuspected abdominal injury. Nearly 10% of patients suspected of "isolated" head injury may have intraabdominal pathology.[114] In a different retrospective study of comatose but normotensive trauma victims, the use of clinical signs alone resulted in more missed injuries than did using an objective test (in this study, DPL).[27] The authors suggested that all unconscious blunt trauma patients undergo objective testing of the abdomen to avoid missing life-threatening injuries.

Multi-System Injury

In patients with more than one critically injured bodily system, a rigid management algorithm does not and should not exist. In these situations, the decision-making needs to be fluid and responsive to the minute-to-minute changes of the patient.

It is correct that active and substantive intraperitoneal hemorrhage in an unstable patient demands immediate attention—specifically, life-saving laparotomy. However, a patient can have a minor splenic injury with evidence of hemorrhage on US, DPL, CT, or some combination of tests, yet other demands (such as an unstable pelvic fracture) will be greater at that point in time. Likewise, certain intraperitoneal injuries such as a perforated jejunum require operation, but a delay of at least eight hours is acceptable while more pressing concerns are addressed.

In summary, the key point is that an unstable patient with a significant hemoperitoneum must undergo laparotomy or face imminent exsanguination.

Pelvic Fracture

An unstable patient with a significant pelvic fracture and bloody peritoneal aspirate or positive US finding must proceed to emergency laparotomy. (See "Clinical Pathway: Management Of Combined Pelvic Fracture And Abdominal Trauma" on page 14.) This is due to the fact that approximately 85% of such patients will have active intraperitoneal hemorrhage at laparotomy. Some unstable patients with severe pelvic fracture will demonstrate a negative US, a negative peritoneal aspirate, or both. Barring other non-abdominal sources, the presumed origin of shock is the retroperitoneum. Therefore, the patient would then proceed to angiography for possible embolization to staunch hemorrhage.

Before proceeding to angiography, a pelvic stabilizing device is indicated to reduce pelvic volume, stabilize displaced fracture segments, and tamponade venous bleed. The PASG, vacuum splint, or even a tightly wrapped sheet about the pelvis when necessary can serve in this capacity.[16] The placement of an external fixator, typically by an orthopedist, is advised by some.[115] However, this requires a much more laborious application, and there are no prospective, randomized trials to support its use.

In a patient with pelvic fracture and apparent hemodynamic stability, a CT of the abdomen is usually warranted. If an ultrasound was performed and demonstrated some measure of fluid, CT can help decipher the need for laparotomy. If DPL effluent returns with a positive RBC count only (but a negative aspirate), CT should again be used to establish whether significant intraperitoneal injury exists, as the RBC count alone in this circumstance can be falsely positive.

Closed-Head Injury

Patients with surgically correctable injuries of both the head and the abdomen are rare, although the literature is divided regarding which injury is more common in the comatose hypotensive patient.[116,117] The presence or absence of lateralizing findings (such as a unilateral blown pupil or asymetric posturing) is key. Generally speaking, patients with severe closed-head injury but without lateralizing findings do not require craniotomy.[117] Should lateralizing features and blunt abdominal injury coexist, the clinician is faced with the choice of rapid pre-laparotomy CT scan of the head vs. preemptive burr holes in the ED or during laparotomy. (See "Clinical Pathway: Management Of Combined Head And Abdominal Trauma" on page 15.) Neurosurgeons prefer the former approach

whenever possible, but hemodynamic instability may compel the latter. The emergency physician sorting this out must measure the timeliness of CT availability, when the neurosurgeon is expected to arrive, and, most importantly, the severity and direction of hemodynamic changes.

One study suggests that patients with hemoperitoneum and lateralizing signs are candidates for emergent head CT *only if their blood pressure stabilizes with fluids or blood.*[118] However, immediate laparotomy is indicated in patients who remain hemodynamically unstable.[116]

Blunt Aortic Disruption

Potential blunt aortic disruption (BAD) presents even more controversies. (See "Clinical Pathway: Management Of Combined Wide Mediastinum And Abdominal Trauma" on page 16.) The injury itself is frequently lethal, and its time course is highly unpredictable. The delay to rupture may entail hours to days (and, rarely, weeks). The time-bomb metaphor is supremely apropos.

The usual indication for diagnostic evaluation is an abnormal chest x-ray. The chest film shows characteristic or suggestive findings in at least 93% of all patients with aortic injury.[119] Unfortunately, many chest x-rays in acute trauma are necessarily acquired in supine anteroposterior fashion, and a significant number of patients *without* aortic injury may have a wide mediastinum on the supine view.[120] An upright or reverse Trendelenburg inspiratory film is helpful if the patient can tolerate this position.

Even the pristine, upright, inspiratory PA film is imperfect in predicting presence or absence of this lesion. More accurate means of determination include helical chest CT, transesophageal echocardiography, and angiography. However, these tests take precious time.

In the relatively stable patient, there is good evidence to show that a normal *helical* (not standard) contrast-enhanced CT of the chest reliably excludes aortic injury.[121] The unstable patient with hemoperitoneum must proceed immediately to laparotomy. The patient can undergo

Ten Excuses That Don't Work In Court

1. "We thought the hypotension was caused by head injury, not abdominal trauma."

Not so—with few exceptions. First, the infant with cephalohematoma, intracranial hemorrhage, or both, can house sufficient blood in those spaces to cause hemorrhagic shock. Second, patients in the agonal phase of severe closed-head injury may demonstrate hypotension. This is simply a pre-terminal event.

2. "Hey, the abdomen was definitely soft and nontender on my exam, and even the bowel sounds were normal."

Many factors can confound the patient's ability to sense pain and the physician's skill in determining tenderness. These include distracting injury, altered sensorium, and spinal cord injury. Even in the alert patient without confounders, false-positive and false-negative examinations can still occur. When the mechanism is worrisome and the patient cannot be reliably examined and re-examined, abdominal diagnostic studies are in order. As far as the bowel sounds are concerned, that's a definite "so what."

3. "You can't perform DPL in pregnant women."

Yes, you can, but the technique may have to be modified. In the first trimester, no alteration is necessary. In the second and third trimesters, as the uterus has risen out of the protective confines of the pelvis, an open and supra-uterine technique should be utilized. The interpretation of peritoneal aspiration and DPL fluid is unchanged. Ultrasound, of course, is an acceptable alternative.

4. "The patient had a horrible pelvic fracture, and we knew external fixation and angiography were the only steps that could save him."

In some cases, that may well be true. However, when pelvic fracture is present, intraperitoneal hemorrhage is frequently present as well. The abdomen should be assessed in all cases of pelvic fracture. In the unstable patient, ultrasound or DPL is indicated to rapidly determine whether there is intraperitoneal hemorrhage. If there is significant hemoperitoneum on ultrasound or a positive aspirate on DPL (not simply a positive lavage), urgent laparotomy is indicated prior to angiography.

5. "We screened our patient with our standard measures: hematocrit, urinalysis, and chest and abdominal films. They were all normal."

Unfortnately, you did the wrong tests. The hematocrit is not used as a marker for the presence of intraperitoneal trauma. Serum amylase and lipase, and amylase isoenzymes, have very low positive predictive value for pancreaticoduodenal injury.

Plain films of the abdomen are practically of historical interest only. The discovery of free intraperitoneal injury by these can be useful, but sensitivity and specificity are so incredibly low in comparison with US, DPL, and CT that this film is not routinely obtained.

6. "Sure, the radiology department is one floor above our ED. But CT is a much better test than US."

Continued on page 19

mediastinal evaluation with transesophageal echocardiography during the operation.[122]

Angiography, once the sovereign diagnostic modality in aortic injuries, is now relegated to a subordinate role in many trauma centers.[123,124]

Special Populations

Pediatrics

As with adults, motor vehicle crashes cause most of the morbidity and mortality in cases of pediatric trauma; auto/pedestrian accidents and falls out of cars represent a large subset of these. Handle-bar injuries and lap-belt-only restraints are much more likely to be seen in children and can lead to pancreaticoduodenal and small bowel injury.[21] Child abuse is both common and terribly harmful. Abdominal injuries are second only to head injuries as a cause of death in abused children.

A child's abdomen has poorly developed musculature and a relatively small anteroposterior diameter. These facts amplify the vulnerability of intraperitoneal organs to compressive forces. The rib cage is very compliant in children, and while less prone to fractures, it provides limited protection against upper quadrant solid visceral injury. Solid organ injuries predominate in children and are responsible for two-thirds to 90% of intraperitoneal pathology.

As in adults, most hematologic and serum chemical studies do not have adequate positive or negative predictive value to warrant their routine use.[125] *Perhaps the most valuable lab test for intraabdominal injury in children is the urinalysis.* In one retrospective study of 285 injured children, the physical examination combined with urinalysis showing more than 5 RBC/hpf had a sensitivity of 100%, and a specificity of 64% in detecting intraabdominal injury.[125]

Microscopic hematuria portends a reasonable likelihood of injury to the liver, spleen, or kidneys. It may also be a reflection of a previously unknown coagulopathy or intraabdominal anomaly (e.g., Wilms' tumor). The threshold at which consideration should be given to further diagnostics, notably CT, varies from

Ten Excuses That Don't Work In Court (continued)

The statement that CT is superior to US for definition of intraperitoneal organ injury is absolutely correct. Unfortunately, the patient in this case was hemodynamically unstable, a direct result of a grade IV splenic injury. When patients present to the ED in shock, a test that can quickly visualize peritoneal blood allows timely triage to the operating room. DPL or US serves this function well; CT does not. Unstable patients should rarely be removed from the safety of the ED.

7. "The patient had a bad head injury, and we needed a head CT right away."

Sure, there is a natural compulsion to get head-injured patients to CT. But first, the abdominal cavity must be considered. If the patient is hemodynamically unstable, DPL or US should be undertaken immediately in order to determine the likelihood of intraperitoneal bleeding. The patient in this case had no localized findings on neurologic examination; therefore, the chance of an operative lesion was extremely low. Besides, you can't save a patient from a head injury if she dies from intraperitoneal hemorrhage first.

8. "Okay, there was a seat-belt mark, but the examination was otherwise just fine."

A low-lying transverse abdominal ecchymosis has a strong association with hollow viscus injury. In turn, hollow viscus injury often does not produce any pain or tenderness until 6-8 hours following the traumatic event. At a bare minimum, patients with lap-belt contusions should undergo serial abdominal examinations over this time course. Findings of abdominal tenderness should prompt diagnostic study (e.g., abdominal CT) or laparotomy.

9. "It was just an isolated head injury. His pulse and blood pressure were fine, and his abdomen was not distended."

Physical examination (including vital signs) cannot rule out abdominal injury in the comatose patient. If you wait for the abdomen to distend from blood loss, it's time to call the coroner, not the surgeon.

10. "The orthopedist had a full schedule in the morning, and it was getting close to 2 a.m."

Consequently, the orthopedist absconded with this multisystem injured and profoundly intoxicated patient to the OR for a washout of a matching pair of open tib-fib fractures. No abdominal studies were undertaken, and the small pneumothorax was unknown to the ortho operating team. In the OR, the combination of tension pneumothorax induced by intubation and positive-pressure ventilation plus the grade III liver injury led to a patient who was hard to bag and a pulse that was impossible to palpate.

Practically any consultant, including the orthopedist in this scenario, will have blinders on. They typically see a general trauma patient from the perspective of their single discipline—in this case, a large bone. The emergency physician, together with the trauma or general surgeon, should orchestrate the resuscitation and determine the disposition. ▲

20-50 RBC/hpf.[126]

The important diagnostic tests used in adults with abdominal trauma (CT, US, and DPL) have somewhat different roles in children. Ultrasound has been found to have comparable ability to screen for intraperitoneal hemorrhage as in adults.[127,128]

However, DPL is used differently in the injured child. It has an important role in the hypotensive child with multi-system blunt trauma in whom US is unavailable or equivocal. However, children with stable hemodynamics and hemoglobin who have blood discovered in their abdomen are much more likely to be managed without laparotomy than adults. Therefore, DPL is generally not indicated if the child can be stabilized with blood and fluids.

CT, with its ability to discern specific organ pathology both in the peritoneal and retroperitoneal spaces, remains a mainstay diagnostic test. The important caveat that applies to CT in adults applies to children as well; false-negative rates for hollow visceral and pancreatic injury are substantial, at 26% and 15%, respectively.[129,130]

Some authors believe that serial physical examinations are more important than CT in the diagnosis of pediatric bowel injury. In one retrospective study, all children with major intestinal injury had suggestive signs on presentation or shortly thereafter.[131] These signs included seat-belt ecchymoses or diffuse abdominal tenderness. The abdominal CT was insensitive in making the diagnosis and detected only one in 13 bowel injuries. Another study confirmed that the initial and serial physical examinations are more reliable than diagnostic testing in children with small bowel injuries.[132]

Geriatrics

The diagnostic approach to the elderly patient is unchanged. However, it is critical to bear two facts in mind. These patients are far more likely to have significant comorbid disease and to be on medications that alter their presentation, including vital signs, as well as their ability to tolerate these injuries. In addition, this group has increased morbidity and mortality for virtually any injury sustained when compared with younger cohorts.[133] As such, management and disposition decisions should lean well toward the conservative end of the spectrum. At least one study suggests that an elevated base deficit (more negative than -6) during the first hour of care can help predict severe injury or death in the elderly trauma victim.[134]

Pregnancy

Trauma is frequent during pregnancy. Women are more subject to falls after 20 weeks of gestation compared with nonpregnant patients, and the incidence of physical abuse is 4%-17% during pregnancy.[135]

Certain physiologic changes affect the approach to abdominal trauma. The systolic and diastolic blood pressures decline 2-4 mmHg and 5-15 mmHg, respectively, in the first and second trimester and then normalize in the third trimester; in addition, an increase in pulse of 10-15 bpm can be anticipated throughout. The clinical diagnosis of shock is impaired during pregnancy due to the significant cardiovascular changes. A pregnant woman may lose 30%-35% of her blood volume—1.5 liters—prior to demonstrating any physiologic signs of shock.[136] In addition, stretching of the peritoneum decreases the ability of the physician to detect hemoperitoneum. In an early series, 50% of pregnant women with massive hemoperitoneum had no peritoneal signs.[137]

The management of shock also changes in pregnancy. The "supine hypotensive syndrome" may occur after 20 weeks' gestation. This syndrome is caused by uterine pressure on the inferior vena cava, resulting in a drop in cardiac output of up to 28% and systolic blood pressure of 30 mmHg.[138] One of the first interventions by prehospital care providers and ED personnel alike is to "unload" the vena cava by pushing the uterus to the left. Alternatively, towels placed under the right side of a backboard will cause the uterus to fall to the side, accomplishing the same purpose.

The three primary diagnostic agents can be utilized throughout pregnancy, with certain precautions. Ultrasound is presumed safe and accurate in this setting, but a large, prospective trial has not yet been conducted. With regard to CT, the fetus is most vulnerable to radiation while it is from 2-7 weeks' gestational age. A modified abdominal CT limited to the areas above the uterus (basically the liver and spleen) incurs a safe dosage of less than 3 rads to the fetus. Including the pelvis in the scan generates an undesirable 3-9 rads. However, spiral CT reduces fetal radiation exposure 14%-30%.[139] DPL is known to be accurate in pregnancy[137,140] but should be performed by the open supraumbilical technique after the first trimester.[86] Cut-off values for DPL effluent are identical to those of nonpregnant patients.

Maternal resuscitation is the prevailing tenet, and indications for abdominal laparotomy are unchanged. One disposition matter is key. Patients beyond 20 weeks' gestation (i.e., in whom the fetus is viable) who sustain torso trauma of any magnitude and who appear otherwise well should undergo at least four hours of fetal monitoring. This allows early detection of placental abruption, a complication of even trivial trauma.[141]

Alcoholic Patients

"Bacchus has drowned more men than Neptune."
—Thomas Fuller[38]

Both acute and chronic alcohol usage increase the risk of abdominal trauma. From a physiologic perspective, alcoholics tend to have a lax abdominal wall and therefore incur greater morbidity from anterior-posterior compressive and burst forces.[142] Alcoholic

hepatitis and cirrhotic liver disease lead to an enlarged liver and congested spleen, respectively. As such, these are afforded less protection by the rib cage, and their increased intracapsular pressure decreases their resistance to blunt forces. Pancreatic pseudocysts are also subject to rupture from blunt trauma.[143] Finally, chronic alcoholism may result in coagulopathy with resultant exacerbated hemorrhage and complicated management.

The clinical examination and major diagnostic procedures can all be affected by acute and chronic intoxication. In a recent series, intoxicated patients were nearly five times more likely to have an unsuspected injury than patients who had a negative blood alcohol level.[144] If the patient's mental status is impaired by acute intoxication or hepatic encephalopathy, the ability of the patient and the examiner to appreciate intraperitoneal and retroperitoneal manifestation is impaired. Ascites can create difficulties in the interpretation of DPL, CT, and US. If coagulopathy is present or suspected, some authorities suggest that DPL should be performed by the semi-open or fully open technique with careful attention to hemostasis. Portal hypertension in the chronic alcoholic can lead to engorgement of umbilical veins that pose additional hazard to the performance of DPL, particularly if percutaneous. Combativeness obviously is problematic for any of the procedures, but appropriate administration of butyrophenones should place the patient (and thus the treating physician) in a much better mood.

Acutely intoxicated patients with suspected minimal trauma can be observed or committed to one or more of the diagnostic tests. This is a clinical decision that rests with the understanding of the mechanism, the clinical circumstances of the patient, and the institutional resources. For example, a very busy ED with limited personnel should move more quickly toward definitive diagnostics rather than serial observations. Finally, in patients with known intraperitoneal injury as determined particularly by CT, expectant management (i.e., the deliberate observation of a patient in whom laparotomy may be unnecessary) is more hazardous than in the nonalcoholic patient.[145]

Disposition

Three central issues face the emergency physician: consultation, transfer, and discharge home.

Consultation

Consultation should be made as soon as the need is apparent. This can be based on the paramedic report from the scene or one glance at the patient being wheeled by stretcher through the doors of the ED. The purpose of consultation is, in turn, twofold.

Need For Operation

This is the easy one. Consultation is made as soon as there is strong suspicion or knowledge that laparotomy is necessary. The tricky part is knowing whom to call. In a trauma center, there is rarely debate, as a trauma surgeon is on call and usually in-house. At the other end of the spectrum is the community hospital that has no trauma designation and limited commitment to trauma. Here, the call should go to the general surgeon, who should respond in a timely manner. Unfortunately, the willingness and expertise (or lack thereof) of this consultant can vary. Obviously, hospital and inter-related departments need to acknowledge these scenarios and be proactive instead of simply reactive.

Need For Evaluation

For the obviously and seriously injured trauma patient, an immediate consult to the trauma or general surgeon allows the team to evaluate, then expedite care. It's right for the emergency physician, the surgeon, and the patient.

The approach to the relatively stable patient varies among and within hospitals. Optimally, the emergency medicine, surgical, sub-surgical, and radiology groups will have convened and agreed upon diagnostic and management algorithms. Otherwise, the number of permutations in management is enormous.

Admission practices vary widely among hospitals. Many authorities favor admitting multiple trauma patients with, for example, orthopedic concerns to the trauma or general surgeon with consultation by the orthopedist and not vice versa—at least for the first 24-48 hours of care. This basic principle applies to the pregnant, pediatric, and geriatric patients as well. However, no prospective studies have evaluated this approach.

Transfer

The patient must be transferred if the base hospital is incapable of providing adequate care. The missing ingredient(s) may include a diagnostic test, operating room, surgical staff, surgeon, monitored bed, or specialist. Once it becomes clear that transfer is needed, delay in transfer should be strictly avoided. In general, diagnostic studies—particularly those that are time-consuming—should be undertaken at the receiving hospital, unless that test is integral to determining the need for transfer in the first place.

The transfer itself should abide by EMTALA regulations. The mode of transfer and the type of personnel involved rest with the patient's clinical status, available resources, weather conditions, traffic patterns, and the like.

One thorny issue that may arise in smaller hospitals relates to the hypotensive patient with probable intraabdominal bleeding. Such patients may not survive the transfer to a higher level of care. In such cases, it is useful to consult the local surgeon regarding the possibility of "damage-control" laparotomy. In such a case, the local surgeon would perform an emergent laparotomy with the sole purpose of staunching life-threatening hemorrhage. When the

bleeding is controlled, the patient may then be transferred (even with an open abdomen with packs in place) to the trauma center.[146,147]

If damage-control surgery is an option, then the emergency physician may elect to perform a DPL or US on such unstable blunt trauma patients early in the course of evaluation.

Discharge Home

Certain patients—notably, those with single-system trauma and stable vital signs—can be discharged home after a period of observation with or without US, DPL, CT, or some combination thereof. These patients can be sent home only if their mental status, vital signs, and host status (immune, coagulation) are at or close to baseline and their social support systems competent. The emergency physician must be very cautious for those at increased risk for delayed presentation or worsening, such as the patient with mechanism (e.g., spearing, as in our young friend with the handlebar injury) or clinical features (e.g., seat-belt mark) consistent with hollow viscus injury. In these situations or for patients with persistent abdominal tenderness following serial observation, it is far wiser to consult the trauma surgeon and proceed with further observation or studies.

For patients with a negative CT, conservative pundits argue that 12-24 hours of in-hospital observation is mandatory. This is to enable discovery of late presenting injury, particularly bowel disruption missed by CT, as well as allow the opportunity for CT overread by the institution's expert the following morning. However, one recent observational study of 2299 blunt trauma patients demonstrated that a normal abdominal CT scan ruled out significant injury in 99.63% of patients. In this series, there were only six therapeutic laparotomies in patients with an initially normal CT scan (intestine in three, bladder in one, kidney in one, and diaphragm in one). The authors concluded that most patients with a negative CT scan after suspected blunt abdominal trauma do not require either hospital admission or prolonged observation.[24]

The approach to discharging a patient with a normal abdominal CT and no other significant injuries is best individualized according to the center and the patient. Consider the resources available to the patient and his or her ability to recognize clinical worsening and then return should it occur.

Summary

The recipe for successful abdominal trauma management calls for just a few main ingredients. First, the prospect of the existence of abdominal pathology must be considered. When that suspicion has arisen, appropriate diagnostic studies, clinical observation, or both should identify those with abdominal injury in reasonably short order. For injuries that may be missed because of insensitivity of the physical examination and inaccuracy of the diagnostic study, further observation or testing is warranted. Patients whose medical needs can't be met should be delivered to regional centers for care as quickly as possibly. Finally, close cooperation with trauma-related services and administrators encourages good outcomes and efficient resource utilization. ▲

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Evidence-based medicine requires a critical appraisal of the literature based upon study methodology and number of subjects. Not all references are equally robust. The findings of a large, prospective, randomized, and blinded trial should carry more weight than a case report.

To help the reader judge the strength of each reference, pertinent information about the study, such as the type of study and the number of patients in the study, will be included in bold type following the reference, where available. In addition, the most informative references cited in the paper, as determined by the authors, will be noted by an asterisk (*) next to the number of the reference.

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Physician CME Questions

65. In patients with known pelvic fracture, DPL should be performed by which one of the following?
a. Seldinger technique infraumbilically
b. Seldinger technique supraumbilically
c. Fully open technique infraumbilically
d. Fully open technique supraumbilically

66. A multiple blunt trauma patient has blood pressure of 70, severe closed-head injury (GCS 6, non-localizing neurologic examination), a negative AP pelvis film, and greater than 10 cc gross blood by DPL. He is most likely to have:
a. an epidural hematoma.
b. an intraventricular bleed.
c. a grade III liver laceration.
d. significant retroperitoneal hemorrhage.

67. "Spearing" mechanism to the mid-abdomen is likely to result in:
a. splenic fracture.
b. retroperitoneal hematoma.
c. perforated ileum.
d. myocardial contusion.

68. The pneumatic antishock garment (PASG) has been proven to:
a. diminish mortality in penetrating trauma patients.
b. diminish mortality in blunt trauma patients.
c. decrease systemic vascular resistance.
d. decrease retroperitoneal hemorrhage in certain pelvic fractures.

69. A motor vehicle crash victim presents to the ED with a blood pressure of 118/70, pulse of 92, upper chest abrasions, and bilateral open tib-fib fractures. He smells of alcohol but is clinically sober. Under what circumstances should the patient undergo ultrasound prior to going to the OR for washout of the fractures?
a. No matter what
b. If the abdomen is tender to examination
c. Only if the hemoglobin is less than 12 gm/dL
d. Only if the serum ETOH is greater than 100 mg/dL

70. CT has less sensitivity for the detection of which pair of the following?
a. Large bowel, liver
b. Small bowel, pancreas
c. Kidney, pancreas
d. Kidney, liver

71. A pedestrian struck by a car presents with a blood pressure of 60, pulse of 124, 400 cc in a right chest tube, and a right femur fracture. Because of hypotension, he should next undergo which one of the following?
a. Abdominal laparotomy
b. Abdominal CT
c. DPL
d. Serial abdominal examinations

72. A patient falls out of a two-story window, lands on his buttocks, and sustains a pelvic fracture. His blood pressure at the scene is 100 mmHg, and in the ED after 500 cc normal saline it is 120 with a pulse of 100. The aspiration portion of DPL is negative, but the RBC count of the recovered effluent is 100,000 RBC/hpf. He should now undergo:
a. abdominal laparotomy.
b. abdominal ultrasound.
c. abdominal CT.
d. pelvic angiography.

73. A pedestrian struck by a car presents with a blood pressure of 80, pulse of 110, a moderately wide mediastinum without hemothorax on an anteroposterior film, and a positive FAST for intraperitoneal fluid. The next step for this patient should be:
a. PA upright chest film.
b. abdominal CT.
c. thoracotomy.
d. laparotomy.

74. Regarding diagnostic studies in pediatric blunt abdominal trauma patients, which one of the following is *false*?
a. Ultrasound has excellent ability to determine the presence of hemoperitoneum.
b. CT is the procedure of choice for nonoperative management.
c. DPL is useful in hemodynamically unstable patients.
d. Serum amylase and liver function tests are effective screens for intraabdominal injury.

75. Which of the following should be absolutely avoided in the third-trimester blunt trauma patient?
a. Abdominal ultrasound
b. Infraumbilical Seldinger technique DPL
c. Upper abdominal CT
d. Abdominal helical CT

76. A 26-week-pregnant 21-year-old presents after falling down three steps. Her examination is entirely normal, including ultrasound that demonstrates a fetal heart rate of 130 and no intraperitoneal fluid. The correct disposition for her is:
a. helical abdominal CT.
b. fetal monitoring for four hours.
c. fetal monitoring every 24 hours.
d. discharge home.

77. Which of the following is true regarding isolated small bowel injury?
a. Clinical signs are often delayed by more than six hours.
b. DPL red cell threshold of 100,000 is usually exceeded.
c. Ultrasound is usually grossly positive.
d. Plain film always demonstrates free air.

78. A 10-year-old child presents with abdominal pain after being tackled in a football game. His examination, including vital signs, is unremarkable. His hemoglobin is 13.4 and UA reveals 50 RBC/hpf. He should now receive:
a. IVP.
b. abdominal CT.
c. abdominal ultrasound.
d. follow-up with his pediatrician.

79. What measure of pulse change (bpm) can be expected throughout pregnancy?

a. Increase of 10-15
b. Increase of 20-30
c. Decrease of 10-15
d. Decrease of 20-30

80. When compared with the normal patient, which of the following regarding the chronic alcoholic blunt abdominal patient is true?

a. Intraperitoneal solid organ injury is less likely following compressive forces.
b. Intraperitoneal hollow viscus injury is less likely following "spearing" mechanism.
c. Expectant management of known intraperitoneal injury is more successful.
d. Mortality is greater for comparable levels of intraperitoneal injury.

Class Of Evidence Definitions

Each action in the clinical pathways section of *Emergency Medicine Practice* receives an alpha-numerical score based on the following definitions.

Class I
- Always acceptable, safe
- Definitely useful
- Proven in both efficacy and effectiveness

Level of Evidence:
- One or more large prospective studies are present (with rare exceptions)
- High-quality meta-analyses
- Study results consistently positive and compelling

Class II
- Safe, acceptable
- Probably useful

Level of Evidence:
- Generally higher levels of evidence
- Non-randomized or retrospective studies: historic, cohort, or case-control studies
- Less robust RCTs
- Results consistently positive

Class III
- May be acceptable
- Possibly useful
- Considered optional or alternative treatments

Level of Evidence:
- Generally lower or intermediate levels of evidence
- Case series, animal studies, consensus panels
- Occasionally positive results

Indeterminate
- Continuing area of research
- No recommendations until further research

Level of Evidence:
- Evidence not available
- Higher studies in progress
- Results inconsistent, contradictory
- Results not compelling

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