# INTRODUCTION

Blunt abdominal trauma (BAT) is seen with increasing frequency in emergency rooms and continues to be associated with significant morbidity and mortality in spite of its improved recognition, diagnosis, and management.[1] The care of the trauma patient is demanding and requires speed and efficiency. Evaluating patients who have sustained blunt abdominal trauma remains one of the most challenging and resource-intensive aspects of acute trauma care.[2]

The management of patients with multiple traumas remains one of the mainstays of emergency medicine practice. Emergency physicians play a vital role in the stabilization and diagnostic phases of trauma care. Management of these patients involves complex, time-dependent decision-making, leadership capability, and technical skill. Proper resuscitation can lead to functional outcomes, even in severely injured patients.[3]

Often the emergency physician is the sole physician in attendance during the initial phase of resuscitation; what happens in this period often determines the outcome of care.[4]

Trauma is mechanical damage to the body caused by an external force**.** The trauma patient has been defined as "an injured person who requires timely diagnosis and treatment of actual or potential injuries by a multidisciplinary team of health care professionals, supported by the appropriate resources, to diminish or eliminate the risk of death or permanent disability.[5]

Blunt force trauma: Injuries resulting from an impact with a dull, firm surface or an object. Blunt force trauma may cause contusions, lacerations of the internal organs and soft tissues, as well as fractures and dislocations of bony structures. [6]

## Incidence and epidemiology:

The incidence of abdominal trauma increases each year. Blunt abdominal trauma generally leads to higher mortality rates than penetrating wounds & presents greater problems in diagnosis. [7]

Injury to the abdomen is a common occurrence in everyday practice worldwide in both military and civilian practice.[8] Abdominal trauma is an important issue as it represents leading cause of death in different age group.[9] It is one of the most common causes of preventable, trauma-related deaths.[10]

Abdomen is the third most common injured region with injuries requiring surgery in about 25% of civilian trauma victims.[7] Despite these developments, a small number of patients with catastrophic intra-abdominal injuries will continue to require immediate and skilled surgical intervention combined with expert resuscitation. [11]

## Morbidity and mortality:

Abdominal trauma is a major cause of death. Nearly 40% of deaths from abdominal trauma are due to blunt trauma caused primarily by motor vehicle accidents.[12] In these circumstances, abdominal trauma is often associated with head, chest, and extremity

injury. There is high mortality rate associated with multiple abdominal organ injuries than with single organ injuries. [13]

Missed intra-abdominal injuries and concealed hemorrhage are frequent causes of increased morbidity and mortality, especially in patients who survive the initial phase after an injury. [14]

# Blunt Abdominal Trauma

Blunt abdominal trauma is a leading cause of morbidity and mortality among all age groups. Identification of serious intra-abdominal pathology is often challenging. Many injuries may not manifest during the initial assessment and treatment period. Mechanisms of injury often result in other associated injuries that may divert the physician's attention from potentially life-threatening intra-abdominal pathology.[15]

## Mechanism of injury:

Trauma is defined as injury that occurs to human tissues or organs when mechanical energy is transferred from the environment. Actual injury only occurs when this transfer of energy is beyond the body's resilience.[13]Injury to intra-abdominal structures can be classified into 2 primary mechanisms of injury–compression forces and deceleration forces:[8, 16]

- Compression or concussive forces may result from direct blows or external compression against a fixed object (e.g., lap belt, spinal column). Most commonly, these crushing forces cause tears and sub capsular hematomas to the solid viscera. These forces also may deform hollow organs and transiently increase intraluminal pressure, resulting in rupture. This transient pressure increase is a common mechanism of blunt trauma to the small bowel.

- Deceleration forces cause stretching and linear shearing between relatively fixed and free objects. These longitudinal shearing forces tend to rupture supporting structures at the junction between free and fixed segments. Classic deceleration injuries include hepatic tear along the ligamentum teres and intimal injuries to the renal arteries. As bowel loops travel from their mesenteric attachments, thrombosis and mesenteric tears, with resultant splanchnic vessel injuries can result.

- Liver and spleen injuries commonly occur in both head-on lateral impact collisions.

- Falls, assaults and sporting incidents also produce a large number of blunt injuries.

- Motorcyclists that have been ejected from their bike frequently sustain pelvic fractures and intraabdominal trauma.

- The lap portion of the seat belts frequently causes injury to hollow organs particularly small, colon and abdominal wall. [13]

- Serious, devastating intra-abdominal injuries may be present despite the absence of external signs of trauma. This understanding underscores the importance of a complete evaluation in patients suffering high-energy trauma (Table 1).[17]

**Table 1. High-energy trauma** [17]

| |
|---|
| • Ejection from a vehicle |
| • Motor vehicle crash at speeds exceeding 45 miles/h |
| • Motorbike accident |
| • Major fracture of long bones or pelvis |
| • First rib fracture |
| • Lower costal rib fracture |
| • Seat belt restraint mark |

## Frequency

Blunt abdominal trauma are present in about 25-30% of multiple injured patients and represent the most common type of abdominal injuries. [18]

Falls from height of less than 5 meters are the leading cause of injury, and automobile crashes are the next most frequent cause. These data reflect all injuries, not just blunt injuries to the abdomen. [13]

## Anatomy Review [19, 20]

The abdominal cavity, which extends from the diaphragm down to the pelvis, is divided into 4 anatomical areas:

The first area: is the intrathoracic abdomen, which is the portion of the upper abdomen that lies beneath the rib cage. Its contents include the diaphragm, liver, spleen and stomach. The rib cage makes this area inaccessible for palpation and complete examination. Due to the height of the diaphragm during exhalation, all injuries below the level of the nipple line should be suspected to be an abdominal injury until proven otherwise. Spleen and liver injuries are the most common organs involved.

The second area: is the pelvic abdomen, which is defined by the bony pelvis. Its contents include the urinary bladder, urethra, rectum, small intestine and in females, the ovaries, fallopian tubes and uterus. Injury to these structures may be extraperitoneal in nature and therefore difficult to diagnose, Tenderness of this area may indicate pelvic organ injuries.

The third area: is retroperitoneal abdomen, which contains the kidneys, ureters, pancreas, aorta and vena cava. Injuries to these structures are very difficult to diagnose based on angiography, and an intravenous pyelogram.

The fourth area: is the true abdomen, which contains the small and large intestines, the uterus (if gravid), and the bladder (if distended). Perforation of these organs is associated with associated significant physical findings and usually manifest with pain and tenderness from peritonitis.

# Assessment of Blunt Abdominal Trauma

## (1) Initial Assessment

Historical data, while often lacking, may provide invaluable information to the emergency practitioner when evaluating a patient with abdominal trauma. If the patient was involved in a motor vehicle collusion MVC, information regarding fatalities at the scene, vehicle type and velocity, roll over, intrusion, steering wheel deformity, use of seatbelts and air bags, and the patient's location within the vehicle offer guidance in management. [21-23]

## (2) Physical Examination

While some studies cite physical examination as only 55% to 65% sensitive for diagnosing injury in those sustaining BAT, it is still the cornerstone for primary assessment.[24]

Patients with BAT may present to the Emergency Department ED anywhere on the spectrum from normotensive and alert to obtunded and in shock. Careful attention to physical findings helps drive decision making and proper sequencing of diagnostic tests.

Hypotension after BAT typically results from visceral organ injury and hemorrhage, usually of the spleen.[1] These patients need emergent evaluation of the peritoneal cavity, and coincident appraisal of any extra-abdominal injury creating hemorrhage or hemodynamic instability, such as long bone fracture, scalp laceration, hemothorax, pneumothorax, or, in infants, severe head injury.[25]

In awake hemodynamically stable patients with isolated BAT, abdominal pain, tenderness, and peritoneal signs are the most reliable findings for intra-abdominal injury and can be found in up to 90% of those with injury. However, several studies demonstrate that even in these patients, significant injury may be missed with physical exam alone. Therefore, absence of physical findings does not preclude injury and the need for further observation and diagnostic testing.[26, 27]

Other circumstances in which the physical examination is unreliable include alcohol or drug intoxication, spinal cord injury, pregnancy, Glasgow coma score GCS <10, and multiple extraabdominal injuries.[17]

When extra-abdominal injuries are present, suspicion for concomitant intra-abdominal injury is paramount. Up to 10 % of those with closed head injury, and 7% of those with a distracting extremity injury, will have an abdominal injury even with no signs or symptoms of abdominal trauma.[28, 29] Pleuritic left costal margin pain may indicate underlying splenic injury.[30] Ecchymosis across the lower abdomen, a ''seatbelt sign,'' portends intra-abdominal injury in up to one third of patients.[31]

Some recent studies suggest that in awake, hemodynamically stable adult patients who are going to the operating room for extra-abdominal injuries, physical exam will exclude most intra-abdominal injuries requiring immediate operative intervention. [32-34]

## (3) Laboratory Investigations

Most hematologic and blood chemistries serve only as adjuvants in the management of patients with abdominal trauma.[8]

**Complete Blood Count (CBC):**

A baseline hemoglobin and hematocrit may be useful, but rarely will alter emergent management. [8] Blood typing should routinely be sent for any patient with abdominal trauma and signs of hemorrhage or potential need for transfusion.[35, 36]

**Coagulation Profile:**

Routine prothrombin time (PT)/activated partial thormboplastin time (aPTT) determination upon admission is warranted. Obtain PT/aPTT in patients, who have a history of blood dyscrasias (e.g. himophilia), who have synthetic problems (e.g. cirrhosis), or who take anticoagulant medications (e.g.warfarin or heparin). [37]

**Complete urine analysis:**

Urinalysis with detection of hematuria (both gross and microscopic) indicates renal injury, and coupled with abdominal tenderness predicts intra-abdominal injury following BAT with 65% sensitivity and 94% specificity.[38, 39]

Toxicologic studies have little value in the acute management of abdominal trauma, unless there is unexplainedaltered mental status.[40]

## (4) Imaging & Diagnostic Procedures

Diagnostic imaging plays a key role in the management of patients after poly-trauma and has considerable impact on therapeutic decision making. The information generated by diagnostic imaging procedures not only serves to tailor therapy to individual needs of the patient, but also helps to determine overall prognosis and outcome.[41]

**A-Plain X-Ray:**

In the 9$^{th}$ Edition of the ATLS Guidelines (2012), three x-rays are recommended as part of the primary survey: cervical spine, thorax and pelvis. Even though the guidelines leave some room for interpretation, pelvic x-ray is generally thought to be mandatory in polytraumatized patients. [20, 42]

Antero-posterior chest radiograph provide clues to associated thoracic and diaphragmatic injury and it is initial radiographic study of choice in all poly-trauma patients. It is an important initial step in the diagnosis of many conditions.[43, 44]

Chest injuries using plain x-ray include rib fracture, Strenal fracture, Pleural effusion (collection), Pneumothorax and Mediastinal injuries.[45]

Pelvi-abdominal X-ray may help of detecting small amounts of free intrapreitoneal or retroperitoneal air in patients with gastric, duodenal, small bowel, or colonic perforation, but it is not a part of the survey of the poly trauma patients. A search should be made for pelvic, vertebral body, and transverse spinous process fracture, as these warrant special

consideration for nearby visceral damage. At least 800 ml of interpreitoneal blood is required to be evident on plain abdominal radiography.[45, 46]

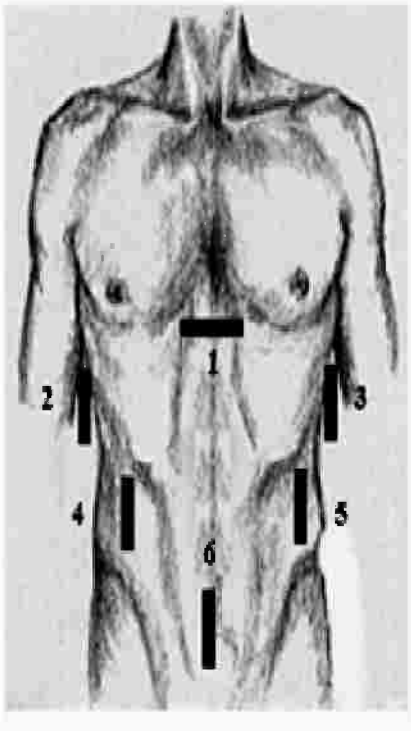
**B-Focused Assessment with Sonography for Trauma (FAST) :[47]**

Over the last decade, focused assessment with sonography for trauma (FAST) has become an indispensable tool, supported by a level I recommendation for use that adds another domain to the physical examination. In the poly-trauma patient, the goal of clinician-performed sonography is to quickly identify or confirm obvious pathology so that invasive interventions can be directed with greater accuracy. With continued training and with the simplification of the technology, ever-expanding indications and techniques are becoming available to examine new organ systems or anatomic regions. It is important that non experts maintain a high index of suspicion and not rely on a negative examination as a definitive test.[48]

The FAST scan can be completed in less than 5 minutes and may involve up to six views (Figure 1), depending on examiner preference. These views include (1) a subxiphoid or parasternal view to detect pericardial fluid; (2) a right upper quadrant view to assess the hepatorenal interface (Morison's pouch) and right chest; (3) the right paracolic gutter; (4) a left upper quadrant view to assess the splenorenal interface and left chest; (5) the left paracolic gutter; and (6) longitudinal and transverse pelvis views (the pouch of Douglas) to look for free fluid adjacent to the bladder.[49, 50]

The Morison pouch view has been shown to be the most sensitive, regardless of the etiology of the fluid (Figure 2).[51]

FAST assessment is indicated in trauma patients who give a history of abdominal trauma, are hypotensive, or are unable to provide a reliable history because of impaired consciousness due to head injury or drugs. FAST is an adjunct to the Advanced Trauma Life Support (ATLS) primary survey and therefore follows the performance of the ABCDE. The ultrasound machine should be immediately available in the trauma room and its use should not interfere with the on-going assessment and management of the patient.[47]




| Examination view | Space/ Location |
|---|---|
| 1 Transverse, Subxiphoid | Pericardial |
| 2 Longitudinal right upper guadrant | Perihepatic |
| 3 Longitudinal left upper quadrant | Perisplenic |
| 4 Right lateral | Paracolic gutter |
| 5 Left lateral | Paracolic gutter |
| 6 Longitudinal, Transverse Pelvis | Pelvic |

**Figure 1. FAST examination views** [50]

**Figure 2 Free fluid in Morrison's Pouch.**

**Ultrasound's advantages include:**

- Portability Speed: rapid trauma assessment can be performed. Readily available at the patient's bedside. As part of the initial evaluation of trauma patients and in detecting abdominal free fluid. Emergent abdominal sonography is the screening test of choice for blunt abdominal injury at many trauma centers. Can be repeated in the case of changes in the patient's hemodynamic status or physical examination.[50]
- The sensitivity of the (FAST) for detecting hemoperitoneum in victims of blunt abdominal trauma to be between 63% and 100%, and the specificity between 90% and 100%. [52]
- Technique is easy to learn. [53, 54]
- Noninvasive requires no radiation or contrast Serial exams are easily. [50, 55-57]
- Less expensive than CT or peritoneal lavage.[52, 55, 58]
- FAST is a rapid screening tool for detection of free intrapritoneal & intra pericardial fluid.[59]
- The use of US in the unstable patient some studies cite near 100% sensitivity for hemoperitoneum requiring surgical intervention in the hypotensive patient. [60]

**Ultrasound's disadvantages include:**

- US is notoriously poor at identifying organ subcapsular injury, bowel injury, injury to the retroperitoneum or diaphragm. Intra abdominal free blood may not descend to Douglas pouch in patient who has had a previous laprotomy. [61-63]
- It is operator-dependent, the amount of intraabdominal fluid necessary for a positive FAST scan is debatable and operator-dependent, but data suggest that it is between 250 and 650 mL, depending on whether the patient is placed in the supine or Trendelenburg position. [50]
- Cannot differentiate ascites from blood.[50]
- Can be difficult to interpret in patients with obesity uncooperative patients, bowel gas, and subcutaneous air interfere with image quality. [50, 64, 65]
- The diagnosis of hollow viscus injury remains a challenge in abdominal trauma patients.[62, 63]
- Evaluation of retroperitoneal conditions may be difficult in the face of ileus and an associated gas blockage.[65]

**Indications and contraindication of FAST:**

FAST should even be applied in cases of poly-trauma, haemodynamically unstable patients, and equivocal physical examination and there are multiple rib fractures or any lower rib fractures and altered sensorium due to any cause. [60]

FAST cannot be used when there is obvious need for laparotomy and inadequate training or experience of the trauma team member performing the examination.[48]

**C- Computed Tomography (CT):**

Although expensive and potentially time-consuming, CT scan often provides the most detailed images of traumatic pathology and may assist in determination of operative intervention.

Transport only haemodynamically stable patients to the CT scanner. When performing CT scan closely and carefully monitor vital signs for clinical evidence of decompansation.[61]

**Advantages of CT:**

- It is relatively noninvasive and its complications reported to date have been few.[66]
- Scans of the head, chest, abdomen, spine, or pelvis can be performed as the same time.[66]
- It is very useful in predicting the grade of injury in order to select the appropriate management of trauma patients (Fig. 3).[67]
- It is very useful in predicting the grade of injury in order to select the appropriate management of trauma patients. [67]
- The vascular integrity of organs, especially the kidneys, can also be evaluated. [61]

**Disadvantages of CT:**

CT is seldom present in all Emergency Department ED, so multiple trauma patients have to be transferred to CT unit. It also needs experienced personal to monitor the patient during CT scanning. The coast of the procedure should be considered.[51, 68]

Suboptimal sensitivity for pancreatic, diaphragmatic, bowel and mesentery injury CT scanning may miss injuries to the diaphragm and perforations of the GI tract, especially when CT scanning is performed soon after the injury.[51]

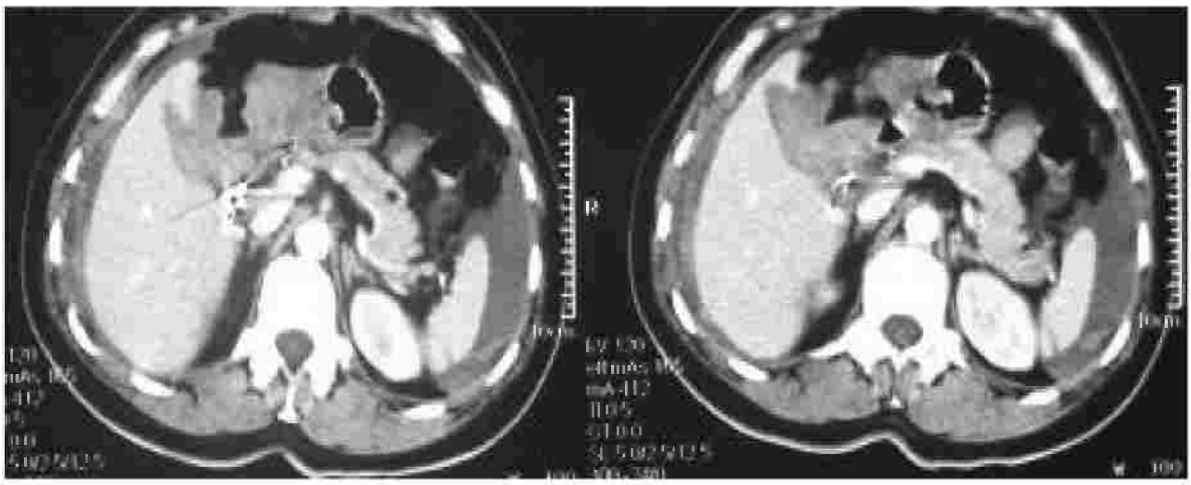


**Figure 3. CT scan showing contrast extravasation (grade III splenic fracture); perisplenic and perihepatic hemoperitoneum.**

**Contraindications to CT scan :**[69, 70]

- Obvious need for celiotomy.
- Hemodynamic instability.
- Uncooperative patient.
- Allergy to contrast agents (e.g. due to renal failure or severe allergy).
- Contraindication to radiation exposure.

**Diagnostic Peritoneal Lavage (DPL):**[51]

DPL is performed less frequently with the ready availability of FAST in the unstable patient and CT in the stable. However, it is cheap and fast, although somewhat invasive.

- A grossly positive DPL means that gross blood is aspirated from the DPL catheter following its insertion.
- A microscopically positive DPL usually refers to a DPL with >100,000 red blood cells per mm3 as measured following the collection of the DPL effluent.

In an unstable patient a grossly positive DPL is an indication for operation.If only microscopically positive (usually manifest as an inability to read newsprint through the blood-stained fluid), the source of blood loss is usually the abdomen, but other occult sources of blood loss (e.g. the pelvis) should also be considered.

As DPL is very sensitive to small amounts of blood loss, operating on stable patients with a microscopically positive DPL will result in a high rate of non therapeutic laparotomies. If the DPL fluid is seen flowing out through the urinary catheter or the chest tube, the patient should undergo laparotomy for suspected bladder rupture or diaphragmatic rupture, respectively. This scenario is rare, but should be considered. Similarly, if gross enteric contents are seen upon aspiration of the peritoneal fluid, laparotomy for bowel injury is mandated. Bacteria present on Gram-stain might either represent a bowel injury, or more commonly, placement of the DPL catheter (or needle) into the bowel. With this limitation in mind, DPL is the most sensitive test for a bowel injury and because of this strength, it is the test of choice in patients where the possibility of such an injury is high – typically in a patient with a seatbelt sign.

# Emergency Management of BAT

## Unstable patients:

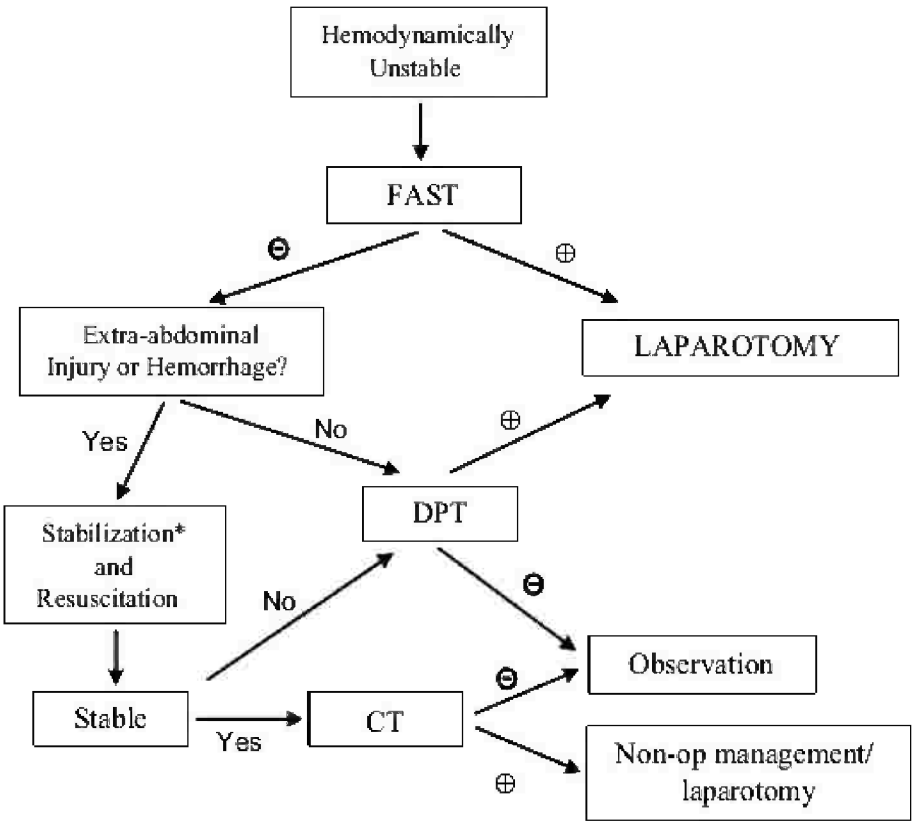
Determining need for emergent operative care is the top priority in the evaluation of patients sustaining BAT. In those patients who are hemodynamically unstable, the presence of intra-abdominal hemorrhage must be expeditiously established. Risk of death from isolated intra-abdominal in-jury increases with time spent in the emergency department and severity of hypotension (Fig. 4).[71]

Traditionally, bedside diagnostic peritoneal lavage or tap (DPL or DPT) quickly triages unstable patients with multisystem trauma. If 10 cc of gross blood is aspirated then intra-abdominal hemorrhage is present and the patient requires urgent laparotomy. This knowledge is especially useful when multisystem trauma is present and the physician must decide which therapeutic path to tread, be it exploratory laparotomy or angiography with embolization. However, with the advent of bedside ultrasonography (US), DPL is being employed less and is no longer the standard diagnostic procedure in these unstable patients.[8]

Recent literature shows mixed opinion on the use of US in the unstable patient. While some studies cite near 100% sensitivity for hemoperitoneum requiring surgical intervention in the hypotensive patient[60], others show a wide range of sensitivity and

caution against its sole use in this patient population, especially when no intraperitoneal free fluid is detected.[62]

Chest and pelvic radiographs determine the presence of extra-abdominal causes of hypotension or hemorrhage, namely pneumothorax or hemo-thorax and pelvic ring fracture, respectively (Fig. 4). Needle decompression, chest tube placement, or pelvic wrapping and subsequent angiography control further blood loss and aid in resuscitation. Large scalp lacerations may also prove a source of hemorrhage and should be whip-stitched (or Rainey clipped) closed.[8]




* Pelvic wrap, chest tube placement, whip stitch
FAST – Focused Abdominal Sonography for Trauma
DPT – + if ≥ 10 cc blood aspirated; - if <10 cc blood aspirated.
CT – Computed Tomography

**Figure 4. Unstable patients with blunt abdominal trauma.**

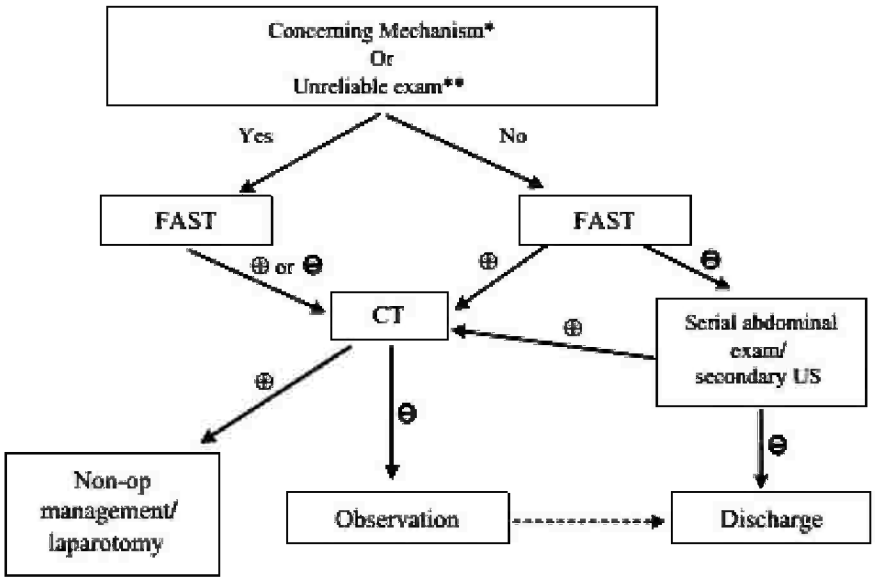
## Stable patients:

New advances in computed tomography and ultrasound continue to alter the management of stable patients with BAT (Fig. 4). Hemodynamically stable patients allow for a more time intensive evaluation and alternative testing to diagnose intra-abdominal injury. While physical exam in the stable, alert, nonintoxicated patient is reasonably accurate, it is not infallible and clinical observation with serial examinations is warranted.[26]

Most centers employ US as part of their initial survey in trauma resuscitation. Studies demonstrate a range in sensitivity for hemoperitoneum from 65% to 95%, although most recent studies cite ranges of 86% to 89%.[72-74]

If the FAST is noted to be positive, these stable patients then proceed to CT for delineation of intraperitoneal injury and quantification of the hemoperitoneum (Fig. 5). If the FAST is negative, concern for intra-abdominal injury is still present, as US is notoriously poor at identifying solid organ subcapsular injury, bowel injury, or injury to the retroperitoneum or diaphragm.[62, 63, 75]

However, some report that a negative FAST coupled with a negative physical exam, followed by an observation period of 12 to 24 hours in an alert, stable patient virtually excludes intra-abdominal injury.[76] Others recommend serial abdominal US to increase the sensitivity of the FAST exam.[77, 78]




* Concerning mechanism: fatality at scene, rollover, intrusion, prolonged extrication
** Unreliable exam: altered mental status, intoxication, distracting injury
FAST – Focused Abdominal Sonography for Trauma
CT – Computed Tomography
DPT – + if ≥ 10 cc blood aspirated; - if <10 cc blood aspirated.

**Figure 5. Stable patients with blunt abdominal trauma.**

The 2004 American College of Emergency Physicians Clinical Policy statement, based on review of the literature, states CT as reliably excluding liver and spleen injury after BAT. This clinical policy also reports that CT alone could not reliably rule out hollow viscus, diaphragmatic, or pancreatic injury.[68]

Hollow viscus injury (HVI) remains difficult to detect despite advances in diagnostic modalities. Coincident solid organ injury often masks CT findings of HVI, increasing morbidity and mortality because of delay in diagnosis.[79] Recent studies suggest physical examination for signs of peritonitis, coupled with CT with intravascular (IV) contrast only, may be adequate for diagnosing bowel injury. However, the low incidence of HVI makes large prospective studies for noncontrast CT identification difficult.[80-83]

In 2003 the Eastern Association for the Surgery of Trauma (EAST) multi-institutional hollow viscus injury study reviewed trauma registries from 95 trauma centers over 2 years. They concluded that no test or combination of findings could reliably exclude colonic injury. They noted that, though only used in 22 % of cases, DPL was the only diagnostic test with a sensitivity of 97% and negative predictive value of 80% for HVI.[80]

If liver or splenic injury is detected by CT in a hemodynamically stable patient, non-operative management with close observation, serial examinations, and hematocrits is now standard.[84-86] This is in part due to improved resolution on CT, which allows better definition of the injury and quantification of hemorrhage.[85] Even high-grade liver lacerations can be initially managed nonoperatively; however, complications and the possible need for therapeutic laparotomy should be expected.[86]

In 2005, Kozar and colleagues evaluated 230 patients with grade 3 or higher blunt hepatic injury initially managed nonoperatively. Of these, 25 had complications (11%) including bleeding, biliary tract related complications, abdominal compartment syndrome, liver abscesses, and liver necrosis. Grade 5 injuries had a 63% complication rate, whereas only one of the grade 3 patients had a complication (a peripheral bile duct leak). Operative intervention was required in 5.2% of all study subjects initially managed nonoperatively.[86]

# Non-Operative Management of BAT

Over the past two decades, there has been a major shift from operative to selective non-operative management of traumatic injuries.[87] Physicians are becoming increasingly comfortable in managing such injuries non-operatively.[88] Despite these developments, a small number of patients with catastrophic intra-abdominal injuries will continue to require immediate and skilled surgical intervention combined with expert resuscitation.[89]

The increased utilization of non-operative or 'conservative' management of abdominal solid organ injuries is facilitated by the various sophisticated and highly accurate non-invasive imaging tools at the trauma surgeon's disposal. [90]

Holmes and colleagues' study, published in 2009 validate clinical prediction rules consisting of hypotension, GCS score less than 14, costal margin tenderness, abdominal tenderness, femur fracture, hematuria level greater than or equal to 25 red blood cells/high powered field, hematocrit level less than 30%, and abnormal chest radiograph result (rib fracture or pneumothorax) can aid physicians in the evaluation of adult patients with blunt torso trauma. Patients without any of the high risk variables are at very low risk of intra-abdominal injury and are unlikely to benefit from abdominal CT scanning.[91]

Reducing abdominal CT use would have several potential benefits, including decreasing patient ED length of stay, patient care costs, and associated risks (radiation-induced malignancy, aspiration of oral contrast, intravenous contrast reactions, and contrast-induced nephropathy).[92-95]

The non-operative approach relies heavily on the availability of trauma trained surgeons, modern radiographic imaging (particularly computed tomography), accurate interpretation of such high quality radiographic images, as well as the presence of appropriate supporting infrastructure and ancillary services.[90]

If a CT scan demonstrates an injury to the liver or spleen and the patient remains hemodynamically stable without evidence of peritonitis, then an initial attempt at non-operative management is warranted. This is the preferred approach and is easily accomplished in most patients. The patient should be admitted to an intensive care unit or other closely monitored environment for at least 24 hours with careful serial abdominal examination and repeat hemoglobin evaluation. If stable, the patient can be transferred to a regular ward bed with less intensive monitoring for the 3–5 days, depending on the patient might require pelvic angioembolization postoperatively. If time interval from injury is very short, repeat FAST prior to discharge from the emergency department or within an hour of arrival severity of the injury. Serial imaging studies have been recommended by some, but it there is preference to limit repeat imaging studies to those who develop evidence of complications. Patients are told to avoid contact sports or any activity that might put the injured organ at risk for approximately 3 months. [51]

The hemodynamically stable or easily stabilized trauma patient can be admitted in a non-ICU ward with the provision of close monitoring, splenic injury especially with multiple site free intra-abdominal fluid in abdominal computed tomography carries a high risk for non-operative management (NOM) failure, in this series, the main criterion for a laparotomy in a NOM patient was hemodynamic deterioration after a second rapid fluid

load. [80] Neither grade of injury nor amount of hemoperitoneum on CT predicts the outcome of NOP management and mandates laparotomy. [96]

Appropriate candidates for nonoperative management are those without active bleeding from solid viscera injury without evidence of hollow viscus or mesenteric injury. Observation requires hemodynamically stable patients in whom ongoing evaluation and observation can be performed. Quality CT imaging, a monitored environment, and access to emergent intervention are required. (Table 2) [17]

Whereas non-operative management carries the inherent risks, laparotomy carries a different set of risks that are related to the surgeon, the anesthesia, the nature of operation and potential complications, and patient-related risk factors. Evidence seems to support the contention that the choice between the two modalities of management should be guided by hemodynamic considerations rather than the severity of organ injury. [97]

**Table (2): Requirements for non-operative management.**

| **Requirements for non-operative management**. |
|---|
| • Hemodynamically stable |
| • Absence of peritonitis |
| • Contrast-enhanced CT without evidence of active bleeding |
| • Monitoring in an intensive care unit |
| • Staff available for repeated observation |
| • Operation room available 24 h |

**The risks associated with NOM are**: [14, 98]

- Missed injuries.
- Delayed diagnosis and treatment.
- Retained hematoma, sepsis and/or abscess.
- Bowel/biliary/pancreatic/urinary leaks.
- Pseudoaneurysm formation and delayed rupture.
- Delayed treatment of vascular injuries and their complications.
- Risks involved in blood transfusion.

## Indications for Laparotomy: [99]

**At Initial Presentation:**

1. Hemodynamic instability with evidence of intraabdominal bleeding (grossly positive DPL or positive FAST).
2. Peritoneal signs.
3. Chest radiograph showing evidence of diaphragmatic tear.

**After Diagnostic Testing:**

Diagnostic tests showing:

1. Active extravasation from a major abdominal vessel or a contained hematoma adjacent to a major vessel suggesting injury.

2. Solid organ injury with active extravasation.
3. Pancreatic injury major ductal injury.
4. Hollow viscus injury.
5. Intraperitoneal bladder rupture.

**During Hospital Observation:**

1. Patient with solid organ injury being managed non-operatively developing hemodynamic instability or requiring > 2 units of packed cell transfusion related to the solid organ injury.
2. Development of peritonitis.
3. Persistent urinary leakage or persistent hematuria from a fragmented kidney.
4. Patient with negative initial evaluation but not improving or showing clinical deterioration, with no other explanation.

# Management of specific organ injury

## Spleen

Although the spleen is rather protected anatomically by the lower rib cage; it possesses the distinction of being the most commonly injured organ in blunt abdominal trauma. The spleen is the abdominal organ most frequently injured by trauma; such injuries to the spleen represent approximately 25% of all blunt abdominal injury of the abdominal viscera. [100]

The diagnosis of splenic injury is usually difficult in sustaining abdominal trauma. The clinical manifestations are the systemic symptoms and signs of hemorrhage and local evidence of peritoneal irritation in the region of the spleen. A tender abdomen with guarding and distention is apparent in only about 50-60% of those patients with splenic rupture. [101]

In unstable he patient, ultrasound or DPL will provide the most rapid diagnosis of haemopertonium, the source of which is commonly the spleen.

In stable patient suffering from blunt injury, CT imaging of the abdomen allows delineation and grading of splenic injury. The most common finding on CT in association with a splenic injury is haemopeirtoneum.

The use of abdominal CT and understanding of the importance of splenic function have resulted in the preservation of many injured spleens, by either non-operative management or splenorrahaphy. Management of splenic injury depends primarly on the haemodynamicss stability of the patient on time of presentation. Other factors include age, associated injuries, and the degree of the splenic injury.

1. Non-operative management of splenic injury is successful in >90% of children, irrespective of the grade of splenic injury.

2. Non-operative management of blunt splenic injury in adults is becoming more routine, with approximately 65% to 75% of adults ultimately managed none operatively for blunt injury to the spleen.

If hermodynamically stable, adult patients with grade I or II injury can often be treated none operatively, Patients with grade IV or V splenic injuries are usually unstable. Grade III (certainly in children and selected adults) can be treated none operatively based on stability and reliable physical examination. Risk of failure of non operative management of blunt splenic injury correlates with grade of splenic injury and quantity of haemoperitoneum. Most failures occur within 72 hours of injury.

Patients with significant splenic injuries treated non-operatively should be observed in a monitored unite and have immediate access to CT scan, a surgeon, and an operating room OR. Changes in physical examination, haemodynamics stability, ongoing blood, or fluids requirements indicate the need for laparotomy.[101, 102]

## Liver

The liver remains one of the most common injured intra-abdominal organs despite its protected location in the right upper quadrant under the rib cage. The management of liver injuries has dramatically changed during the past three decades, particularly for blunt trauma. The management of liver trauma ranges from non-operative strategies to operative treatment involving perihepatic packing in damage control and occasional hepatic resection. Liver injury remains common both in blunt and penetrating trauma. Blunt trauma remains the commonest source of liver injury in Europe (80-90% of all hepatic injuries). [103]

Hepatic-related mortality was defined as deaths caused by ongoing liver bleeding or liver failure, or deaths related to complications of massive fluid resuscitation. Hepatic-related complications were defined as bleeding if intervention, either angioembolization or laparotomy, was required. Liver related infection including a hepatic or perihepatic abscess or hepatic necrosis; biliary, including the development of a biloma (whether sterile or infected), biliary – venous fistula, bile peritonitis, or bile duct injury, missed hollow viscus injury and development of abdominal compartment syndrome. [104]

Over the past three decades, a substantive change has occurred in the diagnosis and management of patients with blunt hepatic injuries. Before the1990s, liver injuries were identified primarily by diagnostic peritoneal lavage, computed tomography (CT), or operative exploration. Historically, the accepted standard of care was uniform operation for suspected liver injuries with repair of vascular, parenchymal, or biliary structures and drainage of the perihepatic spaces to control biliary leaks and to avoid potential perihepatic sepsis.[105]

Severe hepatic injuries require surgical intervention due to hemodynamic instability. Low-grade injuries can be managed nonoperatively with excellent results, while patients with hepatic trauma with associated organ injuries require surgery, because they continue to have significantly higher mortality.[106]

NOM of hepatic injuries is the treatment modality of choice in hemodynamically stable patients, irrespective of the grade of injury.[104, 107] It is associated with a low overall morbidity and mortality and does not result in increases in length of stay, need for blood transfusions, bleeding complications, or visceral associated hollow viscus injuries as compared with operative management. [104] Patients with failure of NOP management had significantly worse admission hemodynamic parameters. NOP management does not lead

to longer hospital stay. Low grade injuries can be managed non-operatively with excellent results. [108]

Operative management of blunt hepatic trauma should be undertaken for hemodynamically unstable patients. Operative management strategies have shifted in the last twenty years from resection and debridement to damage control relying heavily on hemostatic techniques.[12]

The advent of improved and expeditious imaging technologies for the diagnosis and treatment of liver injuries accompanied by advances in critical care monitoring prompted a paradigm shift toward non-operative management for the treatment of liver injuries. [109]

The use of helical computed tomography (CT) in the diagnosis and management of blunt liver trauma is mainly responsible for the notable shift during the past decade from routine surgical to nonsurgical management of blunt liver injuries. CT is the diagnostic modality of choice for the evaluation of blunt liver trauma in hemodynamically stable patients and can accurately help identify hepatic parenchymal injuries, help quantify the degree of hemoperitoneum, and reveal associated injuries in other abdominal organs, retroperitoneal structures, and the gastrointestinal tract.[110]

In the initial reports of NOM, there was concern that it would lead to higher transfusion requirements and to prolonged ICU and hospital lengths of stay. Although there have been reports about excessive blood being transfused in the hope that bleeding will stop, in the recent studies, NOM does not carry with it a greater need for transfusion than operative management. Most reports suggest that transfusion requirements are less with NOM.[85, 108] Angiography with embolization has been widely used in selected cases, with or without surgery.[111]

## Pancreas

Pancreatic trauma is uncommon and most trauma surgeons have little experience in managing the condition.[112] Isolated pancreatic injuries resulting from non-penetrating trauma are rare. Less than 10% of all major trauma events result in injury of the pancreas, and most of them are associated with other solid organ injuries. Several series report a range of 1.6 to 4.5 associated injuries per patient. Rarely, the pancreas is the sole organ injured.[97]

Laboratory findings are often nonspecific (in particular, initial serum amylase levels may be normal in about 25% of patients), and underestimation of the severity of pancreatic injury on the initial computed tomogram is possible during first 72-48hours. Lastly, it is possible for low severity blunt abdominal trauma to be associated with isolated pancreatic injury.[97]

The pancreas is deeply seated in the retroperitoneum and there are difficulties using physical examination, sonography and diagnostic peritoneal lavage to investigate this area.[109, 113] If the patient is stable enough to undergo imaging, the initial test of choice is a high- definition CT scan performed with intravenous contrast.[110] False negative results or underestimation of initial CT scan grading may be associated with unopacified bowel loops adjacent to the pancreas, motion and streak artifacts, as well as suboptimal bolus enhancement. CT can also be useful in demonstrating complications such as abscesses,

fistulae, pancreatitis and pseudocysts. However, the reliability of CT in detecting pancreatic trauma is still debated. [114, 115]

The majority of cases of pancreatic trauma had associated organ injuries. Four-slice helical CT identified most pancreatic trauma and provided practical therapeutic guide. However, CT missed a small portion of pancreatic trauma. Patients with superficial pancreatic injuries were candidates for non-operative therapy while deep pancreatic lesions revealed on CT required surgery. Delayed operation resulted in complications and was associated with prolonged hospital stays.[116]

While non-operative management of other solid organ injuries (spleen, liver) is an accepted practice, non-operative management of pancreatic injuries is controversial. The integrity or disruption of the pancreatic duct is the principal determinant in the management of pancreatic injuries. Because prompt surgical intervention is usually undertaken in patients with penetrating injuries or multiple organ involvement, delay in diagnosis of a pancreatic ductal injury most commonly occurs in patients with BAT isolated to the pancreas. Some authors claim that CT grading of the degree of severity of blunt pancreatic trauma can be useful in predicting ductal integrity or disruption, although this is not universal.[81]

Non-operative management of low grade pancreatic injury diagnosed by CT was successful in the majority of hemodynamically stable patients, with low morbidity and mortality. [117] Major ductal injury is an indication for laparotomy, while if the injury does not involve the major ducts, the patient maybe managed non-operatively.[99] The role for early ductal injury detection with endoscopic retrograde cholangio-pancreatogram or magnetic retrograde cholangio-pancreatogram should be incorporated to better analyze the most appropriate treatment.[117] That the failure rate of non-operative treatment for pancreatic trauma was much higher than for other abdominal solid organs.[118]

## The Diaphragm

All diaphragm injuries should be operatively repaired. If repair is not done in the acute setting these patients may present years later with chronic diaphragmatic hernias and respiratory compromise, or strangulation. Larger ruptures are easily detected by chest radiography. Smaller injuries can be missed. None of the available diagnostic modalities are reliable in detecting such injuries. The newer generation helical scanners may show some subtle signs such as thickening of the hemidiaphragm. In the absence of a reliable diagnostic test, the surgeon has to maintain a high index of suspicion based on the history – more common with a mechanism involving a crushing force to the upper abdomen or chest. If the index of suspicion is high, laparoscopy may be utilized to not only diagnose the injury, but repair it also. In rare cases exploratory laparotomy may be necessary to establish the diagnosis and repair.[99]

## Urinary Tract

### ○ Kidney

The majority of renal injuries can be managed nonoperatively, with few absolute indications for surgical intervention.[119] With higher rates of renal salvage and decreased morbidity compared to primary surgical management.[120]

Laparotomy and repair is indicated if there is:

1. Persistent bleeding or blush on CT scan, hemodynamic instability.[99]
2. Urinary extravasation that is persistent over 48–72 hours. In most patients presenting with gross hematuria, the hematuria usually resolves. In cases where the hematuria does not resolve and the imaging studies suggest renal fragmentation.[99]
3. It may be required to remove whole or part of the kidney. The warm ischemia time for the kidney is four to six hours, and hence attempts at revascularization after traumatic avulsion or thrombosis of the renal artery are usually futile. In rare instances when the diagnosis has been made early, the patient is hemodynamically stable, and it is important to preserve renal parenchyma (solitary kidney, borderline renal function), laparotomy for revascularization may be justified. [99]
4. Presence of an expanding or pulsatile hematoma, or when a hilar injury is suspected.[51]
5. Moderate severity injuries can be controlled usually by cortical renorrhaphy and drainage; occasionally, a polar nephrectomy may be indicated. A shattered kidney or a vascular hilar injury requires nephrectomy.[51]

The non-operative management involves a period of bed rest, monitoring of vital signs and serial hematocrit measurements, with either selective or routine use of early follow-up imaging.[121] NOM is successful in the majority of patients without peritonitis or hemodynamic instability and should be considered regardless of the severity of renal injury. Predictors of failure may exist on the basis of injury severity, fluid and blood requirements. [122]

- **Urethra**

Partial urethral injuries may be treated with prolonged foley catheter drainage if catheter passage is possible. Complete urethral distraction injuries are generally treated with percutaneous or open suprapubic tube management followed by delayed repair 3-12 months after recovery. Many authors recommend early realignment surgery with antegrade and retrograde placement of a catheter however immediate operative repair has been demonstrated to have a significantly higher rate of complications including stricture and erectile dysfunction. [123]

- **Ureter**

Blunt ureteric injury is rare and usually occurs with other major injuries that require laparotomy. [99]

- **Urinary Bladder**

Intraperitoneal rupture of the bladder is usually seen in association with a pelvic fracture or when there has been a blow to the lower abdomen with a distended bladder. In conscious patients peritoneal signs are present. CT scan usually shows free intraperitoneal fluid. Injury may be confirmed by retrograde or CT cystography. Once the diagnosis is made, laparotomy is indicated to repair the bladder.[99] Patients with extraperitoneal bladder ruptures may be treated with simple catheter drainage, if not requiring exploration for associated injuries. That the majority of extraperitoneal bladder ruptures can be managed with catheter drainage alone. Relative contraindications to conservative

management include bone fragments projecting into the bladder, open pelvic fractures, and bladder injuries associated with rectal perforations. [123]

## Hollow Viscus

Hollow viscus injury HVI is the third most common injury seen after blunt abdominal trauma. The incidence of bowel and mesenteric injuries in 5% of blunt abdominal trauma (BAT) patients, at laparotomy.[124] Delay in operative therapy following such injuries can lead to significant morbidity and mortality. Patients with peritoneal signs, either at initial presentation or during observation in the hospital, should undergo laparotomy without delay. Therefore, solid organ injuries and their direct consequence, hemodynamic instability, draw the attention much more quickly and present a higher priority in the emergency management of the BAT patient, leaving the HVI undiagnosed unless the clinical picture is highly suggestive. [125-127]

Hollow viscus injury (HVI) remains difficult to detect despite advances in diagnostic modalities. Coincident solid organ injury often masks CT findings of HVI, increasing morbidity and mortality because of delay in diagnosis.[79] Recent studies suggest physical examination for signs of peritonitis, coupled with CT with intravascular (IV) contrast only, may be adequate for diagnosing bowel injury. [80, 83] Current helical scanners have increased the accuracy considerably.[128]

Findings suspicious of blunt bowel/mesenteric injuries on CT include unexplained intra-peritoneal fluid, pneumoperitoneum, bowel wall thickening, mesenteric fat streaking, mesenteric hematoma, and extravasation of either luminal or vascular contrast. And prompt further tests or laparotomy. In a recent report the number of CT findings was found to directly correlate with presence of injury. There is report suggest doing a DPL for a single CT finding, and proceeding with laparotomy if more than one finding is present. [128]

## Retroperitoneal Hematoma

Retroperitoneal traumatic lesions are among the most challenging and serious emergencies, and necessitate a maximum of attention and expertise by the surgical team involved. Only with a careful judgment about the tactics and the procedures to carry on it is possible to obtain valid results, which often means to safe the patient's life. [129, 130]

Traumatic retroperitoneal hematoma (RPH) may arise from injury to bony structures, major blood vessels, and intestinal or retroperitoneal viscera. To categorize the management of RPH, the retroperitoneum may be divided into three zones. Zone 1 (central) extends from the esophageal hiatus to the sacral promontory. Zone 2 (lateral) extends from the lateral diaphragm to the iliac crest. Zone 3 (pelvic) is confined to the retroperitoneal space of the pelvic bowel.[131]

Although the guidelines for exploration are clear-cut during laparotomy for associated intra-abdominal injuries, this is not the case with isolated retroperitoneal haematoma. For the traumatized patient with RPH, laparotomy is mandated by persistent hemodynamic instability despite intensive volume replacement. The judgment of whether and when to explore the retroperitoneal hematoma is guided by the mechanism of injury (blunt or penetrating) and the location of the RPH. Central hematomas always need exploration. All penetrating wound tracts should be explored, irrespective of the site of the

haematoma, to exclude vital structural injury. Lateral and pelvic hematomas may be selectively explored should be evaluated by CT and/or angiography; ongoing hemorrhage may respond to therapeutic embolization. [131, 132]

Retroperitoneal hematoma is frequently due to blunt trauma and is a challenging problem. Incidence of this complication in adults is high, but in childhood is uncommon. Retroperitoneal hematoma in infancy should be treated conservatively. [133]

The presence of lesions on the retroperitoneum generally worsens the prognosis in traumatic pathology; it implies more attention and skills from both the medical and surgical aspect. Mortality is high, compared to abdominal traumatic lesions confined within the peritoneal sac. Treatment of single or associated lesions requires a multidisciplinary approach, as the surgical repair implies a specific knowledge and experience on different organs, whose habitual pathology lies on the hands of more surgical specialists. Lesions of great vessels are immediately life-threatening; moreover the choice to "open" a patient for a retroperitoneal hematoma has to be taken upon a careful estimation. It could be better in more than a situation leave such hematoma in its place, especially in the iliac region, waiting for the spontaneous resolution of the hemorrhagic source and of the hematoma itself. The involvement of esophagus, duodenum or pancreas determines instead a poorer prognosis at a distance. [129]

## Pelvic Hematoma [51]

With the exception of isolated fractures of the iliac crest, fractures involving the pelvic or obturator rings and/or sacrum have the potential for significant bleeding leading to shock and death. The bleeding arises from disrupted pelvic veins, branches of the iliac (usually internal) arteries and cancellous bone. For this reason, all patients with a significant mechanism of injury undergo a simple anteroposterior radiograph of the pelvis as part of their initial evaluation.Additionally, simple lateral or anteroposterior compression of the pelvis might demonstrate instability of the pelvic ring.

With this degree of pelvic instability, particularly in the presence of a dropping hemoglobin and/or hemodynamic instability, we wrap a sheet around the iliac crests and tie it tightly, effectively reducing the volume of the pelvis, and increasing the potential for tamponade by the pelvic retroperitoneum.