INTRODUCTION

Blunt trauma is defined as any injury sustained from blunt force, which may be related to motor vehicle accidents (MVAs), falling from height, jumps, blows, crush injuries from animals, blunt objects or unarmed assailants.[1]

Trauma remains one of the major cause of death in children and young adults over the world. Adult and pediatric victims differ significantly in both mechanism and physiologic response to injury. Blunt trauma was reported to be responsible for most adult (82.8%) and pediatric (94.3%) injuries, although it was relatively more in the pediatric group.[2] Head and limb injuries occur most frequently; however, injury to the abdomen can occur in up to 8% of injured children.[3] These injuries can be potentially life -threatening, and therefore, they require a systematic approach to identification and treatment.[3]

Because of their body habitus and relatively immature musculoskeletal system, children are at increased risk of sustaining injuries to intra-abdominal organs after blunt abdominal trauma.[4] Compared with the adult patient, the child's intra-abdominal organs are proportionally larger and are in relatively close proximity to each other. The small size of a child causing a greater degree of force per body surface area, which can lead to significant injury to multiple organs. Furthermore, there is little fat or connective tissue to cushion the organs, and the abdominal wall is less muscular, providing little protection to the intra abdominal contents. The incompletely ossified rib cage is also higher and thus provides limited protection to the liver, spleen, and kidneys. Finally, the increased ratio of body surface area to volume causing an increased propensity toward hypothermia.[4] Several studies have shown that men tend to be affected slightly more than women.[5] With a male to female ratio of 3:2.[5]

Etiology Of Injury

The etiology of injury with respect to age is comparable; however, several differences are noted. Children are more likely to be injured as pedestrians struck by motor vehicles, and are also more likely to be injured in bicycle accidents.[2,7] Children are injured in falls twice as often as adults (Zorludemir et al., 1988)[8]. Mortality is higher for children than adults involved in motor vehicle accidents (MVAs), but lower when children are injured as pedestrians. This latter finding may reflect the fact that most pedestrian accidents occur at home (e.g. when a parent is backing out of the drive way) and are therefore more likely to be low-velocity.[9]

Pathophysiology Of Injury

Injury to intra-abdominal structures can be classified into 2 primary mechanisms of injury which include; compression forces, and deceleration forces.[10,11]

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 subcapsular hematomas to the solid viscera.
These forces

also may deform hollow organs and transiently increase the intra luminal pressure, resulting in rupture. This transient increase in the pressure is a common mechanism of blunt trauma to the small bowel.[10,11]

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, for example, the distal aorta is attached to the thoracic spine and decelerates much more quickly than the relatively mobile aortic arch. As a result, shear forces in the aorta may cause it to rupture. Classic deceleration injuries include hepatic tear along the ligamentumteres 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. [10,11]

Specific Organ Injury

The spleen is the most commonly injured organ, followed by the liver. Liver trauma does not differ significantly between adults and children, and the incidence and degree of severity of the injuries are similar. The third most common intra-abdominal injury in both groups is retroperitoneal hematoma (9.5% of adults and 8.5% of children).[12,13] Genitourinary injuries are infrequent in both adults and children, and the specific type of injury does not differ significantly between the two groups. The most common renal injury is contusion (< 4% incidence in both groups).[14]

Spleen

The spleen is the most commonly injured organ in blunt abdominal trauma (BAT); accounting for approximately 25% of injuries.[15] A direct blow to the abdomen may bruise, tear or shatter the spleen. Trauma to the spleen can cause varying degrees of damage, the major problem is associated with internal bleeding. Mild splenic subcapsular hematomas are injuries in which bleeding is limited to small areas on and immediately around the spleen. Splenic contusions refer to bruising and bleeding on and around larger areas of the spleen. [16,17] Laceration (tears) are the most common splenic trauma injuries. Tears tend to occur on the areas between the three main blood vessels of the spleen. Because of the abundant blood supply, splenic trauma may cause serious internal bleeding. Although most injuries to the spleen in children heal spontaneously, yet, abdominal injuries including splenic trauma are the most common cause of preventable deaths in children.[16,17]

Spleen injury grading scales:

The spleen injury scale was developed by the Organ Injury Scaling Committee of the American Association for the Surgery of Trauma (AAST).

Table 1. AAST spleen injury scale [18]

Grade	Type of Injury	Description of injury
I	Hematoma Laceration	• Subcapsular, <10% surface area • Capsular tear, <1cm parenchymal depth
II	Hematoma Laceration	• Subcapsular, 10% to 50% surface area intraparenchymal<5 cm in diameter • Capsular tear, 1-3 cm parenchymal depth that does not involve a trabecular vessel
III	Hematoma Laceration	• Subcapsular, >50% surface area or expanding; ruptured subcapsular or parenchymal hematoma; intra parenchymal hematoma ≥ 5 cm or expanding • >3 cm parenchymal depth or involving trabecular vessels
IV	Laceration	• Laceration involving segmental or hilar vessels producing major devascularization (>25% of spleen)
V	Laceration Vascular	• Completely shattered spleen • Hilar vascular injury with devascularizes spleen

Liver

Liver injuries are one of the most serious and a common consequence of motor vehicle crashes (MVCs).[19] In the unstable patient, early detection of liver injury based on clinical suspicion will improve acute trauma care and outcomes. Liver injuries are strongly associated with a safety belt restraint in use in absence of air bag deployment during MVC.[20] This data may have profound importance to the trauma surgeon as an early indicator for liver injury during resuscitation. These findings also have important implications for future research efforts to improve safety systems in motor vehicles and reduce morbidity and mortality from MVCs.[21]

Liver injury grading scales:

The liver injury scale was developed by the Organ Injury Scaling Committee of the American Association for the Surgery of Trauma (AAST). Originally convened in 1987, this scoring system is modified and updated by the Committee. This scale provides a common nomenclature by which physicians may describe injuries and their severity. [18]

Table 2. AAST liver injury scale [18]

Grade	Type of Injury	Description of injury
I	Hematoma Laceration	• Subcapsular, <10% surface area • Capsular tear, <1cm parenchymal depth
II	Hematoma Laceration	• Subcapsular, 10% to 50% surface area • intraparenchymal<10 cm in diameter • 1-3 parenchymal depth, <10 cm in length
III	Hematoma Laceration	• Subcapsular, >50% surface area; ruptured subcapsular or parenchymal hematoma; intraparenchymal hematoma > 10 cm or expanding • >3 cm parenchymal depth
IV	Laceration	• Parenchymal disruption involving 25% to 75% of hepatic lobe or • 1-3 Couinaud's segments
V	Laceration Vascular	• Parenchymal disruption involving >75% of hepatic lobe or >3 Couinaud's segments within a single lobe • Juxtahepatic venous injuries; ie, retrohepatic vena cava/central major hepatic veins
VI	Vascular	• Hepatic avulsion

Small-Bowel Injury

The Seat belt Syndrome. The small intestine is injured much less frequently than either the spleen or liver. However, intestinal injuries can often pose a diagnostic dilemma and thus results in delayed diagnosis. [22,23] A frequent mechanism of small intestinal injury is the lap-belt or seatbelt syndrome. The mechanism of these injuries involves rapid deceleration, resulting in flexion of the upper body around the lap belt and compression of the intestines against the spine. The sudden increase in intra luminal pressure can result in "blowout" or perforation of the intestine. [22,23]

Lumbar spine fractures, the so-called Chance fractures, are also detected in a significant proportion of children with lap-belt injuries. Children classically present with a transverse mid abdominal ecchymosis, abdominal pain and back pain. [24,25]

Renal trauma

If one includes the posterior abdomen and retroperitoneum in the definition of BAT, then the kidney is a commonly injured solid organ in BAT. The most likely cause of this type of injury is a motor vehicle collision. [26] Like hepatic and splenic injuries, most renal traumatic injuries heal without surgical intervention; however, the combination of significant flank/abdominal trauma and hematuria (even microscopic) is indication for a Computed Tomograhy (CT) scan to assess for renal injury. [26]

Kidney injury grading scales:

The kidney injury scale was developed by the Organ Injury Scaling Committee of the American Association for the Surgery of Trauma (AAST).

Table 3. AAST kidney injury scale [18]

Grade	Type of Injury	Description of injury
I	Contusion Hematoma	• Microscopic or gross hematuria, urologic studies normal • Subcapsular, non expanding without parenchymal laceration
II	Hematoma Laceration	• Non expanding perirenal hematoma confirmed to renal retroperitoneum • <1 cm parenchymal depth of renal cortex without urinary extravagation
III	Laceration	• <1 cm parenchymal depth of renal cortex without collecting system rupture or urinary extravagation
IV	Laceration Vascular	• Parenchymal laceration extending through renal cortex, medulla, and collecting system • Main renal artery or vein injury with contained hemorrhage
V	Laceration Vascular	• Completely shattered kidney • Avulsion of renal hilum which devascularizes kidney

Assessment of Trauma Patient

The initial assessment of a trauma patient begins at the scene of the injury, with information provided by the patient, by standers, or paramedics.[27]

The initial evaluation and care of a pediatric trauma patient uses the same protocols and procedures employed in adult trauma patients, the exception being that children should not be considered as little adults.[28,29]   In the same manner as in adults, the primary survey entails ABCDE: **A** is for <u>A</u>irway maintenance/access with control of the cervical spine (C-spine); **B** is for <u>B</u>reathing; **C** is for <u>C</u>irculation with external hemorrhage control; **D** is for <u>D</u>isability and neurological screening; and **E** is for <u>E</u>xposure/Environmental control with thorough examination.[30]

• Full history taking with special emphasis on age and mode of trauma.

• Key elements of the patient's history include the following: AMPLE history.[27]

    A   **A**llergies.

    M   **M**edications (anticoagulants, insulin and cardiovascular medications specially).

    P   **P**revious medical/surgical history.

    L   **L**ast meal (Time).

    E   **E**vents/Environment surrounding the injury; i.e. Exactly what happened.

Victims were managed according to guidelines of advanced trauma life support which are: [31]

ABCDE assessment

- **Airway** patency which was checked in all studied victims, associated with C-spine immobilization especially during endotracheal insertion either by manual in line stabilization or by neck collar, Spinal precaution was removed once X-rays are free or the patient may be awake, alert and no signs of spinal cord damage (i.e. numbness, tingling and inability to move the fingers and toes). [32]
- **Breathing**: all patients were examined for breathing by inspection, palpation, percussion and auscultation of the chest, examination of trachea and observation of skin colour also breathing was assessed by determining the victim's respiratory rate and by subjectively quantifying the depth and effort of inspiration. A pulse oximeter was applied to measure oxygen saturation continuously and maintained at greater than 95%. [33]

- **Circulation**: all victim's hemodynamic state were checked including the following: [34]

    1- Measure Blood pressure, record heart rate.
    2- The presence and equality both central and peripheral pulses.
    3- Capillary refill.
    4- Skin color, moisture and temperature.
    5- Mental status.

    Intravenous fluids were given to all studied victims of BAT.

    Withdrawal of blood sample for full laboratory investigations was done to all studied patients.
- **Disability**: which was evaluated in all studied patients by **AVPU score**(Alert, Voice, Pain, Unresponsive) [35], examination of pupils for equality and reactivity and checking random blood sugar.
- **Exposure** : examination of studied patients was done after completeexposure to detect other hidden injures.

Once the airway has been secured, the quality of the circulation is evaluated. A multiply injured child and adult should undergo placement of two large-bore intravenous catheters. If intravenous access proves to be difficult, insertion of an intraosseous catheter can be life-saving in children of <6 years of age. An intraosseous catheter can be used for fluid resuscitation and administration of medications. After the initial resuscitation has been performed using an intraosseous catheter, intravenous attempts are often successful. [36]

The infusion of warm crystalloids (Ringer's lactate or normal saline solution) are the initial fluids of choice for most trauma patients. [37]
The blood volume of a child is approximately 80-85 ml/kg. The American College of Surgeon's fluid resuscitation guidelines recommend an initial bolus of 20 ml/kg of warm

lactated Ringer's solution, which may be repeated.[13] If the patient remains hemodynamically unstable after 40 ml /kg of lactated Ringer's solution, administration of blood should be strongly considered, and a thorough evaluation for the source of bleeding should be undertaken.[13]

In hemodynamically normal adult patient without obvious injury, limit the initial fluid resuscitation (first hour) to 1 liter. In normotensive adults with tachycardia or obvious sources of blood loss infuse 2 liters of crystalloids as rapidly as possible. In hypotensive adults who respond to initial fluid resuscitation, continue maintenance crystalloids (100-150 ml/h) after the initial 2 liters. In hypotensive adults who are transient or non responders to the initial fluid resuscitation, infuse blood as early as possible.[38]

Resuscitation is performed concomitantly and continues as the physical examination is completed. This is followed by a thorough secondary survey, which examines the injured patient from head to toe.[39]

Physical Examination

The evaluation of victims with BAT must be accomplished with the entire patient in mind, with all injuries prioritized accordingly. This implies that injuries involving the head, the respiratory system, or the cardiovascular system may take precedence over an abdominal injury.[40]

The abdomen should neither be ignored nor be the sole focus of the treating physician and surgeon. In an unstable patient, the question of abdominal involvement must be expediently addressed. This is accomplished in some cases by identifying free intra abdominal fluid using diagnostic peritoneal lavage (DPL) or the Focused Assessment with Sonography for Trauma (FAST) examination. The objective is to rapidly identify patients who need a laparotomy.[41]

The initial clinical assessment of patients with BAT is often difficult and notably inaccurate. Associated injuries often cause tenderness and spasm in the abdominal wall and make diagnosis difficult. Lower rib fractures, pelvic fractures, and abdominal wall contusions may mimic the signs of peritonitis. In a collected series of 955 patients, (Powell et al, 1982) [42] reported that clinical evaluation alone has an accuracy rate of only 65% for detecting the presence or absence of intraperitoneal blood. In general, accuracy increases if the patient is examined repeatedly and at frequent intervals. The greatest compromise of the physical examination occurs in the setting of neurologic dysfunction, which may be caused by head injury or substance abuse.

The most common presenting features of intra-abdominal injury are abdominal pain, tenderness, guarding and distention.[43] Other symptoms such as shortness of breath or chest pain may also be associated with significant abdominal injuries. One must remember, however, that 40% of patients with significant hemoperitoneum have no peritoneal signs.[38,40]

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.[44] In addition, pre morbid 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 beat /minute.[45]

The definition of unstable blood pressure differs according to age as following:[44]

a. Adults:

- Systolic Blood Pressure (SBP) <90 mmHg.

b. children:
- Infant <2 years : (SBP) <65 mmHg.
- Child 2-5 years : (SBP) <70 mmHg.
- Child 6-12 years : (SBP) <80 mmHg.

Abdominal Examination

The abdominal examination must be systematic. The abdomen is inspected for abrasions or ecchymosis. The seat belt sign is highly correlated with intra-peritoneal pathology. Ecchymosis involving the flanks (Grey Turner's sign) or the umblicus (Cullen's sign) indicates retroperitoneal hemorrhage, but this is usually delayed for several days. Visual inspection for abdominal distention, which may be due to pneumoperitoneum, gastric dilatation secondary to assisted ventilation or swallowing of air, or ileus produced by peritoneal irritation, is important.[40] Palpation may reveal local or generalized tenderness, guarding, rigidity, or rebound tenderness, which suggests peritoneal injury. Peritonitis due to intra-abdominal hemorrhage may take several hours to develop. Crepitation or instability of the lower thoracic cage indicates the potential for splenic or hepatic injuries associated with lower rib injuries. Tenderness on percussion constitutes a peritoneal sign of irritation. Auscultation of bowel sounds in the thorax may indicate the presence of diaphragmatic injury.[40] Pelvic instability indicates the potential for lower urinary tract injury, as well as pelvic and retroperitoneal hematoma.

A nasogastric tube should be placed routinely (in the absence of contraindications, e.g. basilar skull fracture) to decompress the stomach and to assess for the presence of blood. If the patient has evidence of a maxillofacial injury, an orogastric tube is preferred.[46]

As the assessment continues, a Foley catheter is placed and a sample of urine is sent for analysis for microscopic hematuria. If injury to the urethra or bladder is suggested because of an associated pelvic fracture, then a retrograde urethrogram is performed before catheterization.[47]

With respect to the primary and secondary surveys, pediatric patients are assessed and treated—at least initially—as adults. However, there are obvious anatomic and clinical differences between children and adults that must be kept in mind, including the following:[4]

- The different physiologic response to injury in a pediatric patient.
- Effective communication with a child is not always possible.
- Physical examination findings become more important in children.
- A pediatric patient's blood volume is smaller, predisposing to rapid exsanguinations.
- Technical procedures in pediatric patients tend to be more time consuming and challenging.

Diagnostic Imaging

The diagnosis of significant intra-abdominal injury is a challenge in the management of patients with BAT.[48,49] The clinical history and physical examination alone are usually unreliable, as nearly half the patients may have no complaints or external signs of abdominal injury on admission to hospital.[50] Diagnostic tools that help the treating doctor to take critical decisions like the need for laparotomy or conservative treatment are mandatory if we aim for a favorable outcome. Diagnostic peritoneal lavage (DPL) had been the gold standard to detect intraperitoneal fluid since the sixties. Use of Focussed Assessment Sonography for Trauma (FAST) and helical CT scan have dramatically changed our methods for diagnosing BAT, refined our decisions, and enabled us to select patients for conservative treatment. The choice of a particular modality depends on the hemodynamic stability of the patient, the reliability of physical examination, the severity of associated injuries, and the availability of a particular diagnostic modality.[50,51]

Focused AssessmentSonography for Trauma (FAST)

Focused assessment sonography for trauma (FAST) is a goal directed study answering a simple question as to whether there is intraperitoneal fluid or not. It is a safe quick diagnostic tool that can be learnt easily.[52,53] (Figure 1). It is of great value for those patients who are hemodynamically unstable and who cannot be shifted to CT scan room. One of the great advantages is that it can be done bedside during resuscitation without the need to move the patient from the resuscitation room. The great value of FAST lies in its high sensitivity for detecting intraperitoneal fluid which accumulates in dependent areas around the liver, spleen and pouch of Douglas.[51] This sensitivity may reach up to 100%. The finding of free intraperitoneal fluid in a hypotensive patient alerts the treating doctor that the patient may need an urgent laparotomy.

Limitations of ultrasound have to be well understood when using FAST. Ultrasound is not accurate in obese patients due to lack of penetration of sonographic waves. Furthermore, it will be difficult to visualize intra-abdominal structures in case there is ileus or surgical emphysema under the skin. Ultrasonography is highly accurate in detecting intraperitoneal fluid but it cannot differentiate between blood, urine, bile or ascites. That is why the sonographic findings have to be correlated with

the clinical findings to make critical decisions. Focused assessment sonography for trauma has to be used within a diagnostic algorithm to have a proper role.[54] Ultrasound should be used as the clinician's stethoscope in the clinical setting. In case the patient is hemodynamically stable then the CT scan of the abdomen is the diagnostic modality of choice.[55] Ultrasound will miss 25% of intra-abdominal injuries in

Ultrasound should be used as the clinician's stethoscope in the clinical setting. In case the patient is hemodynamically stable then the CT scan of the abdomen is the diagnostic modality of choice.[55] Ultrasound will miss 25% of intra-abdominal injuries in case it is the only diagnostic tool.[54,55] Furthermore, ultrasound is not accurate in detecting retroperitoneal or gastrointestinal lesions.[56,57]

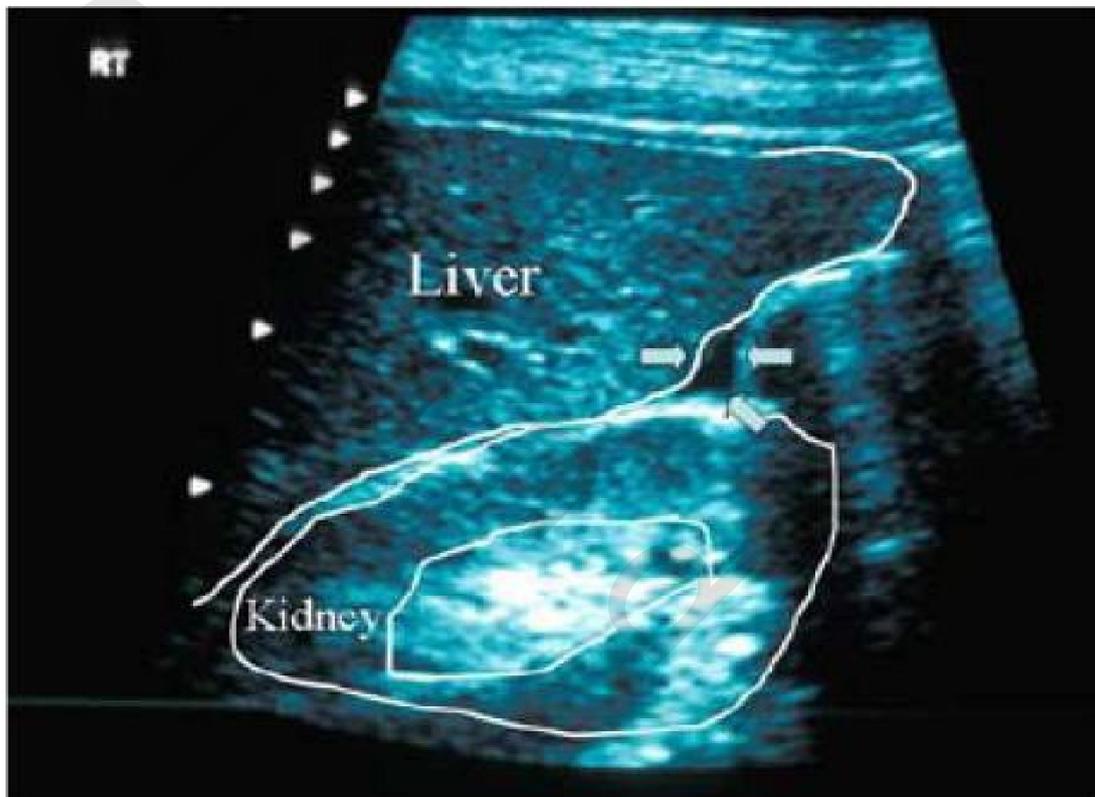
Figure 1. Sonographic sagittal section of the right upper quadrant showing the liver, kidney and free fluid in hepatorenal pouch (arrows).[58]

Computed Tomograhy (CT)

The contrast enhanced CT scan is a non invasive procedure. It has become the gold standard radiographic modality in evaluating BAT patients.[58] Computed tomography scanners are available now in most trauma centers. With the advent of helical CT scan, scan time has become significantly shorter to the degree that CT scan of abdomen and pelvis takes seconds.

Computed tomography scan is indicated in BAT inhemodynamically stable patients with equivocal findings on physical examination, neurological injury or impaired sensorium due to drugs or alcohol, multiple extra-abdominal injuries,[59] and

when the mechanism of injury is suggestive of duodenal or pancreatic injury.[60] Computed tomography scan is contraindicated in a BAT patient with clear indication of laparotomy and in hemodynamically unstable patient.

Computed tomography scan has a high accuracy reaching about 95%. It has a very high negative predictive value reaching almost 100%.[59] Despite that, patients with suspected abdominal injury should be admitted for at least 24 hours in the hospital for observation even with a negative CT scan result.[61] Computed tomography provides a detailed image of injuries. Finding free intraperitoneal air or rupture diaphragm are definite indications for laparotomy. It is very useful in defining the severity of solid organ injury (Figure 2) and guiding the non operative management and decisions for surgery. Helical CT with contrast enhancement can detect arterial extravasations (contrast blush) in BAT victims (Figure 3). This can be used to localize the anatomical sites of injury and to guide angiographic or surgical intervention.[62] Follow up CT scan is useful to help making clinical decisions when adopting a conservative approach. It allows adequate assessment of retroperitoneal structures. This is a major advantage over the other modalities. Furthermore, it allows the assessment of blood perfusion of different organs (Figure 4). Helical CT scan sagittal and coronal reconstruction images are useful for detecting ruptured diaphragm. Moreover, it seems to improve the diagnosis of gastrointestinal injuries.[63]

Nevertheless, CT scanning has certain limitations. It needs a specialized technician to perform it and a radiologist to read it. Computed tomography scan, although very sensitive in detecting solid organ injuries, may miss mesenteric tears, bowel injury especially small tears, diaphragmatic rupture if coronal reconstruction was not made, and pancreatic injury if done early after trauma.[64,65] A large multi-institutional study has shown that 13% of patients with perforated small bowel injury had a normal CT scan preoperatively.[66] Intravenous and oral contrast have the hazards of aspiration, delay in diagnosis when oral contrast is used, and allergic reaction with the use of intravenous contrast.[67]

The presence of free intraperitoneal fluid in BAT in absence of a detectable solid organ injury creates a clinical dilemma. There is a probability of 25% of missing bowel lesions. Diagnostic peritoneal lavage is advised in that situation if a conservative approach is advocated.[68]
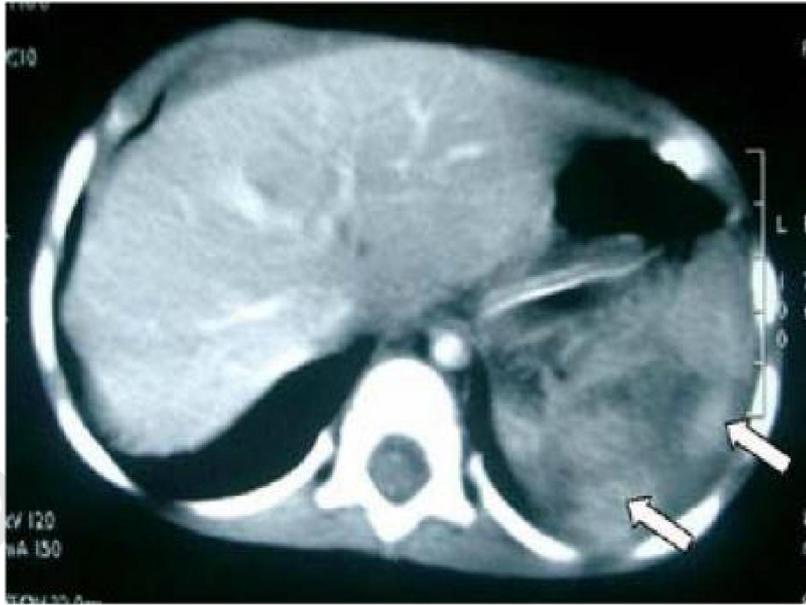
Figure 2. CT scan of the abdomen with intravenous contrast in a 4-years old pedestrian who was hit by a car showing multiple lacerations of the spleen (arrows). The patient was hemodynamically stable and was treated conservatively.[58]
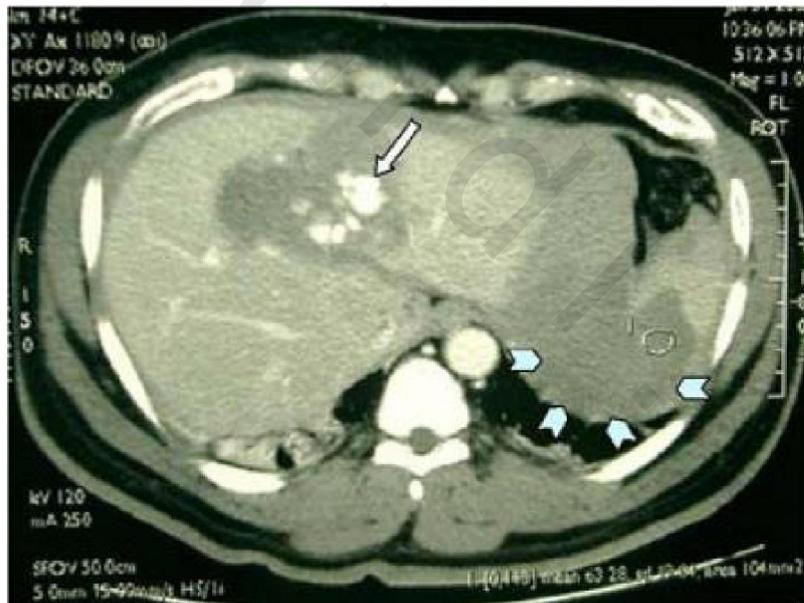

Figure 3. CT with intravenous contrast in a 30 years old male driver who was involved in a road traffic collision. CT has shown active contrast blush inside the liver (arrow). The patient ended with a laparotomy. There is also free fluid near the spleen (arrow heads).[58]
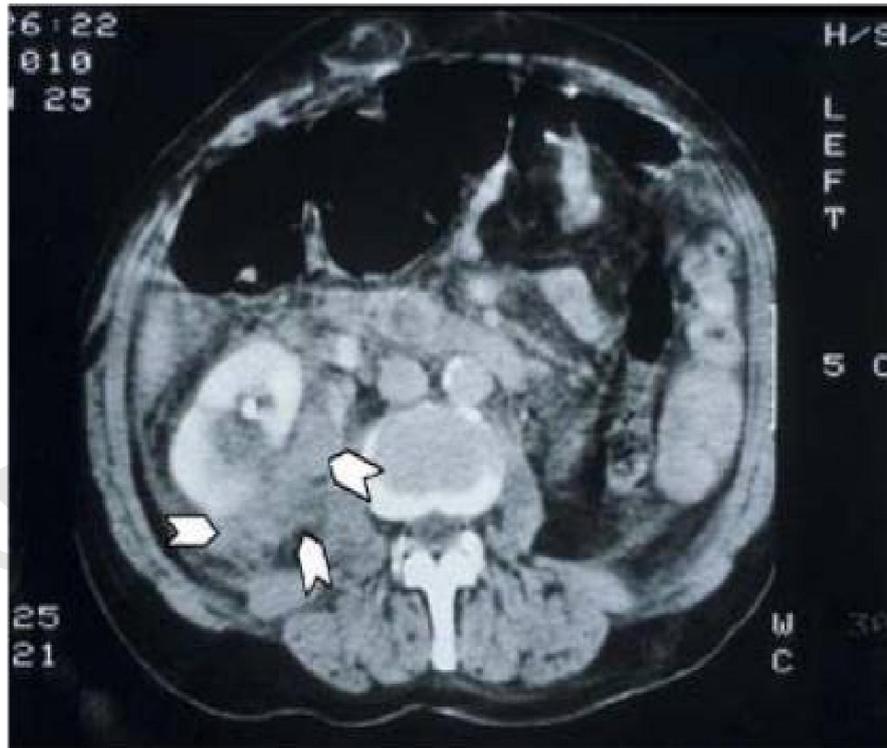
Figure 4. CT scan of the abdomen with intravenous contrast showing good perfusion of the right kidney. There is an injury to the right kidney reaching up to the right pelvis with extravasation of fluid around the kidney (arrow heads).[58]

Diagnostic Laparoscopy:

Diagnostic laparoscopy has been shown to be both diagnostic and therapeutic in abdominal trauma.[69] In hemodynamically stable victims, initial CT of the abdomen is done, if there is either evidence of bowel injury or in equivocal cases, diagnostic laparoscopy is recommended.[70]

Once the decision has been made to perform laparoscopy, the patient is taken to the operating room and the intra-abdominal contents are then systematically evaluated . Once an injury is identified, the surgeon has to take a decision whether to proceed with a laparoscopic repair or convert to an open laparotomy.[71]

Laboratory Studies:

Overall, hematologic and chemical tests provide little assistance to the acute BAT patients.[72]

Complete blood count

• Hemoglobin and hematocrit:

The hematocrit is useful as a baseline study or when significantly low on patient arrival (<30%). 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.[73]

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

- 13 -

loss.[74]Serial levels are often more informative. However, that one liter of intravenous fluids alone (without blood loss) may decrease the hemoglobin level by a point or more.[75]

- **Platelet:**

    Platelet transfusion was used to control active bleeding or to treat patients with thrombocytopenia (i.e. platelet count< 50,000/ mL).[76] The decision to transfuse platelets was based on the extent of surgery/trauma, ability to control bleeding with local measures, rates of bleeding, risk of bleeding, the presence of platelet dysfunction, and other coagulation abnormalities.[77]

- **White blood cells (WBC)**:

    White blood count elevation on admission is nonspecific and does not predict the presence of a hollow viscus injury (HVI).[78]

Coagulation profile

Partial thromboplastin time (PT) / activated partial thromboplastin time (aPTT) was obtained in victims who have a history of blood dyscrasias (e.g. hemophilia), who have synthetic problems (e.g. cirrhosis), or who take anticoagulant medications (e.g. warfarin, heparin).[79]

Blood type and cross match immediately for blood transfusion

Some suggest that the single most important laboratory test in the seriously injured patient is the blood type and cross match.[80]

- **Indications:[81,82,83]**

a. Only used in cases of severe life-threatening hemorrhage not expected to respond to crystalloid resuscitation; can almost always wait until type-specific blood is available.
b. Obvious major bleeding during transport with subsequent impending cardiac arrest due to anemia (not hypovolemia).
c. Major bleeding in the trauma room resulting in hypotension requiring transfusion prior to availability of type specific blood.

Chemical analysis

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 intensive care unit (ICU) and hospital stays, and shock related complications.[84]

Urinalysis

The most consistent sign of serious renal injury is gross hematuria. All victims with gross hematuria require investigation of the genitourinary system. For the stable patients, if the urine is clear yellow on visual inspection, significant renal injury is exceedingly unlikely.[85,86]

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.[87]
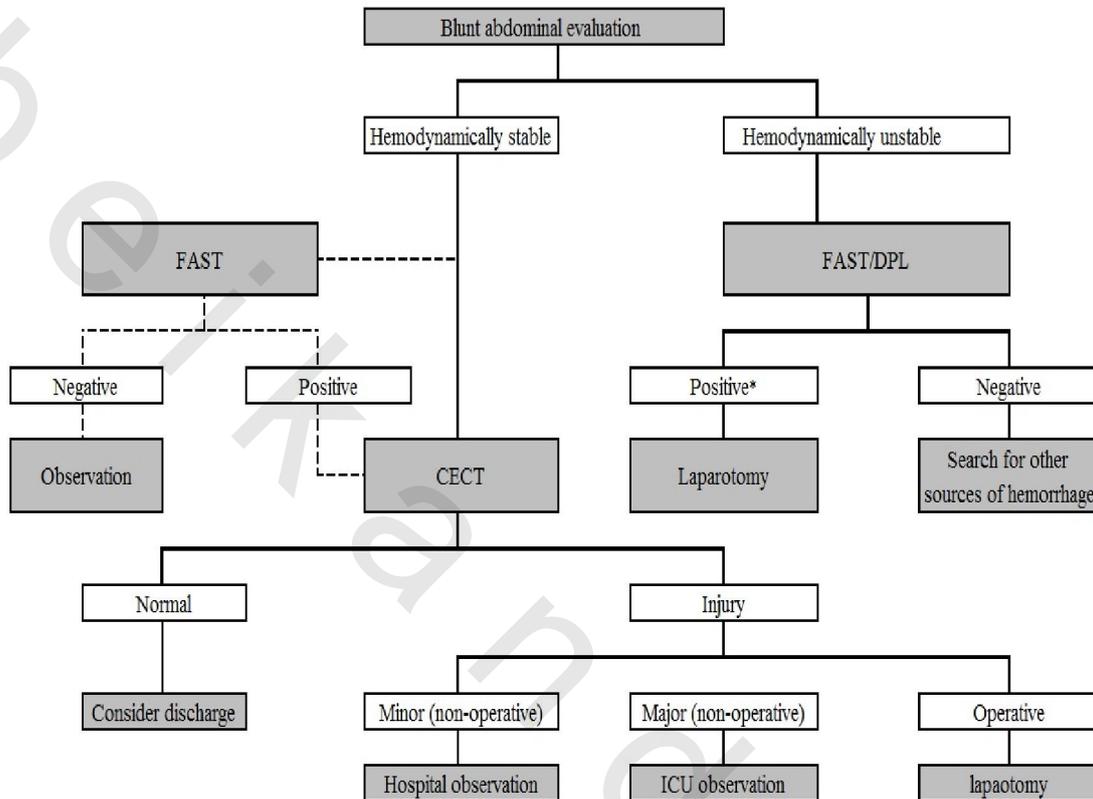
Summary of evaluation of abdomen [88]

Figure 5. Algorithm for abdominal evaluation following blunt trauma.[88]

*Positive DPL: aspiration of >10 ml of gross blood.

Gray boxes: action; White boxes: result; Dashed lines: alternative pathway.

CECT: contrast enhanced CT; FAST: focused abdominal sonogram for trauma; DPL: diagnostic peritoneal lavage

The clinical pathway used to evaluate the abdomen depends on the hemodynamic stability of the patient. The diagnostic priority in the unstable blunt trauma patients is to rapidly determine the source of hemorrhage while resuscitative measures are being carried out. Since such patients cannot be safely transported to the radiology department, the diagnostic modalities are somewhat limited. The two modalities commonly used are DPL, and US.[89]

Blunt trauma patients may be considered hemodynamically stable if after up to two liters of crystalloid infusion the patient is maintaining a systolic blood pressure >90 mmHg (>100 mmHg for older patients), does not have a base deficit (or is normalizing the base deficit), and is making >50 ml of urine every hour.[89] The evaluation of such patients has two aims. First is to rapidly identify patients who will

need operative therapy, and second is to triage patients to optimum level of care observation in the ICU, observation in a regular hospital bed, or discharge without admission.[89]

In a large prospective study over 2000 patients it was shown that patients evaluated by CT after blunt trauma could safely be discharged from the emergency department if the CT was completely normal and the patients did not have any other indication for hospital admission.[90]

Non-operative management (NOM) of BAT

(Schwab et al, 2001)[91] reported that over the past two decades, there has been a major shift from operative to selective NOM of traumatic injuries. Physicians are becoming increasingly comfortable in managing such injuries non operatively.[92] However, a small number of patients with catastrophic intra-abdominal injuries will continue to require immediate and skilled surgical intervention combined with expert resuscitation.[93]

The increased utilization of non operative or 'conservative' treatment, yet surgical management of abdominal solid organ injuries is facilitated by the various sophisticated and highly accurate noninvasive imaging tools at the trauma surgeon's disposal.[94]

The non operative approach relies heavily on the availability of trauma trained surgeons, modern radiographic imaging (particularly CT), accurate interpretation of such high quality radiographic images, as well as the presence of appropriate supporting infrastructure and ancillary services.[94]

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 ICU 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.[95] If time interval from injury is very short, FAST should be repeated prior to discharge from the emergency department. Serial imaging studies have been recommended by some, but there is preference to limit repeated 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.[95]

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 CT carries a high risk for NOM failure. The main criterion for a laparotomy in a NOM patient is hemodynamic deterioration after a second rapid fluid load.[96] Neither grade of injury nor amount of hemoperitoneum on CT predicts the outcome of NOM and mandates laparotomy.[97]

Whereas NOM 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.[98]

Risks associated with NOM:[99,100]

- 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 of laparotomy[85]

At initial presentation

1. Hemodynamic instability with evidence of intra abdominal 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.
4. Hollow viscus injury.
5. Intra peritoneal 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.

Trauma continues to be the major cause of death in children. It is hoped that advances in both prevention and treatment will reduce this toll.