Introduction

Trauma is the leading cause of mortality worldwide, and is a leading cause of death in both men and women under the age of 35 years***(Feliciano et al., 2010).***

Apart from the high incidence of mortality, trauma is responsible for leaving 45 million people per year worldwide with moderate to severe disabilities ***(World Health Organization, 2011).***

It is no surprise that victims of traumatic events have significantly better morbidity and mortality outcomes when treated at centers with designated trauma units, where there are health care professionals that have been trained in specific triage, diagnostic and treatment techniques to manage trauma patients***(Mackenzie et al., 2009).***

One of the main complications leading to high mortality after trauma is exsanguinations from injuries to organs of the abdomen. The liver and spleen are the most common culprits, with the kidneys injured often as well***(Zwingmann et al., 2010).***

Blunt abdominal trauma is most frequently caused by motor vehicle accidents involving both vehicles and pedestrians. A minority of other causes include blows or falls involving the abdomen***(Davis et al., 2013).***

Non-therapeutic laparotomy was the primary method by which trauma personnel uncovered significant abdominal injury but it carries a risk of complication and exposes the patient to the short- and long-term sequelae of the procedure***(Nagy et al., 2012).***

FAST (focused assessment with sonography for trauma) is a bedside ultrasound assessment protocol that can be performed rapidly as a screening tool for the detection of intraperitoneal injury and, less commonly, pericardial tamponade***(Korner et al., 2011).***

The assessment is not overly complex, and can be performed by surgeons and radiologists with equal reliability ***(Branney et al.,2013).***

FAST is performed with the patient supine (if possible) and uses a mobile ultrasound machine, it`s depth of ultrasound wave penetration must be at least 20cm, so the transducer frequency that is usually required is 3.5-5MHz with a convex transducer ***(Korner et al., 2011).***

When performed by experienced sonographers, the entire exam will take no longer than 5 minutes to complete.

However, complications in obtaining the standard views can prolong the assessment***(Korner et al., 2011).***

The FAST protocol has many key advantages that make it superior to diagnostic peritoneal lavage (DPL) in the assessment of abdominal trauma as it boasts relative ease of use, rapidity, availability, and low cost imaging ***(Helling et al., 2010).***

However, limitations to the FAST technique do exist as it doesn`t accurately detect the extent of, in some cases, the precise site of organ injury so FAST-positive patients often need to be followed up with a CT scan to locate the origin of the bleeding and evaluate the extent of the injury ***(Schnuriger et al.,2009).***

Recent evidence suggests that clinical suspicion should still play an important role in determining the therapeutic steps for trauma patients as in a negative FAST result could probably still be followed with a CT scan to ensure that no intra-abdominal injury exists***(Brink et al.,2012).***

However, equivocal results only made up 6.7% of the assessments when FAST was undertaken by trained clinical sonographers***(Boulanger et al.,2009).***

Aim of the Work

The aim of the study is to emphasize the role and the importance of ultrasound in diagnosing and assisting Emergency Physicians, Radiologists and Trauma Surgeons to make timely decision for the stable and unstable patients with blunt abdominal trauma.

The Peritoneal Anatomy & its Reflections

The peritoneum is the largest and most complexly arranged serous membrane in the body. The potential spaces, the peritoneal reflections forming peritoneal ligaments, mesenteries and omenta **(fig.1)**, and the natural flow of peritoneal fluid determine the route of spread of intra peritoneal fluid and consequently disease processes within the abdominal cavity. The peritoneal ligaments, mesenteries and omenta also serve as boundaries for disease processes, and conduits for disease spread. The peritoneal cavity and its reflections are frequently involved by infective, inflammatory, neoplastic and traumatic processes ***(Healy and Reznek, 2000).***

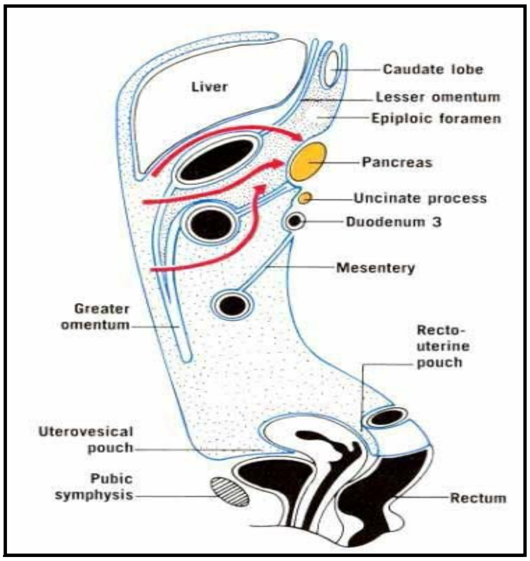

Figure (1): Median section through the abdomen to show the peritoneal cavity. The lesser sac is situated behind the stomach and in front of the pancreas. The caudate lobe invaginates the lesser sac. Below the liver, the stomach, transverse colon, and small intestine are seen in section. The greater omentum and transverse mesocolon are fused posteriorly. The arrows indicate surgical approaches to the lesser sac ***(O'Rahilly, 2009).***

The Spleen:

The spleen's 2 ends are the anterior and posterior end. The anterior end of the spleen is expanded and is more like a border; it is directed forward and downward to reach the midaxillary line. The posterior end is rounded and is directed upward and backward; it rests on the upper pole of the left kidney. The 2 surfaces of the spleen are the diaphragmatic and visceral. The diaphragmatic surface is smooth and convex, and the visceral surface is irregular and concave and has impression **(fig.2)*****(Pai, 2012)*****.**

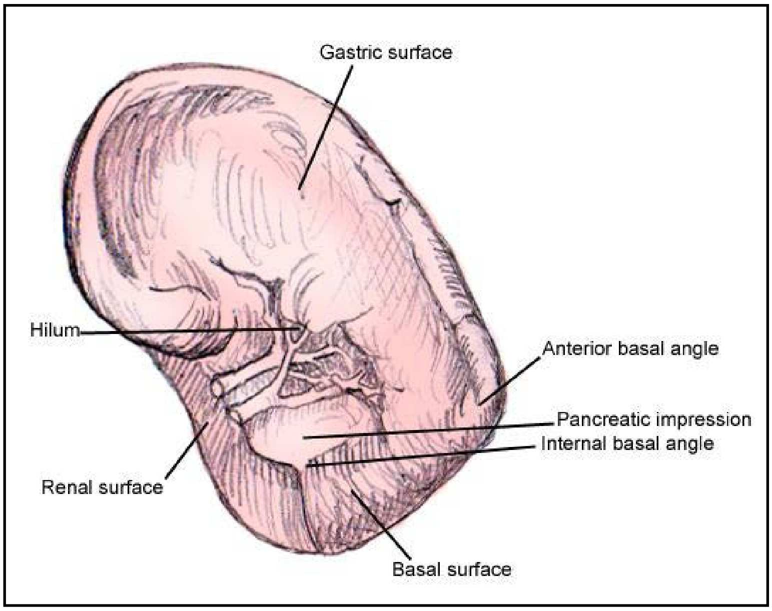

Figure (2): Spleen anatomy. This image shows different surfaces and impressions caused by different organs in relation to the spleen's hilum ***(Pai, 2012).***

Vascular supply:

The splenic artery supplies blood to the spleen. This artery is the largest branch of the celiac trunk and reaches the spleen's hilum by passing through the splenorenal ligament. It divides into multiple branches at the hilum.It divides into straight vessels called penicillin, ellipsoids, and arterial capillaries in the spleen***(Pai, 2012).***

The splenic circulation is adapted for the separation and storage of the red blood cells. The spleen has superior and inferior vascular segments based on the blood supply. The 2 segments are separated by an avascular plane ***(Pai, 2012).***

The Liver:

The upper surface of the liver is percussed at the level of the fifth intercostal space. Superior, anterior, posterior and right surfaces of the liver are continuous with each other and are related to the diaphragm and anterior abdominal wall ***(Kapoor, 2012).***

The anterior surface is separated from the inferior (visceral) surface by a sharp anterior (inferior) border that is clinically palpable. The inferior surface is related to the hepatic flexure (the area where the vertical ascending (right) colon takes a right-angle turn to become the horizontal transverse colon), right kidney, transverse colon, duodenum and stomach. The gallbladder straddles the undersurfaces of liver segments IVB and V***(Kapoor, 2012).***

Anatomic divisions:

Anatomically, the liver is divided into a larger right lobe and a smaller left lobe by the falciform ligament **(fig.3).** This division, however, is of no use surgically ***(Kapoor, 2012).***

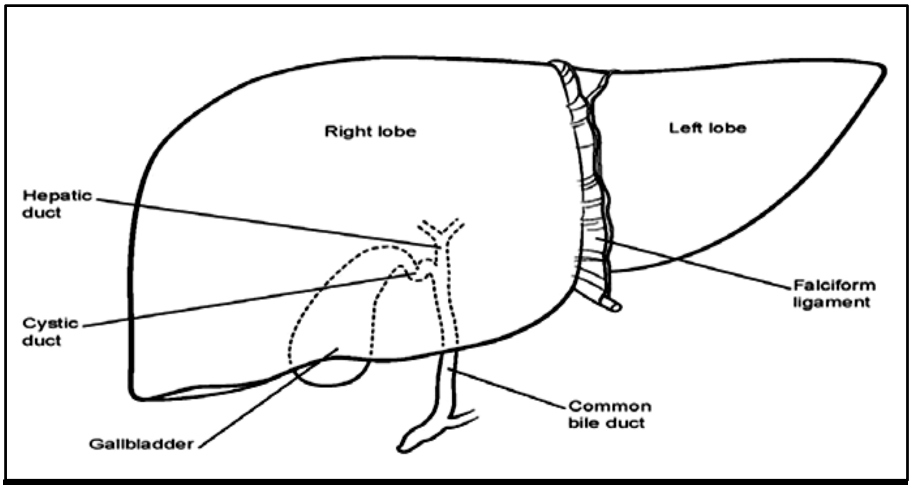

Figure (3): Liver and gallbladder,anterior view ***(Kapoor, 2012).***

From a surgical point of view, the liver is divided into right and left lobes of almost equal size by a major fissure (Cantlie’s line) running from the gallbladder fossa in front to the IVC fossa behind. This division is based on the right and left branches of the hepatic artery and the portal vein, with tributaries of bile (hepatic) ducts following. The middle hepatic vein (MHV) lies in Cantlie's line. The left pedicle (left hepatic artery [LHA], left branch of the portal vein, and left hepatic duct) has a longer extrahepatic course than the right ***(Kapoor, 2012).***

Each lobe is divided into 2 sectors. The right hepatic vein (RHV) divides the right lobe into anterior and posterior sectors; the left hepatic vein (LHV) divides the left lobe into medial (quadrate) and lateral sectors. The posterior sector of the right lobe and the caudate lobe are not seen on a frontal view of the liver; the anterior sector of the right lobe forms the right lateral border in this view***(Kapoor, 2012).***

Liver anatomy can be described using two different aspects: morphological anatomy and functional anatomy. The traditional morphological anatomy is based on the external appearance of the liver and does not show the internal features of vessels and biliary ducts branching, which are of obvious importance in hepatic surgery. C. Couinaud (1957) divided the liver into eight functionally indepedent segments. This classification will be presented here with several illustrations ***(Smithuis, 2006).***

Couinaud classification:

The Couinaud classification of liver anatomy divides the liver into eight functionally indepedent segments. Each segment has its own vascular inflow, outflow and biliary drainage. In the centre of each segment there is a branch of the portal vein, hepatic artery and bile duct. In the periphery of each segment there is vascular outflow through the hepatic veins ***(Smithuis, 2006).***

Portal vein divides the liver into upper and lower segments. The left and right portal veins branch superiorly and inferiorly to project into the center of each segment ***(Smithuis, 2006).***

Because of this division into self-contained units, each segment can be resected without damaging those remaining. For the liver to remain viable, resections must proceed along the vessels that define the peripheries of these segments. This means, that resection-lines parallel the hepatic veins, The centrally located portal veins, bile ducts, and hepatic arteries are preserved ***(Smithuis, 2006).***

Segments numbering:

There are eight liver segments. Segment 4 is sometimes divided into segment 4a and 4b according to Bismuth. The numbering of the segments is in a clockwise manner, Segment 1 (caudate lobe) is located posteriorly. It is not visible on a frontal view **(fig.4)*(Smithuis, 2006).***

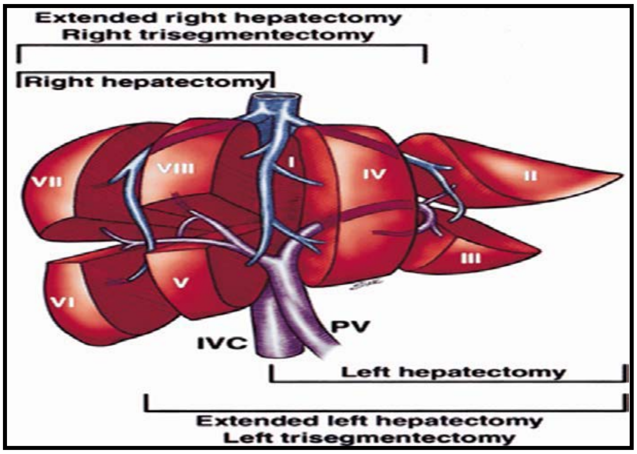

Figure (4): Schematic illustrates Couinaud segmental liver anatomy and the normal portal venous structures. The possible hepatic resection procedures are also shown.*IVC*= inferior vena cava, *PV*= portal vein ***(Madoff et al., 2002).***

Vascular supply

The liver has a unique dual blood supply (about 1500 mL/min) both from the proper hepatic artery (20-40%) and from the portal vein. The celiac trunk (axis) comes off the anterior surface of the abdominal aorta at the level of T12 – L1 between the right and left crura of the diaphragm. It is a short structure (about 1cm) that trifurcates into the common hepatic artery (CHA), the splenic artery, and the left gastric artery (LGA) ***(Kapoor, 2012).***

The Gall Bladder & CBD

The gallbladder is a piriform (pear-shaped) organ that straddles the under surface of segments IVB and V of the liver. It has an inferior peritoneal surface and a superior hepatic surface that is closely applied to the gallbladder bed in the liver. The part of the gallbladder projecting beyond the undersurface of the liver is called the fundus, which continues into the main body of the gallbladder. On computed tomography, the gallbladder neck is seen in higher cuts (sections) than the gall bladder body, which is seen higher than the gallbladder fundus***(Kapoor, 2011).***

The body of the gall bladder narrows into a neck, which leads through an infundibulum to the cystic duct. An inferior sacculation (outpouching) of the gallbladder neck is sometimes present; this is called Hartmann's pouch. A peritoneal cholecysto-duodenal fold connects the gallbladder neck to the first part of the duodenum. A normal gallbladder has a capacity of 30-50 mL but is immensely distensible; an obstructed gallbladder (mucocele) can expand to several times its normal size ***(Kapoor, 2011).***

The right and left hepatic ducts join outside the liver in its hilum (portahepatis) to form the common hepatic duct (CHD). The cystic duct joins the CHD to form the common bile duct (CBD), which travels downward in the HDL along with the hepatic artery to its right and the portal vein behind it ***(Kapoor, 2011).***

The terminal part of the CBD is joined by the terminal part of the pancreatic duct in the pancreatic head to form a common channel (called the hepato-pancreatic ampulla when dilated), which runs through the medial duodenal wall and opens on the dome of the greater duodenal papilla, a nipplelike projection on the medial wall of the middle segment of the second part (C loop) of the duodenum. Both ampulla and papilla are eponymously related to Vater ***(Kapoor, 2011).***

The Kidneys:

The kidneys are paired retroperitoneal structures that are normally located between the transverse processes of T12-L3 vertebrae, with the left kidney typically somewhat more superior in position than the right. The upper poles are normally oriented more medially and posteriorly than the lower poles. They are typically 10-12 cm in length, 5-7 cm in width, and 2-3 cm in thickness **(fig.5)*****(Hoenig, 2011).***

Vasculature:

The kidneys receive approximately 20% of the cardiac output. The blood supply to the kidneys arises from the paired renal arteries at the level of L2. They enter into the renal hilum, the passageway into the kidney, with the renal vein anteriorly; the renal artery; and the renal pelvis posteriorly ***(Hoenig, 2011).***

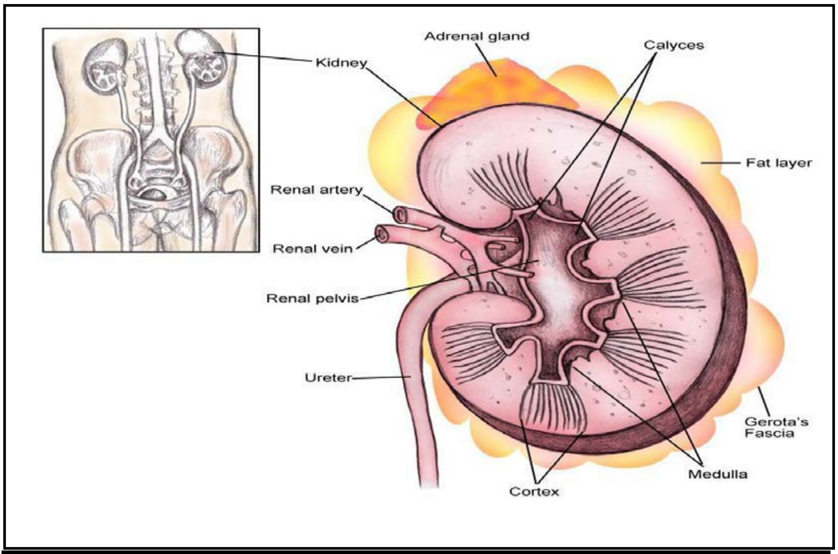

Figure (5): Renal anatomy, renal fascia ***(Hoenig, 2011).***