Introduction

Postoperative bile leakage is one of the commonest causes of sepsis and liver failure after liver resection in liver donor ***(Yamashita YI et al., 2001) (Langer D et al., 2011)***. Various studies have showed that the incidence of postoperative bile leakage after liver resection ranges from 3 to 27% ***(Erdogan D et al., 2008) (Ishii H et al., 2011).***

The timely detection and repair of intraoperative bile leakage is extremely important, but small leakage points are often difficult to detect ***(Liu Z et al., 2012).*** There are different methods for detecting and or preventing bile leakage after partial liver resection, including bile leakage tests, which detect open bile duct stumps on the resection surface through increasing fluid pressure within the duct ***(Lo CM et al., 1998).***

The conventional intraoperative saline test, which involves injecting an isotonic sodium chloride solution through the cystic duct, has been used for detection of leaking points from the transected liver surface ***(Ijichi M et al., 2000).***

One of the main problems in using the conventional bile leakage test is that the isotonic sodium chloride solution is a

transparent solution. Therefore, it is hard to detect the point of bile leakage. A previous randomized study stated that there is no advantage to using the isotonic sodium chloride solution for the bile leakage test during liver resection ***(Ijichi M et al., 2000).***

Recently, intraoperative application of the White test has been demonstrated to reduce the incidence of postoperative bile leakage ***(Li J et al., 2009) (Nadalin S et al., 2008).*** The White test uses fat emulsion (SMOFLIPID), which is a lipid emulsion with a lipid content of 0.2 grams/mL in 100 mL, 250 mL, and 500 Ml that is normally used for parenteral nutrition، can be used for localization of bile leakage (***Morris-Stiff G et al., 2009)***. The use of fat emulsion in bile leakage tests does not require special equipment, contaminate the wound, cause allergic reaction or damage the bile duct and surrounding tissues. It can easily be repeated the number of times necessary to detect and close all leakage points, can pinpoint even small leaks and is inexpensive

In this technique, bile leakage sites on the transected liver surface are noted by injecting a fat emulsion solution through the cystic duct. The previous prospective

observational studies suggested that the fat emulsion solution used in the White test is easily recognized, innocuous and harmless to the tissues, and can be easily removed without misleading tissue staining ***(Li J et al., 2009) (Nadalin S et al., 2008).*** Therefore, this prospective study will assess whether the White test is better than the conventional saline test for the intraoperative detection of bile leakage and better prevention of post-operative bile leakage in partial resection in living donor liver transplant.

Aim of the Work

In this study, we assess whether the White test is better than the conventional saline test for the intraoperative detection of biliary leakage in Donors who will undergo partial liver resection in LDLT setting.

Embryology of the biliary system

The biliary system and liver originate from the embryonic foregut. Initially, at week four, a diverticulum arises from the ventral surface of the foregut (later duodenum (cephalad to the yolk sac wall and caudad to the dilation that will later form the stomach. The development of the liver involves an interplay between an endodermal evagination of the foregut and the mesenchymal cells from the septum transversum. The liver diverticulum initially separates into a caudal and cranial portion. The caudal portion gives rise to the cystic duct and gall bladder and the cranial portion gives rise to the intrahepatic and hilar bile ducts. As the cranial diverticulum extends into the septum transversum mesenchyme, it promotes formation of endothelium and blood cells from the mesenchymal cells. The endodermal cells differentiate into cords of hepatic cells and also form the epithelial lining of the intrahepatic bile ducts (Fig 1(***Larsen W. et al., 1997).***

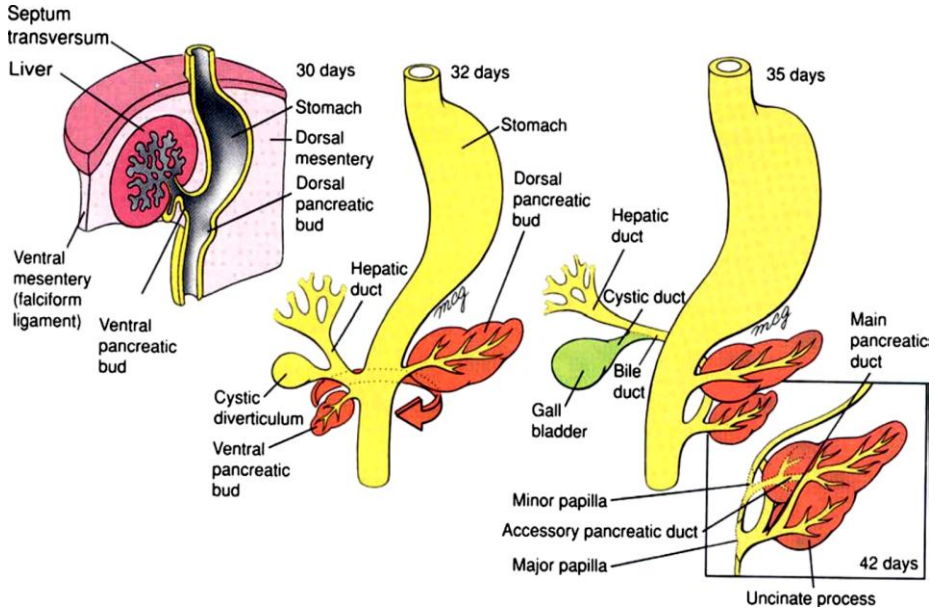

Figure (1): Development of the liver, gallbladder, bile ducts, and pancreas. The liver bud begins to expand into the ventral mesentery during the fourth week. (***Larsen W. et al., 1997).***

The ductal cells follow the development of the connective tissues around the portal vein branches. This developmental process results in the similarity seen between the portal vein branching pattern and the bile duct pattern. At first, the bile duct precursors are discontinuous but eventually they join one another and then connect with the extrahepatic bile ducts. The extrahepatic biliary system is initially occluded with epithelial cells but later it canalizes as cells degenerate. The stalk that connects the hepatic and cystic ducts to the duodenum differentiates into the common bile duct (CBD). Initially the duct is attached to the ventral aspect

of the duodenum but when the duodenum undergoes rotation later on in development, there is repositioning of the CBD to the dorsal aspect of the duodenal wall ***(Moore K., et al 1998)***

ANATOMY OF THE LIVER AND THE BILIARY SYSTEM

The liver is the largest of the abdominal viscera, occupying a substantial portion of the upper abdominal cavity. It occupies most of the right hypochondrium and epigastrium, and frequently extends into the left hypochondrium as far as the left anterior axillary line (**fig. 2)**. (***Patil S et al.,2014).***

The liver performs a wide range of metabolic activities required for homeostasis, nutrition and immune defense. For example, it is important in the removal and breakdown of toxic, or potentially toxic, materials from the blood; the regulation of blood glucose and lipids; the storage of certain vitamins, iron and other micronutrients; the synthesis of proteins and clotting factors; the metabolism of amino acids; and bile production. It is involved in a plethora of other biochemical reactions**. (Kiernan F. 1833)**.

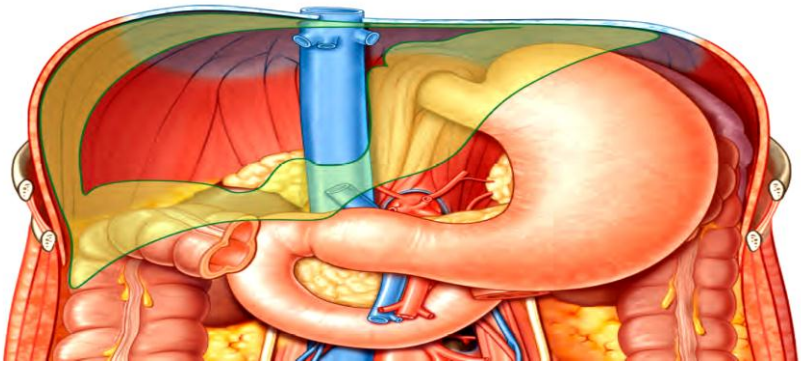

Figure (2): The 'bed' of the liver. The outline of the liver is shaded green. The central bare area is unshaded. (***Adkins et al.,2000)***

Gross anatomical lobes:

Historically, the liver has been divided on the basis of its external appearance into right, left, caudate and quadrate lobes, which are, in part, defined by peritoneal ligamentous attachments**.**

Right lobe the right lobe is the largest in volume and contributes to all surfaces of the liver. It is divided from the left lobe by the falciform ligament anteriorly and superiorly and the ligamentum venosum and fissure for the ligamentum teres inferiorly. On the inferior surface, to the right of the grooves formed by the ligamentum teres and ligamentum venosum, there are two prominences separated by the porta hepatis; the caudate lobe lies posterior, and the quadrate lobe

lies anterior the gallbladder lies in a shallow fossa to the right of the quadrate Lobe ***(Joshi et al., 2009).***

Left lobe the left lobe is the smaller of the two main lobes, although it is nearly as large as the right lobe in young children. It lies to the left of the falciform ligament with no subdivisions. It is substantially thinner than the right lobe, having a thin apex that points into the left Upper quadrant.

Quadrate lobe the quadrate lobe is visible as a prominence on the Inferior surface of the liver, to the right of the groove formed by the Ligamentum teres (and thus is incorrectly said to arise from the right Lobe, although it is functionally related to the left hemi-liver). It lies anterior to the porta hepatis and is bounded by the gallbladder fossa to the right, a short portion of the inferior border anteriorly, the fissure for the ligamentum teres to the left, and the porta hepatis posteriorly. Like the caudate lobe, its morphology varies between individuals ***(Joshi et al., 2009).***

Caudate lobe the caudate lobe is visible as a prominence on the Inferior and posterior surfaces to the right of the groove formed by the ligamentum venosum; it lies posterior to the porta hepatis. To its right is the groove for the inferior vena cava. Above, it continues into the superior

surface on the right of the upper end of the fissure for the ligamentum venosum. In gross anatomical descriptions, this lobe is said to arise from the right lobe but it is functionally separate. **(Joshi et al., 2009).**

Sectors and segments of the liver

Sectors

The sectors of the liver are made up of between one and three segments:

Right lateral sector = segments vi and vii, right medial sector = segment V and viii, left medial sector = segments iii and iv (and part of i) Clockwise from below, starting with segment i and ending with segment Viii **(figure 3).**

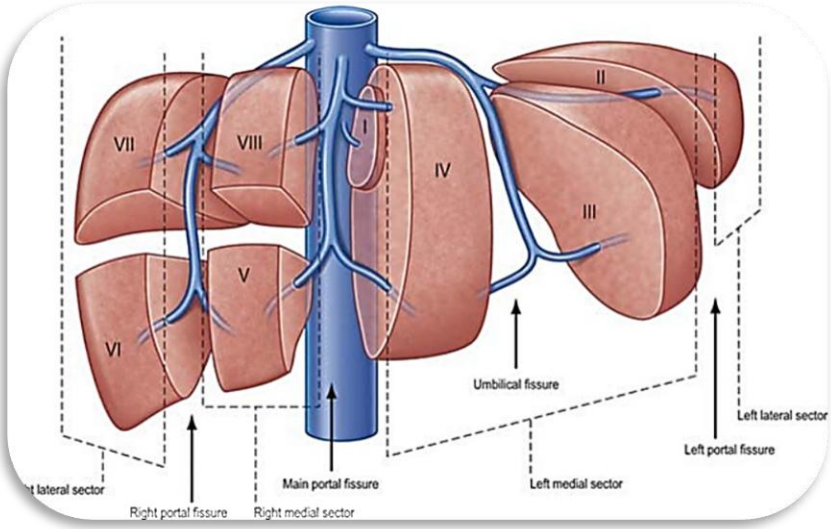

Figure (3): Functional segments of the liver. Reference ***(Adkins et al., 2000)***

Segments of the liver the liver is composed of eight vascular segments, which have their own arterial and portal venous supply, hepatic venous and biliary drainage. In major liver surgeries, transection of liver parenchyma was effected along the boundaries of these segments, so understanding of segmental anatomy and terminology used is essential in various interventional procedures. Several systems of classification of liver segmentation have been proposed without any standardized terminology to describe liver segments. Goldsmith and wood-burn have divided the liver into four segments based on the second order portal vein branching. ***Couinaud and Le Foie*** divided the liver into eight segments based on third order portal vein branching, and this classification system is widely used worldwide ***(Couinaud and Le Foie, 1957).***

The terminology committee of the international hepato-pancreaticobiliary association (IHPBA), in 2000 proposed a standardized terminology for liver segmentation and hepatic resections. The IHPBA described the segmental liver anatomy according to the first, second, and third order branching patterns of the bile ducts and hepatic arteries. The first order division divides liver into the left and right hemi-livers. This watershed border is referred as mid-plane of the liver and passes above through the plane of the middle hepatic vein and below through inferior vena cava and fossa for gall bladder, also known as Cantlie's line. The second-order division demarcates the

section/sector, divides the liver into four sections. The right liver is divided into right anterior (segment V and VIII) and right posterior sections (segment VI and VII). The left liver is divided into left lateral (segment II and III) and left medial sections (segment IV). The segment I, also called as Spigel's lobe defined between fissure for ligamentum venosum and Cantlie's line. It is little different in that, it consists of part of the right and left livers due to multiple vascular pedicles, its venous anastomosis and its direct drainage into the inferior vena cava, accounting for its hypertrophy in Budd-Chiari syndrome. In practice, the terms "quadrate lobe" and "caudate" are often used incorrectly; the lower and anterior part of segment IV, also named as IV-b is the quadrate lobe and left lateral portion of the segment I is designated as caudate lobe. The third order division of portal vein denotes the individual segments of the liver and are referred to as segments 1-8 and are separated by intersegmental planes **(figure 4, 5).**

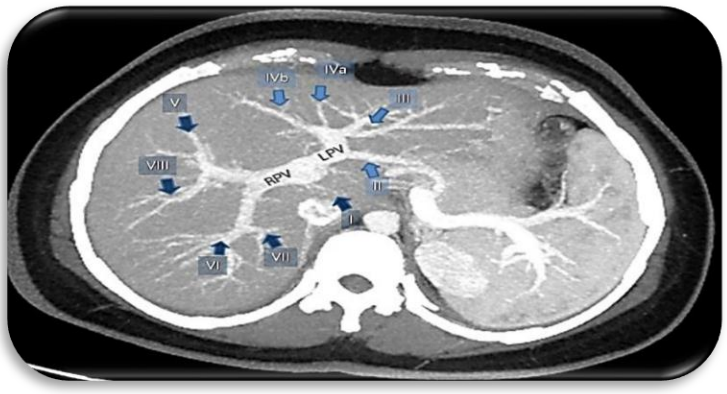

Figure (4): CT Showing segment of the liver. ***(Oliveira et al.,2011)***

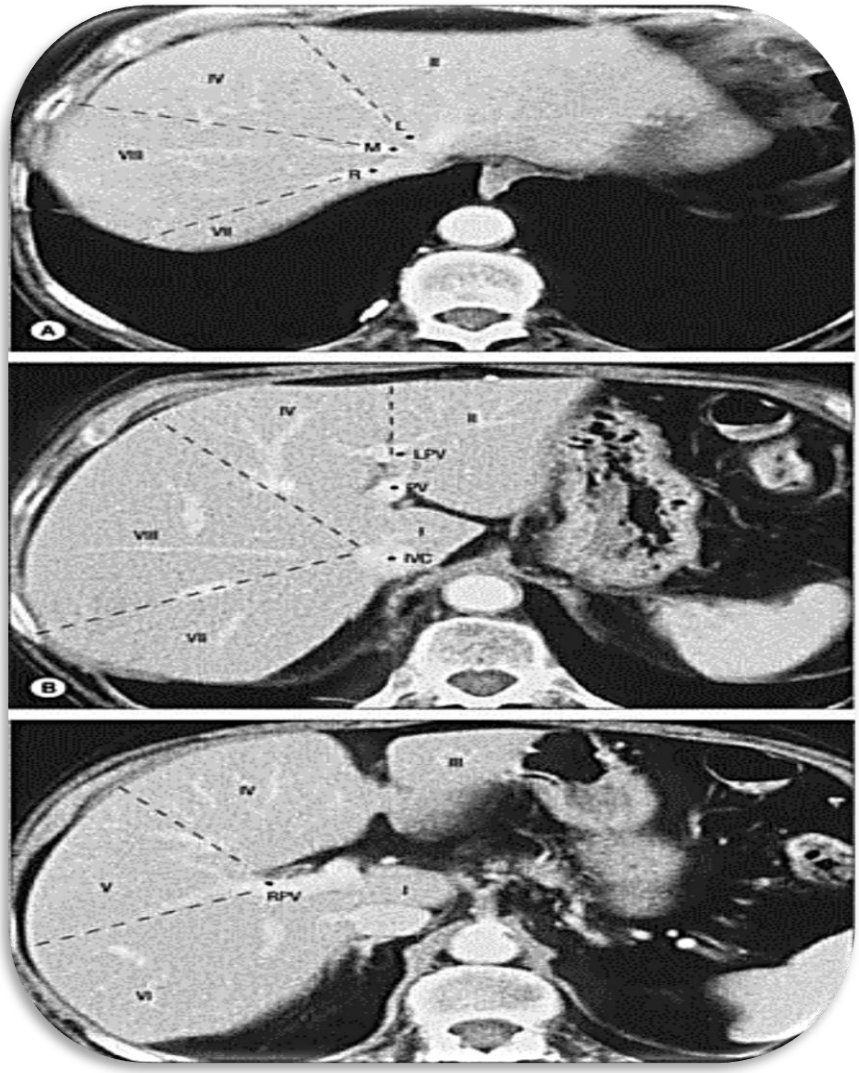

Figure (5): Segments of the liver seen on axial CT scan. A, Contrast enhanced CT shows the left (L), middle (M), and right (R(hepatic veins at the superior aspect of the liver marking the left main and right portal fissures. B, Inferior to this the caudate lobe (segment I(lies between the inferior vena cava (IVC(and the main portal vein (PV). The left portal vein (LPV(separates segment II superiorly from segment III inferiorly. C, The right portal vein (RPV(divides segments V and VI inferiorly (C(from segments VII and VIII superiorly (B)**. *(Oliveira et al.,2011)***

Porta hepatis and hilar plate the porta hepatis is a deep transverse fissure on the inferior surface of the liver. It is situated between the quadrate lobe anteriorly and the caudate process posteriorly, and contains the portal vein, hepatic artery and hepatic nervous plexuses as they ascend into the parenchyma of the liver, and the right and left hepatic ducts and some lymph vessels that emerge from the liver. The hepatic ducts usually lie anterior to the portal vein and its branches, and the hepatic artery with its branches lies between the two. However, the right hepatic artery, sometimes lies anterior to the common hepatic duct; this variation is important during bile duct reconstruction by hepaticojejunostomy.

All these structures are enveloped within a perivascular sheath of loose connective tissue that surrounds the vessels and bile ducts as they course through the liver parenchyma, and is continuous with the fibrous hepatic capsule (of Glisson). The dense aggregation of vessels, supporting connective tissue, and liver parenchyma just above the porta hepatis is often referred to as the 'hilar plate' of the liver. ***(Lanouis and Jamieson, 1993).***

Vascular supply and lymphatic drainage