# INTRODUCTION

Bile duct injuries are an infrequent but potentially devastating complication of biliary tract surgery, with cholecystectomy accounting for the largest proportion of such injuries. The annual incidence of bile duct injuries increased from approximately 0.2% in the era of open cholecystectomy to approximately 0.5% after laparoscopic cholecystectomy became widely available. Biliary injuries are associated with high morbidity and mortality, impaired quality of life, and substantial financial burdens to patients and society ***(Thompson et al., 2013).***

Optimal management of biliary injuries is achieved with a multidisciplinary approach. Successful management depends on the type of injury, timing of injury recognition, presence of complications, condition of the patient, and availability of experienced hepatobiliary surgeons. Radiologists play a key role in diagnosis and treatment. Imaging is vital for initial diagnosis, assessment of the extent of injury, and preprocedural planning. Depending on the type of injury, appropriate management methods may include endoscopic, percutaneous, and surgical interventions ***(Thompson et al., 2013).***

Biliary postoperative complications include biliary stenoses, biliary leaks, fistulas and collection or abscess formation. These complications usually occur due to injury after laparoscopic cholecystectomy, gastric or hepatic resection, bilio-enteric anastomosis and after liver transplantation. In most of the cases a new surgical intervention is not possible. Endoscopic intervention is usually the optimal initial management of these complications; however, in patients with altered enteric passage, tight low biliary stricture, high up obstruction or leakage endoscopic approach becomes impossible. Therefore, the percutaneous trans-hepatic approach is of extreme importance in the diagnosis and treatment of the problem especially in complex cases ***(Krokidis et al., 2013).***

Interventional radiology (IR) has an established role in the diagnosis and management of patients with post-operative biliary complications. Postoperative benign biliary stenoses and/or biliary leaks and fistulas may be effectively treated with dilatation of the narrowed anastomotic tract or bile diversion away from the site of defect in the bile wall. Drain collection and closure of fistulas by emolizing materials such as coils or glue are the other options for bile leak percutaneous treatment. A large variety of combination of dilatation and drainage may be used on a “case-by-case” basis with the use of various techniques and materials ***(Krokidis et al., 2013)***.

# AIM OF THE WORK

This study aims to highlight the spectrum of percutaneous cholangiographic findings and methods of treatment of postoperative benign biliary stenoses, biliary leaks and detect its significance in management of these problems.

# ANATOMY OF THE BILIARY SYSYTEM

The biliary tract has to be seen as integrated in a whole system, each component of which is interrelated in a logical scheme of construction that guarantees reliability and durability, two major characteristics of human living organs.

## I) Gross anatomy of the biliary system:

### A-Description of the biliary tree:

#### (1) Intrahepatic biliary network:

The distribution of the intrahepatic biliary network is exactly the same as that of the portal venous network **(Fig 1)** corresponding to functional sectors and segments of the liver. It should be stressed that the number of ducts seems invariable and there are no anastomoses, like in the portal system, interconnecting the biliary ducts. Segments II, III, and IV correspond roughly to the left lobe, V, VI, VII, and VIII to the right lobe, and I to the caudate lobe. All the branches of the intrahepatic bile network can be identified. Some are of particular importance for cholangiographic identification ***(Rabischong and Pissas.,1997).***

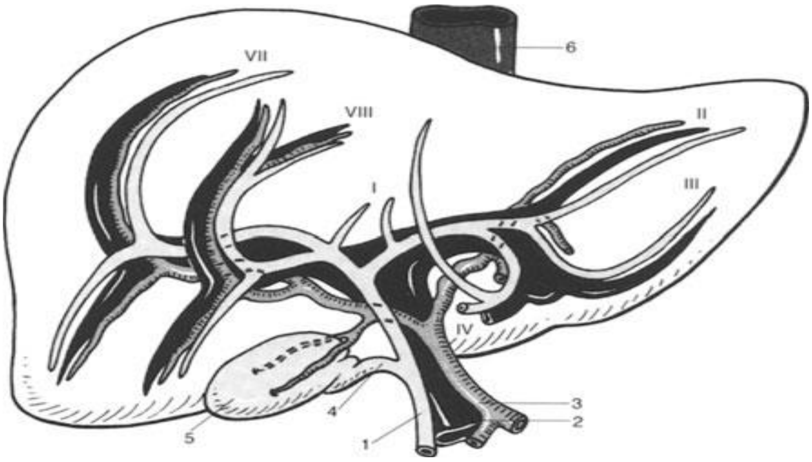


**Figure (1):** Anterior aspect of the liver and intrahepatic biliary network. 1, choledochous duct; 2, portal vein; 3, hepatic artery; 4, cystic duct; 5, gallbladder; 6, vena cava. The roman numbers refer to the hepatic segments ***(Quoted from Rabischong and Pissas.,1997).***

Therefore the general appearance of these ducts is different on the right side, where they are superimposed on each other because the paramedian sector is anterior to the lateral, and on the left, where the network is more transversely disposed. Anyway, all these ducts are contained together with the portal and arterial branches in a special fibrous tissue, GLISSON'S capsule. Bile ducts, arteries, and nerves are included within the fibrous tissue, but veins are separated from them by a connective tissue layer, which makes them easier to identify on sections. Some lymph vessels are also present in this space. ***(Rabischong and Pissas.,1997)***

## *(2) The Hepatic Ducts:*

All the intrahepatic bile ducts finally converge into the two main right and left collectors **(Fig 2).**

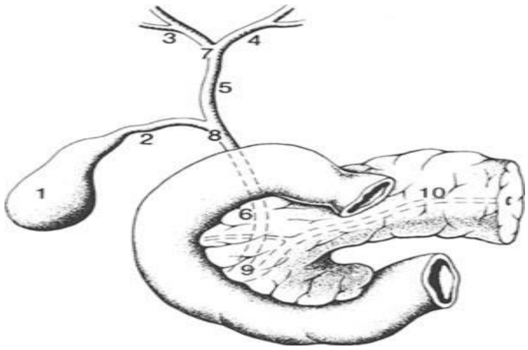


**Figure (2):** General view of the biliary tract. 1, Gallbladder; 2, cystic duct; 3, right hepatic duct; 4, left hepatic duct; 5, common hepatic duct; 6, retropancreatic portion of the choledochous duct; 7, superior biliary confluence; 8, junction with accessory storage circuit; 9, hepatopancreatic canal with the sphincter of Oddi; 10, pancreatic canal ***(Quoted from Rabischong and Pissas.,1997).***

The right hepatic duct is normally relatively short and vertically aligned with the common bile duct. It is made up of the anterior ramus, draining segments V and VIII, and the posterior ramus, for segments VI and VII. The left hepatic duct is more horizontal, in front of the left portal branch. Via a common trunk it receives ducts from segments II and III, in which segments I and IV are connected. It is important to realize that in 40% of subjects the right hepatic duct is missing, and the right ducts may be connected with the left duct or the common duct. In 3% of subjects, all the segmental ducts converge at the origin of the choledochous duct ***(Rabischong and Pissas.,1997).***

**(*3) Common bile duct*:**

The common bile duct has two parts: the common hepatic duct, going from the superior biliary confluence to the junction with the cystic canal, and the choledochous duct, which ends in the second portion of the duodenum. Its total length is normally between 40 and 60 mm, the length of each part varying greatly according to the level of the cystic canal connection ***(Rabischong and Pissas.,1997).***

The general orientation is in a large curve directed anteriorly and to the right. The inferior part crosses behind the duodenopancreas, making a groove in the head of the pancreatic gland, which can in some cases be a real intraparenchymal tunnel. Then the bile duct penetrates the duodenal wall obliquely, 3-4 cm from the pylorus, in the posterior and median zone of the second descending portion of the duodenum, in 60% of cases. ***(Rabischong and Pissas.,1997).***

A special window through the muscular layer of the duodenal wall allows the choledochous duct to join the major pancreatic duct to constitute a common canal. This hepatopancreatic canal has at its end a small dilatation which was described by VATER and is therefore known as the ampulla of VATER. It is of very variable size, and sometimes the junction of the two canals occurs within the pancreas, or else they arrive separately at the level of the papilla. A special sphincter described by ODDI, made of smooth muscle fibers situated around the end of the two canals as well as the ampulla, is a special feature, embryologically and histologically different from the muscular layer of the duodenum ***(Rabischong and Pissas.,1997).***

The size of the sphincter and the disposition of the fibers- whether circular or spiral - are variable. The mucosa within the junction has a different shape than in the common duct. Small folds, corresponding to special glandular systems, may be visible. The opening itself in the duodenal lumen is variable. In most cases it looks like a papilla surrounded superiorly by a mucosal fold and inferiorly by a vertical fold, called the papilla string. However, in some cases, no protrusion of the papilla is visible and only the flow of bile makes possible the identification of the mucosal orifice ***(Rabischong and Pissas.,1997).***

***(4) Gall bladder (bile reservoir):***

An accessory circuit allows storage of bile. The reservoir itself, the gallbladder is normally 8-10 cm long and 3-4 cm wide. It is located in the cystic fossa, a groove in the inferior aspect of the liver. Three different parts can be identified. The fundus emerges from the anterior border of the liver, which means it can be manually palpated from outside. The peritoneum completely covers the fundus, and in certain cases it is long enough to create a mesocyst, explaining why pathological torsion is possible ***(Rabischong and Pissas.,1997).***

The middle part or body is more strongly fixed by thicker peritoneum, representing the vesicular plate in continuity with the hilar plate. The posterior part is constricted, forming the neck, which is very close to the right part of the hilum, making an angulation with the body. The cystic artery, a branch of the hepatic artery, reaches the neck with a variable course. The gallbladder is connected with the common bile duct via the cystic duct, 3-5 cm in length. It is important to note the main differences in the histological structure of the gallbladder, in which three different layers can be identified - mucosa, submucosa, and muscular wall with some circular reinforcements - whereas the common bile duct has only a mucosa with glands inside and an external wall with connective tissue and few muscle fibers. Within the cystic duct, HEISTER described a spiral arrangement of the mucosa, playing the role of a valve (HEISTER'S valve or the spiral fold), and LUTKENS spoke of a special reinforcement of muscle fibers considered as a sphincter (UiTKENS' sphincter).

All these systems are modified by age, which is why one sees passive dilatation of all ducts and the gallbladder in elderly subjects ***(Rabischong and Pissas.,1997).***

## B-Important anatomical relations of the biliary tract:

### (1) Anatomical Topography:

Classically, three different portions of the biliary tract can be isolated. The first, the hilar portion, consists of the superior Biliary confluence, anterior to the division of the portal vein, closer to the right branch, and superior to the division of the hepatic artery. The second part is the pedicular portion - really the surgical part - contained within the hepatoduodenal ligament, a peritoneal fascia going from the transverse hepatic sulcus to the posterior part of the superior portion of the duodenum **(Fig 3)** ***(Rabischong and Pissas.,1997).***

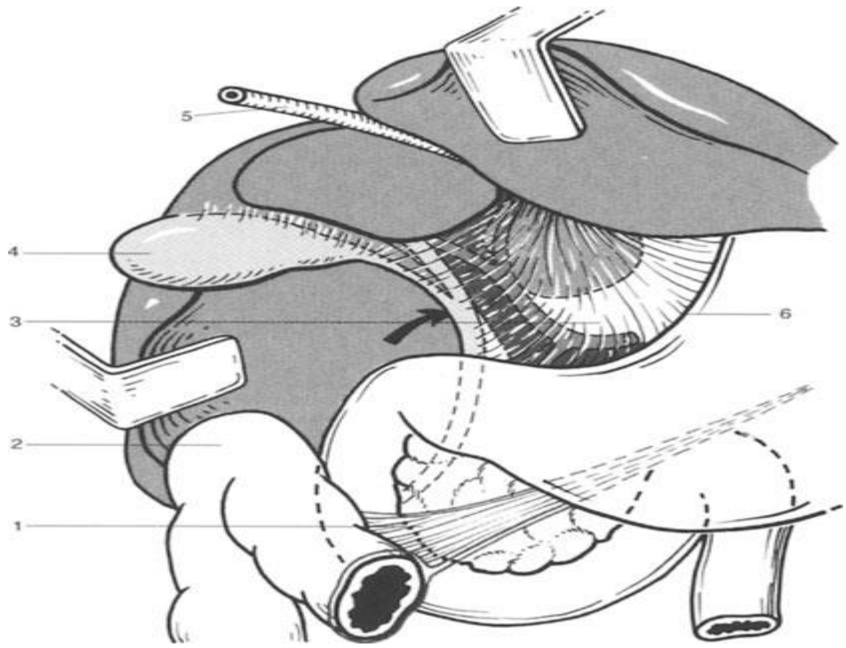


**Figure (3):** Relations between the inferior aspect of the liver and stomach, duodenum, and colon. 1, Transverse mesocolon; 2, right colic flexure; 3, small omentum (hepatogastric ligament); 4, gallbladder; 5, ligamentum teres; 6, right border of the stomach ***(Quoted from Rabischong and Pissas.,1997).***

Inside, schematically, the portal vein is posterior, with on the left side the hepatic artery and on the right the common biliary duct and the cystic duct. The right branch of the hepatic artery normally crosses behind the common hepatic duct, but in 13% of cases it crosses in front**.** The right border of the hepatoduodenal fascia consists of an orifice, the epiploic foramen or Winslow's hiatus, which is the lateral opening of the bursa omentalis, a serous space allowing the stomach to move freely. Just behind the hepatoduodenal fascia is the inferior vena cava, covered by the parietal peritoneum. The third part is the duodenopancreatic portion, in which the choledochous duct crosses the duodenum ***(Rabischong and Pissas.,1997).***

**(2) The Visceral Relationships of the Biliary Tract:**

The biliary tract has roughly two parts, one obliquely located under the visceral aspect of the liver and one contained vertically in the hepatoduodenal ligament **(Fig 3)**.Therefore the first part, represented by the gallbladder, is in close relation with the following peritoneal spaces: the right subphrenic recess and the right subhepatic recess. The right part of the transverse colon and the superior angle of the duodenum are in contact, explaining why biliary fistulas sometimes are found in those organs. The second part has visceral contact by the way of the omentum ***(Rabischong and Pissas.,1997).***

On the left, the gastrohepatic ligament represents the junction between stomach and liver, named pars condensa and flaccida of the small omentum, being in relation also with the right border of the stomach. Behind is the bursa omentalis, a large serous space going from the epiploic foramen to the posterior aspect of the stomach and pancreas. This space is in communication on the right with the right subhepatic recess, and in relation anteriorly with the right lobe of the liver and posteriorly with the right suprarenal gland on the superior pole of the right kidney. This particular hepatorenal recess, called

MORISON'S pouch, is the lowest part of the peritoneal cavity in the prone position ***(Rabischong and Pissas.,1997).***

## C- Blood supply & Innervations of the biliary tract:

### (1) Arterial supply:

The arterial blood supply of the biliary tract is very rich, combining a superficial vascular plexus with many anastomoses and two deep plexuses **(Fig. 4)**.Sometime small independent arteries forming one or two parallel arcades replace the plexus. It is fed by the posterior and superior pancreaticoduodenal artery, a branch of the gastroduodenal artery, as well as by branches of the hepatic artery. Via a special pedicle the cystic artery reaches the gallbladder at the level of the neck, dividing into right and left branches. When doing surgery, it is important to recognize the two most frequent versions of the cystic artery: short, coming from the right branch of the hepatic artery, or long, coming from the trunk of the hepatic artery or, sometimes, from the posterior and superior pancreaticoduodenal artery. All these branches make a large anastomotic network penetrating with the biliary ducts into the parenchyma and making vascular connections between the liver and the pancreas. It is at all events important to remember that the main source of the arterial blood supply of the biliary tract is located at the inferior part of the pedicular portion, which demands great attention during biliary surgery ***(Rabischong and Pissas.,1997).***

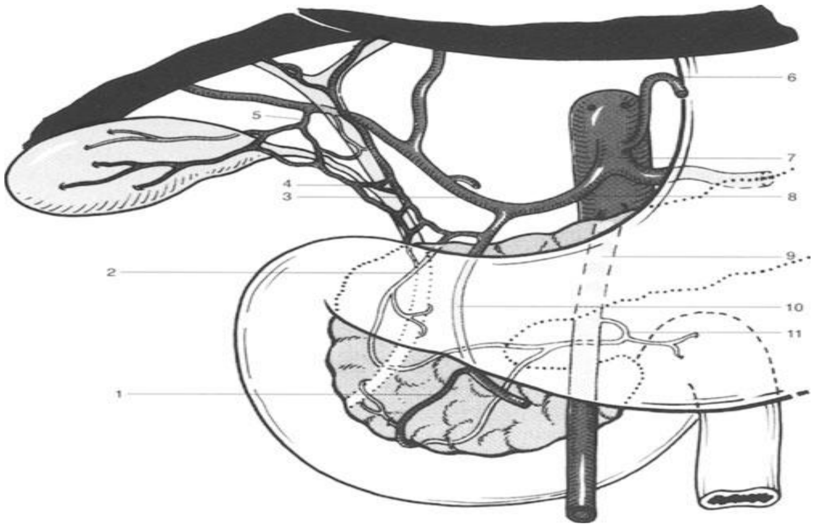


**Figure (4):** Biliary tract arteries. 1, anterior superior pancreaticoduodenal artery; 2, posterior superior pancreaticoduodenal artery; 3, hepatic artery; 4, arterial plexuses of the biliary tract; 5, cystic artery; 6, left gastric artery; 7, celiac trunk; 8, common hepatic artery; 9, superior mesenteric artery; 10, gastroduodenal artery; 11, inferior pancreaticoduodenal artery ***(Quoted from Rabischong and Pissas.,1997).***

**(2) Venous drainage :**

A parabiliary venous arcade runs along the biliary tract anteriorly on the left side, collecting venous blood from pancreaticoduodenal and gastric veins into the portal system. From the gallbladder some veins in the middle part of the cystic fossa go directly to the intrahepatic portal drainage, representing accessory portal veins. In cases of portal obstruction, marked dilatation of the biliary veins can be observed ***(Rabischong and Pissas.,1997).***

**(3) Lymphatic drainage :**

A rich mucosal plexus in the gallbladder and common bile duct is in close relation with the hepatic lymph vessels. Some of the cystic lymph vessels are directly connected with the lymph drainage of segments IV and V. **Caplan** described four different flows, two of them going into the pedicular portion, passing through the gallbladder neck node and then the hiatus node, close to the right border of the hepatoduodenal ligament. The proximity of the choledochous duct explains why it may be compressed by the lymph node. Drainage is then to the celiac nodes following the hepatic artery, and the lumboaortic lymph nodes, following the choledochous duct behind the pancreatic head ***(Caplan , 1982)***

In this area there is a major convergence of nodes, draining the stomach, pancreas, and biliary tract, just before the thoracic canal ***(Rabischong and Pissas.,1997).***

**(4) Innervations;**

The double antagonist function of the biliary tract - contraction of the gallbladder with relaxation of the sphincter of ODDI and vice versa - dictates double innervation by sympathetic and parasympathetic fibers. Sympathetic branches from the right splanchnic nerve mixed with nerves from the