MANAGEMENT OF POSTOPERATIVE BILE DUCT INJURIES

INTRODUCTION

"*Injuries to the bile ducts are unfortunately not rare and often turn to be tragedies"* (Grey-Turner, 1944).

Bile duct injuries have been recorded with open cholecystectomy (OC) long before the introduction of laparoscopic cholecystectomy (LC) (Lillemoe et al, 2000). The introduction of OC by Langenbuch of Berlin in 1882 brought about the world wide use of OC for the management of symptomatic gall stones. After that, injuries to the biliary tree became a recognized complication of operation (Roslyn et al, 1993). Over the last decade, the incidence of bile duct injuries after OC has been estimated at 0.1% to 0.3% (Edmond and Marvin, 2001).

Injuries to the common bile duct during elective cholecystectomy are more emotionally stressful to the surgeon, and are potentially harmful to the patient (Stain, 1997). Bile duct injuries will always be the worst complication of cholecystectomy (Carroll et al 1997). A bile duct injury during cholecystectomy is a complex and serious complication, observed with a frequency of 0.2% to 0.4%. The frequency has not diminished and probably will not. Even as the knowledge advances, lesions continue to occur (Walsh et a, 1998).

The occurrence of bile duct injuries have been more highlighted with the introduction of LC in 1987 by Mouret, from Lyons, who performed the first LC. Only a few years after the introduction of LC, surgeons declared the LC as the gold standard for symptomatic gallstone disease. Early diagnosis and classification of the severity of bile duct injury and careful selection of the different treatment modalities, in particular selection for the endoscopic or surgical approach is essential for successful outcome (Gouma and Obertop, 2002).

LC showed an increase in the incidence of bile duct injury two to three times that seen in OC. (Olsen et al 1997)**.** Despite increasing experience with LC, the incidence of iatrogenic bile duct injuries and strictures remained stable and continue to be a problem well into the new millennium (Lillemoe et al, 2000).

DEFINITION

Azagra et al (2001) defined postoperative bile duct injuries as major complications consisting of bile leaks, duct strictures, duct transections, or ligation of major bile ducts**.**

SURGICAL IMPLICATIONS OF THE VARIATIONS IN THE ANATOMY OF THE EXTRAHEPATIC BILIARY SYSTEM AND ITS BLOOD SUPPLY

- **The gallbladder:** Given the high frequency of cholecystectomies and the fact that most of these procedures are done laparoscopically, the knowledge of the possible variations in gallbladder anatomy is critical. The gallbladder commonly lies on the inferior surface of the right lobe of the liver in the region defined by Couinaud in 1956, as segment IV and V. The gallbladder may be partially or completely intrahepatic. Cases of near complete or complete intrahepatic gallbladder can present a significant challenge to surgeons performing LCs, and may necessitate a conversion to an open procedure for adequate dissection and hemostasis. The gallbladder may have an infundibulum at its neck, known as Hartmann's pouch, and, in some cases, another outcropping known as a Phrygian cap, is present at its fundus. Multiple gallbladders are rare, with a reported prevalence of 0.5% to 1.0%. In cases of multiple gallbladders, a duplication of the cystic duct is almost always present. The second duct may empty separately into the common bile duct or enter as a common channel with the primary cystic duct. In some cases, the duplicate cystic duct may empty into the right or left hepatic duct (Adkins et al, 2000).
- **Cystic duct:** The cystic duct is more commonly found with some type of anatomic variation than it is found to be running its most commonly reported course. In fact, only 33% of patients have the classic anatomic relationship between the cystic duct and the extrahepatic bile ducts and the related arteries. In some cases, the cystic duct drains into the retroduodenal portion or even into the intrapancreatic portion of the main duct. Rarely the cystic duct drains into the left hepatic duct. Accessory cystic ducts are rare, as is the absence of a cystic duct. Given the highly protean course of the cystic duct and extensive variability of its drainage, unnecessary operative manipulation of the duct can be hazardous (Fig.1) (Adkins et al, 2000).
- **Extrahepatic bile ducts:** The common bile duct, unlike the cystic duct, is more constant in its course and size, but some variations exist, especially in the region of the hepatic hilum. The greatest variation in common bile duct anatomy occurs with the different levels where the hepatic ducts may converge. Rarely, nonconvergence of the righ t and left hepatic ducts occurs, resulting in their separate drainage into the duodenum. In case in which choledochoenteric anastomosis is necessary, surgeons must realize the presence of any sectorial duct and define its anatomy (Adkins et al, 2000).

- **Blood supply of the biliary tree:** The primary blood supply to the common bile duct is usually derived from branches of the posterosuperior or anterosuperior pancreaticoduodenal arteries and the gastroduodenal artery. The proximal portion of the common bile duct may receive some circulation from the right hepatic artery and right gastric arteries. Branch vessels course along the common bile duct (Fig.2) medially and laterally in the 3-o'clock and 9-o'clock positions. Given the variety of biliary drainage procedures and increasing necessity for corrective biliary tract procedures because of iatrogenic injury, an adequate understanding of the extrahepatic biliary blood supply is imperative. When the common bile duct is divided or ligated, the lateral 3-o'clock and 9-o'clock arteries are also interrupted. Depending on the level at the point of division, this may result in ischaemia to the proximal or distal portion of the transected duct, which undoubtedly is a major explanation for the poor results and late stricture development that often occur when end-to-end bile duct reconstruction is used following bile duct transections because one side of the divided and anastomosed bile duct is likely to suffer relative ischaemia (Adkins et al, 2000). Northover et al (1985) and Terblanche et al (1983), have argued that, most if not all, biliary reconstruction should be performed with a hepaticojejunostomy using the most proximal bile duct in the hilum of the liver as the biliary segment

HISTORICAL PERSPECTIVES OF POSTOPERATIVE BILE DUCT INJURIES

The possibility of inadvertent injury to adjacent structures has been a part of surgery since the time of barber surgeons. From the moment on July 15, 1882, when Langebuch performed the first planned cholecystectomy, the possibility of injury to the biliary ducts existed (Braasch, 1994).

According to Wahl (1970), the idea of performing an anastomosis between the biliary tract and the intestine is usually attributed to von Nussbaum in 1870. The first reported biliary tract anastomosis to the intestine was a cholecystoenterostomy to the colon by von Winiwater in 1881(Braasch, 1994).

Kappler in 1887 suggested that, the anastomosis should feature a mucosa-to-mucosa apposition. Pakes reported the first dilatation of a stricture in 1885. The first use of a stent was described by Terrier in 1892. The first choledochoduodenostomy for calculi was reported by Doyen In 1892 and Roux reported Roux-en-Y anastomosis of the small intestine in 1897. Kocher's maneuver was described in 1903. (Braasch, 1994)

The first operation for reconstruction of the biliary tract for repair of damage to the biliary tract were not reported until 1905 when Mayo described two cases of choledochoduodenostomy in repair of damaged common bile duct that occurred during the course of routine cholecystectomy. His procedure was a two-layer anastomosis, end of duct to side of duodenum. In the same year, Keher reported an end–to-side choledochoduodenostomy (Braasch 1994).

Fistulous tracts were dissected and anastomosed to the intestine in some patients. It was reported by Lahey in 1924 (Braasch, 1994).

Smith in 1969, created what is called a mucosal graft anastomosis with a transhepatic stent. Transanastomotic stents have included rubber tubes which was first described by Terrier in 1889, and cuffed rubber tubes was first described by Dever in 1904 (Braasch 1994). Y-shaped tubes were described by Warren in 1966. The Keher or T-tube remains the standard stenting device of most anastomosises. It was invented by Keher of Berlin in 1905 (Braasch, 1994).

Percutaneous transhepatic cholangiography (PTC) was reported by Carter and Saypol in 1952. Retrograde cholangiopancreatography (ERCP) by the use of duodenal endoscopy was shown to be possible by McCune et al in 1968 and by Oi in 1970.

Couinaud in 1956 described the hilar plate and the long extrahepatic course of the left hepatic duct, both are of importance in stricture repair because the hilar plate must be dissected, and the left duct is available for the exit of internal stent (T-tube) or for use in biliary tract anastomosis in instances of high strictures(Adkins et al 2000). Longmire and Sanford described the technique of finding a branch of the left hepatic duct for anastomosis in 1948. In this technique, a portion of the left lobe was amputated with subsequent anastomosis of a segmental bile duct (Braasch 1994).

Of great importance has been the recognition by Northover and Terblanche in1979, that the arterial supply to the bile duct in man is syncytial and arises from longitudinal arteries on either side of the duct and from the hepatic and gastrointestinal arteries (Fig.2). They stressed that, surgeons must no longer dissect one cm of duct in preparation for its anastomosis, but keep the dissection just enough to produce duct length for one-layer anastomosis that is, at 2 mm.

In 1965, a new technique of stricture management was proposed by Thomford and Hallenbeck, in which they create a cutaneous stoma for the Roux-en-Y loop of jejunum, which is used for hepaticojejunostomy. They made it available as access to the hepaticojejunostomy for non-operative dilatation of anastomotic strictures (Fig.23).

ETIOLOGY OF BILE DUCT INJURIES

A- Postcholecystectomy bile duct injuries:

OC has a high degree of safety, but it is important to remember that it is a major operation and should never be undertaken lightly. Literatures suggest that, the incidence of biliary injury is roughly two per 1,000 open operations for gall stones (Bismuth, 1982). Bile duct injuries have been highlighted with the introduction of LC (Pleass and Garden, 1998). The incidence of bile duct injuries associated with LC is higher than that associated with OC, but should decrease with the surgeon's experience. Unfortunately, many iatrogenic injuries go unrecognized until they cause complications from delayed stricture formation. (Sachdeva et al, 2000).

Injury to bile ducts can occur during either laparoscopic or open cholecystectomy. Most strictures after LC are short and occur more commonly in the common hepatic duct, distal to the confluence of the right and left hepatic ducts. After OC, strictures are more common in the CBD. This phenomenon is likely due to the ease with which this area may be accessed by the laparoscope. The causes usually are surgical inexperience, failure to recognize abnormal biliary anatomy and congenital anomalies, acute inflammation, misplacement of clips, excessive use of cautery, and excessive dissection around the major bile ducts resulting in ischemic injury (Fig.3). However, a significant proportion of strictures occur during operations described as simple and uneventful (Pande et al, 2002)**.**

B- Bile duct injuries after other abdominal operations:

After cholecystectomy and common bile duct exploration, the two most common operations associated with bile duct injury are gastrectomy and hepatic resection. The most common situation resulting in biliary injury during the course of gastrectomy involves dissection of the pyloric region and the first portion of the duodenum in face of acute and chronic inflammation of peptic ulcer and for gastric cancer. In general, the injury occurs during mobilization of the duodenum either for creation of Billroth I gastroduodenostomy or for closure of the duodenal stump (Lillemoe et al, 1990, and Westcott and Pappas, 1998). The diminishing requirement for surgical treatment of peptic ulceration has meant that gastrectomy is a less frequent cause for bile duct injuries (Pleass an Garden,, 1998).

Bile duct injuries occurring during abdominal surgical operations are important, first, because they are preventable and second, because they increase mortality and morbidity rates far in excess of those recognized for the initial surgical procedure. The results may be particularly tragic because many of the patients so afflicted are young and in the most productive years of life (Blumgart and Matthews, 1997).

Biliary injury during liver resection is most likely to occur when the tumor or cyst being resected is near the hilum and the biliary tree is damaged during dissection. Management of injury due to partial hepatectomy can be extremely difficult, and there can be significant complication if the remaining lobe atrophies. Intraoperative cholangiography may be helpful in identifying the anatomy and avoiding injury in difficult cases (Lillemoe et al 1990).

In addition to iatrogenic bile duct injury during cholecystectomy or other abdominal operations, postoperative bile duct strictures can occur at previous biliary anastomosis. Such stricture can occur at a biliary-enteric anastomosis performed for reconstruction after resection for a disease of the pancreaticobiliary system, following end–to-end repair of traumatic injury, or after liver transplantation. Unfortunately, the recurrence of bile duct strictures after an initial attempt at end-to-end repair is not uncommon and may account for a number of anastomotic strictures (Pelligrini et al, 1984).

When injuries occurred during abdominal surgical procedure, repair must be carried out in precise and expert manner at the first attempt, since repeated operative intervention is associated with less good results (Blumgart and Thompson, 1987).

Accidental ligation of the lower end of the common bile duct was recorded after closure of a perforated duodenal ulcer. Bile duct strictures also can occur as unexpected complications after other surgeries, such hepatic and portal vein surgery. Postendoscopic sphincterotomy, stricture of the lower end of the bile duct is possible (Wakefield et al 2001 and Pande et al 2002)**.** Several cases of low common bile duct injuries have been reported after excision of a duodenal diverticulum. Bile duct stenosis has been reported after choledocal cyst excision (Blumgart and Matthews, 1997, Soybel and Zinner, 1997, and Westcott and Pappas, 1998).

LOCATION AND CLASSIFICATION OF BILE DUCT INJURIES

The locations of postoperative bile duct injury or stricture is of primary importance in dictating the management and predict outcome. In recognition of this, Bismuth (1982) has developed a classification of benign bile duct strictures based on the anatomic pattern of involvement. Bismuth classified benign bile duct strictures or injuries into 5 types. He classified them as; type 1: hepatic duct stump >2 cm, type 2: hepatic duct stump <2cm, type 3: no hepatic duct, confluence intact, type 4: destruction of hilar confluence; and type 5: right sectorial duct injury, with or without common hepatic duct injury (Fig.4).

Although Bismuth's classification did not take into account bile leaks from the cystic duct or accessory ducts; it identifies precisely the level of anatomical injury, which greatly influences the surgical management and subsequent prognosis (Pleass and Garden 1998). It cannot be used for all injuries to select a treatment, especially not for bile leaks after laparoscopic cholecystectomy as well as for patients with limited stenosis of the common bile duct suitable for nonsurgical treatment (Gouma and Obertop 2002). The use of the Bismuth classification appears to be an accurate and practical method for the grading of postoperative bile duct lesions with cholangiography (Chartrand-Lefebvre et al 1994).

The advent of LC has resulted in the development of a number of other classifications. Woods and colleagues (1994) have proposed a simpler and more specific classification with regard to biliary injury as a complication of laparoscopic cholecystectomy. In this classification, group1: consists of cystic duct leaks (which are in fact not true bile duct injuries). Group 2: is made up of major bile duct leaks and/or strictures, and group 3: contains the major ductal transections or excisions. McMahon et al in 1995 suggested a simplified classification for bile duct injuries, separating bile duct injury into major and minor injuries. This is helpful to differentiate the minor lesions as cystic duct leakage from major injuries of the common bile duct, but not to select treatment options.

Strasberg et al (1995) reported a very detailed classification (types A-E) including various subclassifications for further treatment (E1-E5) according to Bismuth classification. Type A injury: bile leaks from minor duct still in continuity with the common bile duct, type B injury: involves occlusion of part of biliary tree which for practical purposes almost always aberrant right sectorial hepatic duct, type C injury: leaks from duct not in communication with common bile duct, type D injury: lateral injury to the extrahepatic bile ducts, and type E injury: circumferential injury of major bile ducts (Bismuth class 1 to 5). This classification is very useful to select treatment by a multidisciplinary approach and to select patients who are candidates for referral centers. Type E injuries cause "separation "of hepatic parenchyma from the lower ducts and duodenum. The separation may be because of a stenosis in the duct, or because of complete occlusion of the duct, or because of loss of ductal tissue as a result of resection or ablation with cautery.

In 1996, Bergman and his colleagues developed a relatively simple classification with direct implication for further treatment. In this classification, a bile duct injury is defined as any clinically evident damage to the biliary system including the cystic duct and intrahepatic duct radicals. Four types of bile duct injuries can be identified (A) cystic duct leaks or leakage from aberrant or peripheral hepatic ducts including the so–called duct of Luschka; (B) major bile duct injuries with or without concomitant biliary strictures; (C) bile duct strictures without bile leakage, and (D) complete transection of the bile duct with or without excision of a part of the bile duct. This classification is helpful to select treatment for patients with bile duct injury and also useful to analyze the long-term results according to severity / nature of a lesion.

In 2001, Bismuth and Majno proposed a classification of biliary strictures which is based on the lowest level at which healthy biliary mucosa is available for anastomosis. The classification is intended to help the surgeon to choose the appropriate technique for the repair. Type (I) strictures, with a common duct stump longer than 2 cm, can be repaired without opening the left duct and without lowering the hilar plate. Type (II) strictures, with a stump shorter than 2 cm, require opening the left duct for a satisfactory anastomosis. Lowering the hilar plate is not always necessary but may improve the exposure. Type (III) lesions, in which only the ceiling of the biliary confluence is intact, require lowering the hilar plate and anastomosis on the left ductal system. There is no need to open the right duct if the communication between the ducts is wide. With type (IV) lesions the biliary confluence is interrupted and requires either reconstruction or two or more anastomosis. Type (V) lesions are strictures of the hepatic duct associated with a stricture on a separate right branch, and the branch must be included in the repair. Also they mentioned that, although this classification is intended for established strictures, it is commonly used to describe acute bile duct injuries. The surgeon must be aware, however, that the established stricture is generally one level higher than the level of the injury at the original operation.

INCIDENCE OF BILE DUCT INJURIES AFTER OC AND LC

The incidence of bile duct injuries after cholecystectomy varies widely and is reported between 0 and more than 1% in several studies, a difference that is partly due to the various definitions of bile duct Injury (Deziel et al, 1993, Go et al, 1993, and Fletcher et al, 1999). In some series, leakage of a cystic duct or duct of Luschka is also included as an injury (minor injuries) whereas in other studies only the more severe common bile duct injuries such as transection and resection are included and reported as major injuries (McMahon et al, 1995, and Strasberg et al, 1995).

The incidence in the different studies is also influenced by the selection of patients as well as the methods for data collection. In two reviews, the incidence after OC was reported as 0.2% (McMahon et al 1995) and 0.7% (Strasberg et al, 1995) whereas the incidence after LC was, respectively, 0.81% and 0.5%. Shortly after the introduction of LC in 1991, the incidence was 0.86% (Go et al, 1993). In a recent audit of nearly 6000 patients, the incidence of bile duct injuries after LC decreased from 0.8% in 1990-1993 to 0.4% during 1995 (Richardson et al, 1996).

Nair et al (1997) reported in their survey an incidence of 0.07% in 4000 patients. The number of patients referred to a specialized center has not decreased during the past years and is currently at 30-35 patients per year (Gouma et al 1999). This does not provide conclusions about the incidence of bile duct injuries but may reflect a change in referral pattern (Gouma and Obertop, 2001).

More than 75% of cholecystectomies are now performed laparoscopically (Fletcher et al, 1999). Despite the overall safety and distinct advantages of LC over OC, a higher incidence of bile duct complications has been reported that resulted in a significant morbidity and mortality. Early recognition and treatment are critical to a successful long-term outcome (Lichtenstein 2000). The 1990s saw a dramatic increase in the incidence of bile duct strictures and injuries from the introduction of and wide use of LC (Azagra et al 2001). In some series, bile duct leakage from the cystic duct or the so-called duct of Luschka, an intrahepatic radical, has been excluded because it is not considered important (Gouma and Obertop, 2002). In another series these minor injuries are included because patient's burden is not always limited and even severe biliary peritonitis and sepsis can occur after these minor lesions (Fletcher et al, 1999).

The incidence of bile duct injuries after LC has been estimated to be about 0.5%, although it is likely that injuries are not always reported. Bile duct injury is thought to be a more frequent complication of LC, and in some series it is reported to be more than 2% of cases (Strasberg et al, 1995). Similarly, other complications, such as cystic duct leakage and subhepatic bile collections, occur more often than after open cholecystectomy (Rossi and Tsao, 1994).

The incidence of major bile duct injuries after OC in a series analyzed by Roslyn et al (1993) was found to be 0.2%. Before the advent of LC technique, bile duct injuries were thought to be steady at about 1 in 300 to 500 procedures (Garden, 1991). In a series published by Deziel et al in 1993, they reported that the rate of bile duct injuries after LC to be twice that associated with OC.

MECHANISMS OF BILE DUCT INJURIES

Different mechanisms of injury have been described, but more recently, Shallaly and Cuschieri (2000) identified two major groups of errors, namely (1) misidentification of the anatomy of the biliary tract as being the dominant factor in around 70% of the injuries and (2) technical errors leading to bleeding and subsequent clipping of the bile duct/artery or leading to bile leakage by inadequate clipping or traction and subsequent lateral wall injuries.

Moossa et al (1992) stated that, bile duct injuries can be traced to one of five errors: 1- the wrong duct is ligated or transected, 2- the lumen of the bile duct is occluded during flush ligation of the cystic duct, 3- the blood supply to the common bile duct is compressed by excessive dissection, 4- the lumen of the bile duct is traumatized by forcible dilatation, and 5- by application of an energy source (electrocautery) which is inappropriate.

RISK FACTORS IN POSTOPERATIVE BILE DUCT INJURIES

Fibrosis in the triangle of Calot, acute cholecystitis, obesity, local hemorrhage, variant anatomy, and fat in the porta hepatis were identified as risk factors for bile duct injuries (Asbun et al, 1993). Moossa et al (1990), just before the widespread use of LC, reported similar risk factors as well as inadequate length of incisions (especially in obese patients) and failure to obtain intra-operative cholangiography.

When all risk factors are examined, three broad categories tend to emerge: dangerous anatomy, dangerous pathologic finding, and dangerous surgery (Martin and Rossi, 1994).

a) Dangerous anatomy and failure to identify anatomy:

Dangerous anatomy predominantly includes conditions of variant anatomy or anatomic conditions that obscure the view of vital structures. Of particular concern are the conditions in which the right hepatic duct inserts low into the common hepatic duct or in which the cystic duct runs along parallel to the common hepatic duct or spirals to enter the common bile duct on its medial surface. Variations in vascular supply also present potentially dangerous situations, not only from the risk of inadvertently dividing the hepatic arterial supply but also from increasing the likelihood of hemorrhage and obscuring of the operative field (Martin and Rossi, 1994).

The common bile duct is mistaken for the cystic duct resulting in clip application and transection of the common bile duct with excision of a portion of the extrahepatic biliary tree (Pleass and Garden, 1998).

b) Dangerous Pathologic findings:

Dangerous pathologic findings include acute cholecystitis, gangrenous cholecystitis, and perforated cholecystitis, polycystic disease of the liver and hepatic cirrhosis. Two processes, the scleroatrophic gallbladder and Mirizzi's syndrome, present unique challenges, and they deserve special attention. The scleroatrophic gallbladder is usually the result of long-standing chronic cholecystitis and is associated with scarring in the porta hepatis .In these patients anterograde dissection is recommended (Martin and Rossi, 1994).

The Mirizzi syndrome can be variably classified, with severity ranging from minor external compression of the common bile duct to frank cholecystobiliary fistula. It can be extremely difficult to ascertain the true relation of the cystic duct junction with the common bile duct by palpation alone in these patients. When this syndrome is encountered, the gallbladder should be opened and the calculi extracted (Fig.5). Cholangiography should be performed to confirm the diagnosis and to delineate the anatomy. Depending on the degree of involvement of the common bile duct, repair may proceed as simple cholecystectomy, partial cholecystectomy, cholecystostomy, or choledochostomy with primary repair of the common bile duct, or patch repair with a piece of the gall bladder. For advanced cholecystobiliary fistula (type III or IV), hepaticojejunostomy may be required (Csendes et al, 1989 a). In the era of laparoscopic cholecystectomy, as preoperative diagnosis of Mirizzi syndrome remains difficult, the use of intra-operative cholangiography together with high index of suspicion is necessary to diagnose the condition and to avoid duct injury (Bagia et al, 2001).

Dangerous pathologic conditions predisposing to bile duct injury are not confined to biliary disorders. Penetrating duodenal ulcers with inflammation can greatly distort the usual relationship of the common bile duct and the duodenum and pancreas. Mobilization of the duodenum for closure of the ulcer can inadvertently lead to bile duct injury under these conditions. Pancreatic disorders, such as acute and chronic pancreatitis, and non-ductal carcinoma and islet cell tumors that may require near-total pancreatectomy also represent a potential hazard to the intrapancreatic portion of the common bile duct. Resections of the liver for infectious and neoplastic processes can also present hazards to the intrahepatic ducts as well as the proximal common hepatic duct and its bifurcation (Martin and Rossi, 1994)

c) Dangerous surgery:

1- **Retraction injuries:** Adequate retraction is absolutely essential for the safe conduct of any biliary operation. In both OC and LC, retraction provides exposure of the operative field and aligns the various ducts in a way that either predisposes to or decreases the likelihood of injury. The goal of retraction in both OC and LC is to expose the cystic duct with opening the triangle of Calot. The Hartmann's pouch is retracted inferiorly and laterally to open the triangle. Retraction of the Hartmann's pouch medially and superiorly closes the angle between the cystic and common hepatic duct and significantly increases the risk of misidentifying the cystic duct. Similarly, retraction of the gallbladder superiorly and laterally causes alignment of the cystic duct and the common bile duct, with the common hepatic duct coursing perpendicular to these ducts. This causes a greater likelihood of excising a portion of the common bile duct (Davidoff et al, 1992).

   The extrahepatic biliary tree may be injured by excessive traction on the gallbladder, producing a tearing of the common bile duct. Excessive retraction can be as dangerous as inadequate retraction overzealous retraction can cause avulsion of fragile cystic ducts (Pleass and Garden, 1998). Similarly avulsion of small vessels during either OC or LC can obscure the operative field, leading to dangerously applied haemostatic clamps and clips or dangerously applied thermal injury. Excessive retraction of the cystic duct can also cause tenting and deformation of the common bile duct, which can predispose to full or partial clipping or ligation of the common bile duct (Martin and Rossi, 1994 and Pleass and Garden, 1998).

2- **Haemostasis:** When inadvertent hemorrhage occurs during dissection, an error often made is blind placement of haemostatic clamps, clips, or sutures or use of electrocautery. Whether the OC or LC is being employed, haemostatic maneuvers should never be performed blindly. If bleeding occurs and the field is obscured during OC, the Pringle maneuver should be performed, better visualization obtained, and accurate clamping of the bleeding site is achieved (Martin and Rossi, 1994).

3- **Injuries of dissection:** Both anterograde and retrograde technique for cholecystectomy can be associated with common bile duct injury, and neither both should lend a false sense of security.

   Excessive or unnecessary dissection or use of the electrocautery in this area should be avoided because it may render the common bile duct ischemic and increase the likelihood of stricture formation (Martin and Rossi,, 1994).

4- **Thermal and Laser injuries:** Excessive or inappropriate use of diathermy within Calot's triangle may produce a burn injury to the adjacent extrahepatic biliary tree. Typically, this produce a pin hole perforation giving rise to bile leak in the postoperative period (Pleass and Garden, 1998)

Recent advances in laparoscopic surgical techniques have brought along with them a greater implementation of electrocautery and laser devices for haemostasis and dissection. Both of these methods are widely used in a safe manner, and neither has conclusively been shown to be safer or more dangerous than the other (hunter, 1993).

One proposed mechanism of delayed stricture formation is the overzealous use of electrocautery in the area of the triangle of Calot. This causes coagulation of the blood supply to the common bile duct and eventually results in a stricture (Davidoff et al, 1992). Care must be taken to avoid inadvertent diathermy to the titanium clips, after these have been applied to the cystic duct or artery. Transmission of current through correctly applied clips is thought to produce bile duct necrosis and stricture formation (Pleass and Garden, 1998).

DIAGNOSIS OF POSTOPERATIVE BILE DUCT INJURIES

The diagnosis of bile leak or bile duct injury can be enigmatic after OC but should always be suspected after LC in patients who fail to show the expected rapid clinical improvement in the early postoperative period (Morgenstern et al, 1993).

Not all forms of diagnostic work-up and treatment are available in all hospitals and there should be a low barrier for referral. The management of patients with bile duct injuries should ideally be performed /discussed in a multidisciplinary team consisting of gastroenterologist, radiologist and surgeons (Gouma and Obertop, 2002).

CLINICAL PRESENTATIONS FOR POSTOPERATIVE BILE DUCT INJURIES

There are three basic modes of presentation for postoperative bile duct injuries (1) those discovered at the time of the initial procedure, (2) those presenting within a few days of surgery, and (3) those that appear weeks to months after the inciting event. The discovery of an injury during surgery is usually precipitated by persistent bile staining, intra-operative cholangiography, or examination of the excised specimen. Patients who presented within a few days of surgery have biliary cutaneous-fistula, bile peritonitis, jaundice, and/or pain. Injuries that present weeks to months after the inciting event are usually lesser injuries that preserve biliary function yet heal with stricture formation. The usual complaints are of recurring fever and rigors indicative of cholangitis. Fatigue and weight loss are common. Jaundice is often not apparent with sectorial or lobular ductal ligation, but this is rarely the lone presenting sign or symptom. Injuries from procedures other than cholecystectomy follow the same general guidelines (Westcott and Pappas, 1998).

Bile duct injuries that follow OC are most often diagnosed several weeks postoperatively. The injuries that complicate LC, however, usually produce early manifestations (i.e., bile leak, biliary ascites or jaundice) (Moossa et al, 1992, and Deziel et al, 1993).

Three different groups of patients can be identified according to the clinical presentation and this is mainly dependent on the time interval between the procedures, and the start of the first symptom (Gouma and Obertop, 2002).

I- Presentation of patients with bile duct injury detected during surgery (Immediate diagnosis):

About 15 %of injuries of the bile ducts are not recognized at the time of operation. In 85 % of cases the injury declares itself postoperatively by: (1) a profuse and persistent leakage of bile if drainage has been provided, or bile peritonitis if such drainage has not been provided; and (2) deepening obstructive jaundice. When obstruction is incomplete, jaundice is delayed until subsequent fibrosis renders the lumen of the duct inadequate (Russell et al, 2000).

If an injury is suspected at the time of LC, cholangiography should be performed. Inability to visualize the intrahepatic ducts should not be assumed to be due to rapid flow of contrast into the duodenum. Conversion to OC should be considered if contrast is not seen in the common hepatic duct, or if the surgeon has significant concern of the integrity of bile ducts (Stain, 1997).

When bile duct injury is suspected at the time of initial operation, intra-operative cholangiography should be performed. In the early postoperative period bile duct injury may cause unexpected abdominal pain, jaundice, drainage of bile (from a drain or through the wound), signs of acute abdomen, and sepsis. HIDA scan is useful in confirming the presence of bile extravasation. Ultrasonography or CT scan may be obtained to detect or exclude an intra-abdominal collection. Definition of the exact location of the ductal injury requires either PTC or ERCP. A minor leak from an accessory hepatic duct is likely to heal spontaneously and merely requires placement of a percutaneous catheter under CT or ultrasonic guidance. If major bile duct injury is detected postoperatively, repair should be undertaken after the initial management, which includes control of the bile leakage and treatment of sepsis (Sachdeva et al, 2000).

If bile duct injuries are detected during the initial surgical procedure, biliary leakage is the first symptom, but in some patients the injuries are detected during intra-operative cholangiography, showing filling of the distal common bile duct with contrast into the duodenum and without filling of the intrahepatic radicals. Most patients with the diagnosis at the time of operation are treated immediately, usually after conversion to an open procedure, and only selected patients are referred to centers as patients with extensive injuries or failures after primary repair at the initial procedure and those patients with unclear lesions during exploration when the surgeon performs a temporary drainage by insertion of a drain near the duodenal ligament (Gouma and Obertop, 2002).

II- Presentation of patients with delayed identification of bile duct injury:

The time interval between the initial procedure and diagnosis of a bile duct injury varies widely in most series. The early symptoms are nonspecific and consist of general malaise, nausea, vomiting, anorexia, abdominal pain and low-grade fever. The vagueness of the symptoms might probably be responsible for the delay in diagnosis. Other symptoms may become manifest later and sepsis and jaundice will eventually lead to the (delayed) detection of the injury. Patients with delayed detection of injury may present with biloma due to intra-abdominal bile leakage. A biloma can exist for a long period of time before symptoms occur (Gouma and Obertop, 2002).

In the series of Bergman and colleagues (1996), the median interval was 7 days. In a recent study by Keulemans and his colleagues (1998), they found that the latency time (interval between symptoms and detection) was decreased to 3.5 days and they attributed this to the more awareness of bile duct injuries by surgeons.

Patients with bile duct injury, as opposed to simple bile leaks, usually present within 30 days of their initial operation. One-quarter of these patients present with painless obstructive jaundice alone. Up to half present with fever and sepsis, while a few present with an external bile leak. Some patients with presumed ischemic or thermal injury may not present for several months or years after the initial surgery when cholangitis or jaundice secondary to the stricture prevails. If a sectorial duct has been ligated, this may cause asymptomatic atrophy of the liver sector. However, the presence of proximal sepsis may cause the patient to present with fever and liver abscess (Pleass and Garden, 1998).

Patients with delayed detection of injuries can be divided into two subgroups: (I) patients with biliary leakage immediately or a few days after laparoscopic cholecystectomy resulting in a biloma and biliary peritonitis: or (ii) patients with total occlusion (clipping) of the common bile duct leading to early obstructive jaundice frequently followed after 1-2 weeks by biliary leakage and biliary peritonitis due to the increasing intraductal pressure and subsequent leakage at the site of the clips (Gouma and Obertop, 2001).

III-Patients presented late with bile duct stricture with long symptom free interval (3 months to even more than one year):

These patients present with obstructive jaundice due to a stricture of the common bile duct generally without cholangitis. It has been suggested that these late bile duct strictures originate from ischemic lesions caused by extensive dissection or partial occlusion of the common duct during the initial procedure. A few patients will present with intermittent obstruction and cholangitis and these patients will frequently have a spontaneous fistula to the duodenum or colon (Gouma and Obertop, 2002).

Late development of stricture leads to obstructive jaundice and recurrent cholangitis, and long-standing strictures may result in biliary cirrhosis and portal hypertension. PTC or ERCP confirms the diagnosis of a stricture (Sachdeva et al, 2000).

The liver may return to near normality following relief of obstruction. Major stigmata of hepatocellular dysfunction such as spider nevi, asterixis, and portosystemic encephalopathy are not common in liver fibrosis due to biliary obstruction (Blumgart, 1978).

PRESENTATION ACCORDING TO THE TYPE OF INJURY

Patients presented with bile leaks:

Bile leaks arising from the cystic duct stump or from accessory ducts within the gallbladder bed are commonly reported (Barton et al, 1995). These bile leaks, as opposed to bile duct injuries, almost invariably present within the first postoperative week. Two–thirds of patients present with abdominal pain and fever, with or without abdominal distension. Other signs of sepsis caused by intraperitoneal collection of bile may be present. One-third of patients, present with bile leaking externally through an abdominal incision or drain. A minority of patients present with vague non-specific symptoms, such as anorexia, and the surgeon should remain vigilant in managing the patient whose postoperative course following cholecystectomy is not uneventful (Pleass and Garden, 1998).

Patients with bile leaks are rarely clinically jaundiced in the immediate postoperative period, but an elevation of levels of alkaline phosphatase and bilirubin is commonly seen and must be assessed with some urgency. It is unacceptable for the surgeon to assume that developing clinical signs associated with abnormal liver function tests (LFTs) are most likely to be due to a retained stone rather than a bile leak, particularly if an operative cholangiogram has not been undertaken (Pleass and Garden, 1998).

Patients presented with major bile duct injuries:

Major bile duct leaks, transections or excisions should be suspected intra-operatively either because of the presence of bile within the operative field, or secondary to abnormalities seen on cholangiography. However less than one-third of such injuries referred to specialist hepato-biliary centers are noted during the primary operation (Asbun et al, 1993).

Patients with bile duct injuries, as opposed to simple bile duct leaks, usually present within 30 days of their initial operation. One-quarter of patients present with painless obstructive jaundice alone. Up to half present with pain, fever and sepsis, while a few present with an external bile leak. Some patients with presumed Ischemic or thermal injury may not present for several months or years after the initial surgery when cholangitis or jaundice secondary to the stricture prevails (Pleass and Garden, 1998).

A HIDA scan has often been used as the first test to exclude a complete transection; but a HIDA scan will not exclude a minor bile duct injury (Stain, 1997).

DIAGNOSTIC PROCEDURES

Many different tools are available to evaluate possible causes of postoperative problems. Each of these has its own value and emphasizes the need for a multidisciplinary approach to biliary disorders. Endoscopic retrograde cholangiopancreatography, percutaneous transhepatic cholangiography, radionuclide biliary imaging, ultrasonography, computed tomography, and magnetic resonance are useful diagnostic and therapeutic purposes when bile duct leak or injury is suspected (Martin and Rossi, 1994)

If bile duct injury is noted at the time of peroperative cholangiography, no further investigation is required. Given that the majority of bile duct injuries present later, their management is often determined by the nature of their presentation (Pleass and Garden, 1998).

Laboratory investigations:

Laboratory investigations will usually confirm the clinical suspicion of obstructive jaundice with a raised serum alkaline phosphatase and bilirubin. Impaired renal function should be excluded. A leucocytosis usually accompanies the patient's fever. Liver function tests (LFTs) of patients with postoperative bile duct stricture usually show evidence of cholestasis. The serum bilirubin may fluctuate and may even be normal. When elevated, serum bilirubin usually ranges from 2 to 6 mg/dl unless secondary biliary cirrhosis has developed. Elevations of bilirubin often are associated with cholangitis and may represent obstruction of the narrow lumen by biliary sludge that forms proximal to the stricture. Serum alkaline phosphatase, gamma glutamyl transferase and 5- nucleotidase also may fluctuate but are usually elevated. Serum transaminase levels may be normal or slightly elevated except during episodes of cholangitis. If advanced liver disease exists with impaired hepatic synthesis function, serum albumin and prothrombin time may also become abnormal. Serum electrolytes and hematologic values are normal unless there is associated biliary sepsis (Pleass and Garden, 1998).

The serum albumin may be decreased as a consequence of chronic illness but may also indicate early cirrhosis. The prothrombin time may be abnormal due to cholestasis and impaired absorption of vitamin K, which must be corrected before surgery. Patients who are jaundiced must kept well hydrated, as they are exceptionally susceptible to renal failure. Serum tests should be performed to exclude the presence of hepatitis viruses, particularly hepatitis C that may have been contracted from blood transfusion (Edmond and Marvin, 2001). The prothrombin time and International Normalized Ratio (INR) may be prolonged and usually can be normalized with parenteral administration of vitamin K. Total cholesterol and lipoprotein levels may be elevated in patients with chronic cholestatic disorders (Pande et al, 2002).

Imaging investigations and interventional procedures:

The main purpose of investigations is to establish the diagnosis safely, but often has the added advantage that therapeutic intervention may also be possible (Pleass and Garden, 1998).

1- Abdominal Ultrasonography (US):

The first step in the diagnostic work-up of patients with abdominal complaints after cholecystectomy, biliary operations, or related operations is ultrasonography which can detect a fluid collection, bile duct dilatation and gross modifications of hepatic parenchyma (Gouma and Obertop, 2002). Ultrasonography also facilitates subsequent percutaneous aspiration of the bile, which will establish the diagnosis and its drainage (Pleass and Garden 1998).

Unfortunately, a fluid collection (suggesting a bile duct injury) is still an indication for exploratory laparotomy for many surgeons without further diagnostic tests leading to unnecessary surgery to establish bile drainage or to inadequate exploration of the bile duct, which may lead to extension of the lesion and subsequent negative effect on the outcome (Gouma and Obertop, 2002).

Sonography can accurately detect dilatation of intrahepatic and extrahepatic bile ducts, thus providing indirect evidence for the presence of bile duct strictures. However, sonography is less accurate for determining the etiology and level of obstruction. The sensitivity of US also depends on the degree of obstruction and has been found to be 94% with a serum bilirubin level of more than 10 mg/dL but only 47% with bilirubin levels of less than 10 mg/dL. (Pande et al, 2002).

2- Magnetic resonance cholangiopancreatography (MRCP):

Magnetic resonance cholangiopancreatography (MRCP) is a new promising method for evaluation of the common bile duct before or during cholecystectomy (Musella et al 1998). Visualization of the biliary tract by MRCP, not only will establish the diagnosis, but also identify the nature and level of the lesion (Gouma and Obertop 2002).

Since its introduction, MRCP has rapidly become an indispensable tool for visualizing the biliary system. MRCP takes advantage of the fact that bile has a high signal intensity images, whereas the surrounding structures do not enhance and can be suppressed during image analysis. The presence of biliary dilation can be accurately detected by MRCP in 97-100% of patients. The level of obstruction is correct in almost 87% of cases. Common bile duct strictures and stones can be differentiated as a cause of obstruction in most cases. MRCP provides a viable alternative to ERCP and allows imaging of the biliary tree when ERCP is unsuccessful, although, unlike ERCP, it is not therapeutic (Pande et al, 2002).

Although MRCP cannot be proposed as a screening method for all patients awaiting laparoscopic cholecystectomy because of its high cost and the limited number of nuclear magnetic resonance units available, nevertheless in asymptomatic patients with biochemical or ultrasonographic signs of common bile duct involvement, or in symptomatic subjects, MRCP should be performed before operation (Musella et al, 1998).

3- Computed tomography (CT):

Some centers have advocated the routine use of computed tomography (CT), although it is unclear whether the additional cost and risk to the patient of further irradiation is warranted. In late bile duct injuries, CT may identify biloma due to bile leakage (Fig.6), hepatic abscess formation, and demonstrate atrophy or hypertrophy of the hemi-liver (Sherlock and Dooley, 1997, and Russell et al, 2000).

Traditional CT scanning and the new technique of spiral CT scanning with 3-dimensional reconstruction have been found to be as sensitive as US for helping detect biliary obstruction. Similar to US, CT scanning also helps detect intrahepatic or extrahepatic bile duct dilatation; however, the main value of CT scanning is its ability to detect the site of obstruction with greater accuracy than US and to help predict the cause of obstruction. CT cholangiography scanning is another technique that rivals ERCP in delineating biliary tract abnormalities but has not achieved widespread use because of some adverse reactions to the contrast material. CT scanning also is superior to US in visualizing the distal common bile duct area because gas artifacts may obscure this region when examined by the latter (Pande et al, 2002).

4- Hepato-biliary scintigraphy (HIDA scan):

Hepato-biliary scintigraphy using radiolabel led iminodiacetic acid derivative (HIDA) has shown to be quite accurate (83-87 %) for predicting the presence of bile leaks after laparoscopic cholecystectomy (Brugge et al,, 1994). The radionuclide is excreted in bile and extravasation outside the biliary tree and gut is used to confirm an ongoing bile leak (Fig.7) (Blumgart and Matthews, 1997, and Pleass and Garden, 1998).

HIDA scanning can help determine the clearance of bile across strictures and surgical anastomosis, thus providing a functional assessment of incomplete strictures and surgical anastomosis. HIDA scan findings suggest complete biliary obstruction if the small intestine is not visualized in 60 minutes. However, HIDA scans are insensitive for helping detect biliary dilatation or the site and cause of bile duct obstruction (Sherlock and Dooley, 1997, and Pande et al, 2002).

5- Endoscopic retrograde cholangiopancreatography (ERCP):

Bile collection from cystic duct leakage can be confused with bile collection from other sources. ERCP frequently removes any doubt regarding the diagnosis, and with nasobiliary drainage, most of these leaks resolve without further therapy. Collections from other sources, such accessory ducts and subvesicular ducts may require percutaneous or open drainage techniques (Martin and Rossi, 1994, and Azagra et al, 2001).

In some patients, ERCP may be needed for definitive diagnosis and has the advantage of being therapeutic. ERCP is a valuable technique in biliary disease and therapeutic interventions (eg, biliary drainage, stent placement) can be carried out at the same time as the primary diagnosis. The success rate of ERCP is often 90-95%, with a complication rate of approximately 3-5%. ERCP can help detect intrahepatic and extrahepatic biliary dilatation, and the site of bile duct stricture with the highest sensitivity and specificity (both approximately 90-100%). ERCP findings show areas of irregular stricturing and dilatation (i.e., beading) of the intrahepatic and extrahepatic biliary tree. Nevertheless, ERCP is associated with significant complications, including pancreatitis, bleeding, perforation, infection, and cardiopulmonary depression (Sherlock and Dooley, 1997, and Pande et al, 2002).

ERCP is performed to delineate the biliary tree and will detect the presence of an active bile leak, stricture or complete obstruction of the biliary tree (Fig.8) (Branum et al 1993). ERCP may identify the level and site of injury. If complete obstruction exists, ERCP will not demonstrate the proximal biliary tree although the position of metallic clips may suggest the type of injury involved (Gouma et al 1999, Russell et al, 2000, and Paczynski et al, 2002.

6- Percutaneous transhepatic cholangiography (PTC):

The gold standard for diagnosis in patients with postoperative bile duct stricture is cholangiography. PTC performed by the percutaneous route (from above), is generally more valuable than ERCP (Fig.9). If the right and left biliary systems are not in communication, separate puncture of the right and left lobes of the liver is necessary (Edmond and Marvin, 2001, and Paczynski et al, 2002).

It is more useful in that it defines the anatomy of the proximal biliary tree, which is used in the surgical reconstruction. Moreover, during PTC, transhepatic catheter can be placed, which can be useful in providing decompression to treat either bile fistula or cholangitis. These catheters may also play an important technical role in surgical reconstruction, and may provide access for balloon dilatation. PTC is a vital investigation in the planning of surgical correction of such an injury. However, PTC is not without risk and should only be performed when percutaneous drainage is required or surgical intervention is planned (Sherlock and Dooley, 1997, Russell et al, 2000, and Azagra et al, 2001).

Indications for PTC in biliary strictures are the presence of biliary-enteric anastomosis (eg, Roux-en-Y anastomosis with hepaticojejunostomy, choledochojejunostomy (Fig.10), and Billroth II gastrectomy), the presence of complex hilar strictures, or when ERCP fails. Both the right and left ductal systems can be accessed using this technique. The success rate of PTC approaches 100% when ducts are dilated. Therapeutic intervention, such as biliary drainage, also can be performed at the same time. Complications, including sepsis, bile leak, intraperitoneal hemorrhage, hemobilia, hepatic and perihepatic abscess, pneumothorax, and skin infection and granuloma at the catheter entry site, can occur in as many as 10% of cases. PTC is contraindicated in patients with bleeding diathesis and significant ascites (Pande et al, 2002).

7- Drainography:

When an abdominal drain is still in site, cholangiography can be performed by this route (drainography) (Gouma and Obertop, 2002).

8- Fistulogram or tubogram:

A fistulogram or tubogram may be helpful in assessing the nature of the bile leak .A communication may not always be demonstrated until a fistula is established, or any associated intra-abdominal collection has resolved (Pleass and Garden, 1998, and Russell et al, 2000).

In postsurgery patients with an external biliary fistula or T tube, contrast medium can be injected into the biliary system through the tube or the fistula. This outlines the intrahepatic and extrahepatic bile ducts and delineates the site of stricture and the anatomy of the fistula. This study can precipitate cholangitis; therefore, patients should receive antibiotic prophylaxis (Pande et al, 2002).

9- Doppler ultrasonography:

Doppler ultrasonography may exclude the presence of portal vein thrombosis and portal hypertension in complex bile duct injuries (Pleass and Garden 1998).

10- Angiography:

Angiography may be of value if injury to the right hepatic artery is suspected from the position or number of clips seen on ERCP. Autopsy studies have shown that the right hepatic artery is injured in 7 % of patients submitted to cholecystectomy and may often go unnoticed unless associated with bile duct injuries (Mathisen et al, 2002)

11- Investigations for cirrhosis:

The investigations of cirrhosis are prompted by clues already noted. Endoscopic examination readily identifies the presence of esophageal varices. A liver biopsy reveals the presence of biliary fibrosis, although the distinction between reversible and irreversible cirrhosis is not always possible histologically. On the other hand, the presence of esophageal varices or ascites is ominous and should preclude repair (Edmond and Marvin, 2001).

METHODS OF MANAGEMENT OF BILE DUCT INJURIES

The management of postoperative bile duct strictures and major bile duct injuries remains a challenge for even most skilled biliary tract surgeon (Lillemoe et al 2000)

In the debilitated patient, temporary external biliary drainage may be achieved by passing a catheter percutaneously into an intrahepatic duct. Also, stents may be passed through strictures at the time of ERCP and left to drain into the duodenum. However, both of these methods may be complicated by cholangitis and are not recommended for all cases. When the general condition of the patient has improved, definitive surgery can be undertaken. For stricture or duct transection, the performed treatment is immediate Roux-en-y choledochojejunostomy by a surgeon well experienced in managing bile duct injuries. For a stricture of recent onset through which a guide wire can be passed, a balloon dilatation with insertion of a stent is an acceptable alternative provided that the service of experienced endoscopist is available (Russell et al, 2000).

Percutaneous aspiration is done if a collection is demonstrated by sonography or CT. If bile is aspirated, a percutaneous catheter is placed for drainage. Operative drainage should be considered for extensive peritoneal collection and is required in patients with biliary peritonitis or following unsuccessful percutaneous drainage (Pleass and Garden, 1998).

INITIAL MANAGEMENT OF PATIENTS WITH BILE DUCT INJURIES

The tents of initial management are control of sepsis and physiological support followed by definition of anatomy, drainage, and finally repairs. An injured bile duct by itself is not a life threatening, but the untreated sequelae of biliary injury can be. Intra-abdominal sepsis, dehydration, electrolyte depletion, and malnutrition are the top of this list. On initial presentation, these possibilities must be addressed because attempts to repair injuries in suboptimal physiologic conditions can be counterproductive. Fluid resuscitation, control of sepsis, and medical optimization should be completed before undertaking diagnosis and repair (Westcott and Pappas, 1998).

The Operative strategy of surgical reconstruction of the injured bile ducts is divided into four steps: (a) discovery of the biliary remnant, (b) identification of the complete ductal system, (c) preparation of the intestinal conduit, and (d) biliary –enteric anastomosis. The first two take most of the time, require most patience, and are the most crucial to the quality of anastomosis and long-term outcome (Edmond and Marvin, 2001).

The majority of bile duct injuries, however, presents late in the postoperative period, by which time the patient may be septic, hypoalbuminaemic and jaundiced. Surgical repair at this stage is technically more demanding, but may still be considered, since good long-term results are possible in experienced hands. Injudicious attempts at repair by the surgeon who has perpetrated the injury may compromise the patient's surgical prospects. Previous repeated and inappropriate attempts at biliary repair are associated with a poor long term result and, for this reason, it is recommended to refer the patient to a specialist center (Pleass and Garden, 1998).

For biliary fistula or stricture which present or referred late, the presence of liver atrophy may influence management. The presence of sepsis, the degree of ductal dilatation and the level of injury must dictate the timing of surgical repair. If sepsis has been well controlled in cases of biliary stricture, the surgeon may wish to await the proximal dilatation of the biliary tree, since this greatly facilitate subsequent hepaticojejunostomy. During this time, consideration has got to patient's nutrition and to the treatment of sepsis with the intent of obtaining a successful surgical repair. Anastomosis to a small non-dilated duct is technically challenging particularly in the face of surrounding fibrosis and sepsis (Pleass and Garden, 1998).

I- SURGICAL INTERVENTION FOR REPAIR OF BILE DUCT INJURIES

Preoperative Management:

Except in case of peritonitis, there is no need for early surgical intervention (Westcott and Pappas, 1998).The preoperative management of a patient with postoperative bile duct injury depends primarily on the timing of presentation. Patients presenting in the early postoperative period with stricture frequently are septic with either cholangitis or intra-abdominal bile collections. Sepsis must be controlled first with broad-spectrum parenteral antibiotics, percutaneous biliary drainage, percutaneous or operative drainage of biliary leaks, or some combinations. Once sepsis is controlled, there is no hurry in proceeding with surgical reconstruction of the bile duct stricture (Lillemoe et al, 1990).

After confirmation of an injury the surgeon must decide whether to perform the repair or refer the patient to a specialized center. Surgeon must assess his competence to define the injury and complete the repair and to fulfill the postoperative and follow-up care requirements (Westcott and Pappas 1998).

Infection is the most lethal complication of repair of biliary tract injuries and strictures. The organisms involved are gram negative, such as Escherichia coli and Pseudomonas. Antibiotics are given before, during, and after the operations. Treatment should be continued for several days after the operative interference (Braasch, 1997).

Because of the risk of renal tubular injury in cholestatic patients, aggressive hydration is essential before surgery. Parenteral vitamin K is sufficient to optimize coagulation in the non-cirrhotic patient. If portal hypertension is present, a preoperative portal decompression with a transjugular intrahepatic portocaval shunt (TIPS) might be considered (Edmond and Marvin, 2001).

Attention should be paid to correct fluid and electrolyte abnormalities, anemia, and nutritional deficits. The combination of proximal biliary decompression and external drainage will allow most biliary fistulae to be controlled or even to close (Ahrendt and Pitt, 2001). After control of sepsis and fistulae, the patient often may then be discharged home to allow 2 to 3 months for resolution of the inflammation in the periportal region and recovery of overall health (Czerniak et al, 1988).

In patients presenting with biliary stricture remote from the initial operation, symptoms of cholangitis may necessitate urgent cholangiography and biliary decompression after delineation of the anatomic pathology (Lillemoe et al, 1990).

Biliary drainage usually is best accomplished by the transhepatic method, although endoscopic stent placement can also be successful. Parenteral antibiotics and biliary drainage should be continued until sepsis is controlled. Other patients presented with jaundice without cholangitis. In these cases, PTC should be performed to define anatomy (McPherson et al, 1984).

Approximately 70-80% of patients responds to medical therapy and do not need urgent intervention. Patients not responding to empiric antibiotic therapy within 24 hours or those with hypotension requiring vasopressors, disseminated intravascular coagulation, or multiorgan system failure should be considered for immediate biliary decompression, which can be performed surgically, percutaneously, or endoscopically. Endoscopic or percutaneous decompression often is associated with lower morbidity and should be considered first (Pande et al, 2002).

Intra-operative bile duct injuries detected during the primary surgery:

Proper management of a bile duct injury recognized at the time of cholecystectomy or other abdominal surgery can avert the development of a bile duct stricture. The optimum time of surgical repair of bile duct injuries detected intra-operatively is immediately when the injury occurred. It has been shown that the morbidity and mortality of such a primary repair is significantly lower than attempted surgery at a later date (Raute et al 1993, Braasch 1997). Immediate surgical repair of bile duct injury offers excellent results with lower morbidity (Abdel Wahab et al, 1996).

Incisional injuries may be managed satisfactorily by the placement of a T-tube and primary repair of the duct. Unfortunately, most transectional injuries are associated with loss of bile duct and a more complex repair is required. If the operating surgeon is not experienced in biliary reconstruction and is unable to gain the immediate assistance of such a surgeon, it is better to advocate tube drainage of the porta hepatis and urgent transfer to a center specializing in the management of bile duct injury. In such case, early reconstruction can be undertaken after appropriate assessment and before sepsis disrupts the operative field (Pleass and Garden, 1998).

Repair of transection type of injury may be done by an end-to-end anastomosis and covering T-tube stent, but such injuries are often associated with ischemia, loss of ductal tissue or sepsis. It is often impossible to effect a repair without tension and the long-term success rate for such repairs is thought to be no more than 50% (Ress et al 1993). The recipient of the proximal bile duct can be the distal bile duct, duodenum, or jejunum. The jejunum may be in the form of a Roux-en-Y loop or simple loop with a side-to-side anastomosis at its base. The anastomosis should be stented for 6 months (Braasch, 1997).

Therapy at the time of surgery:

Repair at the time of the initial surgery has the advantage of working with normal tissues, good physiologic condition, and the possibility of providing a single procedure. Late repair has the advantage of dilatation of the bile ducts, as well as referral to a tertiary care center.

When an intra-operative injury is suspected, injury must be defined. After confirmation of an injury the surgeon must decide whether to perform the repair or refer the patient to a specialized center. In the classic injury pattern the second ductal incision can be avoided if recognized early, all attempts should be made to preserve duct length. A drain should be left in the area of the injury and antibiotics with biliary coverage started (Westcott and Pappas, 1998).

Small partial lacerations can be sutured primarily over a T-tube. Wall defects are repaired with a patch to prevent the loss of cross-sectional diameter. Cystic duct stump and vein patches have been described, but the most accepted method is a Roux loop jejunal anastomosis (Westcott and Pappas, 1998).

Treatment of bile duct injuries detected during laparoscopic cholecystectomy:

The management of bile duct injuries detected during LC is mainly dependent on local expertise. If sufficient experience in hepatobiliary surgery is not available (after consultation), biliary drainage should be performed without exploration and the patient should be referred to a specialized center. If the local anatomy is unclear, one should abandon further exploration because it could lead to proximal extension of the lesion, sacrificing of normal, healthy duct tissue, damage to the arterial supply or clipping or ligation of the right hepatic artery and thus will have a negative effect on the reconstruction in the near future (Lillemoe et al, 2000).

With the help of an experienced surgeon, further laparoscopic or open exploration can be performed to identify the structures in the hepatoduodenal ligament and the severity of the injury. If a common bile duct lesion is adequately identified and not associated with extensive damage or tissue loss and thus suitable for primary repair, an end-to-end anastomosis should be performed over a T-tube for drainage. This procedure is associated with a high incidence of late bile duct stricture, but provides optimal internal biliary drainage with a reasonable chance for cure. It also creates the optimal circumstances for reconstructive surgery by means of an elective hepaticojejunostomy at a later stage. Endoscopic stenting and/or balloon dilatation may be successful in these patients after primary repair and even if not successful does not adversely effect surgical reconstruction. If part of the bile duct is accidentally resected but the proximal duct is well below the bifurcation of the hepatic duct and local circumstances (experience) are optimal, an acute reconstruction by hepaticojejunostomy can be performed (Gouma and Obertop, 2002).

Treatment of delayed detected bile duct injuries:

Patients with bile duct injuries, which are detected at a later phase, should not undergo exploration before classification of the injury, except in patients with severe biliary peritonitis who cannot be managed by percutaneous drainage. In patients with delayed diagnosis, drainage should be performed by ERCP and stent insertion or PTC. Both techniques can be combined with US or CT-guided percutaneous drainage of a bile collection (Mercado et al, 2002).

An important factor for surgical outcome is the timing of reconstruction. It has been suggested that surgical reconstruction by hepaticojejunostomy in the late acute postoperative phase (often in patients with bile leakage and subsequent peritonitis, ileus and the presence of local inflammatory changes in the hepatoduodenal ligament) is associated with a higher risk of postoperative complications such as bile leakage and eventually stenosis of the anastomosis. Therefore, patients are sent home with a drainage catheter and collecting bag and some of these patients will have a nasogastric tube or a percutaneous gastric catheter to replace bile into the duodenum. When an exploration is performed for drainage of a bile collection after unsuccessful attempt at repair, a small bore feeding jejunostomy can be performed to enable re-insertion of bile into the gastrointestinal tract. Reconstruction of the biliary tract is performed electively after 6-8 weeks. During exploration, there is generally a dense inflammatory reaction and fibrosis around the area of injury (Gouma and Obertop, 2002).

Exploration is started by mobilization of the transverse colon and duodenum from the liver, and in particular the gallbladder bed. Dissection of the hepatoduodenal ligament is essential but might be difficult due to fibrosis. Therefore, starting dissection towards the liver hilum and early lowering of the hepatic duct remnant by dividing the hilar plate is mandatory to minimize dissection between the duct remnant and portal vein. The percutaneous drain, the drain tract, or the PTC catheter can be used as guidance in the hilum to the damaged duct (Bismuth and Majino, 2001).

Multiple intrahepatic segmental duct stumps are mobilized and if possible sutured together before one or two-jejunal anastomosis is performed. Usually normal duct mucosal can be seen after resection of the fibrotic tissue. Temporary stenting of the anastomosis is only performed in non-dilated ducts or when a percutaneous transhepatic drainage catheter is already in site (Gouma and Obertop, 2002).

Hepaticojejunostomy is the common method of repair for bile duct injury. Jarnagin and Blumgart(1999), showed three fundamental principles for repairing a biliary stricture at the hepatic hilum: (1) identification of healthy bile duct mucosa proximal to the injury, (2) direct mucosa-to-mucosa anastomosis with interrupted and absorbable sutures, (3) Roux-en-Y anastomosis 70 cm proximal to the enteroenterostomy. In addition, an anterior longitudinal opening of the bile duct followed by side-to-side anastomosis is recommended when circumferential biliary dissection is difficult (Strasberg et al, 1995).

An initial exposure of the left hepatic duct by lowering the hilar plate at the base of segment IV is also recommended. A side-to-side hepaticojejunostomy made by a longitudinal incision of extrahepatic left hepatic duct produces a wide anastomosis, minimizes dissection behind the biliary ducts, and decreases risk of devascularization of the ducts (Blumgart, 1994).

The use of a postoperative transanastomotic stent is controversial. Sutherland et al (1999) recommended its use only when very small ducts are anastomosed because a neglected stent can be the focus of infection or bleeding which increases postoperative morbidity.

A stent is passed through the anastomosis and left in place long enough to prevent stricturing. In the hands of experienced surgeons, excellent outcome from the operative repair is achieved in70% to 90%of patients (Sachdeva et al, 2000).

OPERATIVE TECHNIQUES OF BILIARY TRACT RECONSTRUCTION AND REPAIR

1- *End-to-end Repair:* The important features of the classic end-to-end bile duct repair over a T-tube are minimal loss of bile duct tissue and the presence of enough length of extrahepatic bile ducts to permit a tension-free mucosa-to-mucosa anastomosis in viable duct tissue. The segment of bile duct that has been clipped, suture ligated, or affected by thermal injury should be resected back to healthy viable tissue. The biliary anastomosis is performed using a single layer of interrupted sutures of absorbable monofilament material, perfectly under magnification. A T-tube is placed in the common bile duct, its vertical limb existing at a distance from the anastomosis (Fig.11). The role of the T-tube remains controversial, although most surgeons use it for a variable amount of time (Csendes et al, 1989 b, Blumgart and Matthews, 1997and Westcott and Pappas 1998).

The large experience with end-to-end repair suggests that end-to end repair is associated with about a 40% to 50% long-term rate of failure. This rate is even more when one considers that the most favorable patients underwent end-to-end repair, whereas the less favorable ones, that is, patients with more periductal fibrosis and loss of bile duct tissue. Although some of the failed end-to-end repairs can be salvaged by endoscopic dilatation, whether good long-term results can be achieved remains unclear (Rossi and Tsao, 1994).

End-to-end repair (unlike that done in liver transplantation) has a high failure rate, with late stenosis and/or dysfunction consequent to loss of substance from the duct and ischemia secondary to the dissection (Mercado et al, 2002).

2- *Hepaticojejunostomy*: Repair of extrahepatic biliary tract injuries with hepaticojejunostomy with direct sutured anastomosis between the bile duct and the Roux-en-Y loop of jejunum at a level of good blood supply remains the gold standard for treatment of more severe injuries and strictures of the bile ducts(Fig.12) (Westcott and Pappas 1998 and Sawaya et al 2001). An anastomosis with a Roux-en-Y jejunal loop to prevent reflux of intestinal contents to the anastomosis site is the best option for reconstruction (Mercado et al, 2002).

A tension free mucosa-to-mucosa anastomosis of adequate diameter is the desired aim of this technique, which was first described by Hepp and Couinaud in1956 (Braasch, 1994). In Bismuth type 1 and 2 injuries, an end-to-side hepaticojejunostomy onto the common hepatic duct may be possible. However, these injuries and those involving the confluence (Bismuth type 3 and 4) are often repaired using the extrahepatic portion of the left hepatic duct after the hilar plate has been lowered by blunt dissection. Exposure and incision of the left duct may be useful in the management of acute injuries, since the lack of a distended ductal system is compensated by an adequate length of incised duct on which to perform side-to-side anastomosis. A Roux limb of 70 cm in length should be fashioned. The use of interrupted monofilament absorbable 4/0 polydioxanone sutures is advocated employing an anterior and posterior layers technique (Myburgh, 1993).

On occasion, multiple hepaticojejunostomies above the hepatic bifurcation are required after excision of the fibrotic tissue and stricture at the level of the segmental ducts. Again, dissection of the hilar plate becomes essential in these patients (Rossi and Tsao, 1994, Abdel Wahab et al, 1996). When multiple high hepaticojejunostomies are performed, awareness of the presence of all segmental ducts is important to avoid excluding an area in the liver from draining adequately. In some patients, all ducts can be sutured to the same opening in the jejunum by approximating some of these ducts and creating septa between them. This procedure is carried out under magnification and with absorbable sutures of monofilament material (Rossi and Tsao, 1994).

A transhepatic stent is placed through a small segmental duct primarily to facilitate performance of the anastomosis. Stents are removed within 6 weeks to minimize the deposit of debris within the biliary system and the irritative effect of the stent. Knowledge of the techniques of hilar plate dissection and accurate mucosa-to-mucosa anastomosis is essential to accomplishing a watertight hepaticojejunostomy (Rossi and Tsao 1994).

Leaving the end of the Roux limb in a subcutaneous position has been described as a technique to permit percutaneous endoscopic or radiologic instrumentation of the anastomosis in instances of recurrent stricture (Regula et al, 1991).

3- ***Heineke-Mikulicz plastic repair of stricture*** In this procedure, a longitudinal incision is done through the stricture then transverse closure is done. A T-tube stent is used (Fig.13) (Moorhead and Warren, 1976).

4- ***Construction of hepatic duct bifurcation when bifurcation has been destroyed*** When the hepatic bifurcation has been destroyed, the right and left hepatic ducts can be approximated side to side to make a new septum that can be crushed with a narrow hemostat, producing a new common hepatic duct or extension of the bile duct opening to the left hepatic duct to permit wide anastomosis. In this way, just a single anastomosis is necessary (Fig.14) (Westcott and Pappas, 1998).

5- ***Right and left duct hepaticojejunostomy*** When the two proximal hepatic ducts are too far apart, it is necessary to perform two hepaticojejunostomies. In this instance, it is usually difficult to stent these two anastomosis with a one T-tube, and the use of two transhepatic tubes are suitable (Fig.15) (Braasch, 1997).

6- ***Longmire procedure:*** In 1948, Longmire described an approach to the segment II duct of the left lobe of the liver for use when approaches to the hilus were not possible (Fig.16) (Braasch 1994). The Longmire approach involves excision of a portion of the left lobe of the liver to identify a dilated duct. This technique proved to be associated with a greater blood loss and often less effective biliary enteric anastomosis (Blumgart 1994 and Westcott and Pappas, 1998).

7- ***Intrahepatic cholangiojejunostomy:*** On rare occasions, in the patient with multiple previous hilar operations, the hilum may be frozen and not accessible to the surgeon. Knowledge of the segmental anatomy (Fig.17) is important. Drainage of the left lobe through the duct to segment III and drainage of the right lobe through the duct to segment V are alternatives. Segment III duct is identified to the left of the round ligament. These techniques replaced the Longmire technique of excising a portion of the left lobe of the liver to identify a dilated duct. Techniques of cholangiojejunostomy are complex and require considerable expertise in hepatobiliary surgery (Rossi and Tsao, 1994).

Mercado et al (1999) described a technique for intrahepatic reconstruction of the biliary tree after complex high injuries is described. The fundament of the procedure is the removal of a wedge of segment IV at the level of the hilar plate. When the hilar plate is reached and no adequate exposure of the ducts can be obtained, removing a one by one inch wedge of segment IV between the gallbladder bed and the round ligament exposes the left and right ducts. An anteroposterior view of the plate is obtained instead of a caudocephalic dissection, exposing healthy, and nonscarred ducts for reconstruction. Adequate exposure of the ducts has been obtained, with a high success rate of patency of the anastomosis at a mean follow-up of 3 years with a good quality of life and no restenosis.

8- ***Mucosal graft (Rodney Smith technique):*** A mucosal graft technique was introduced and popularized by Smith in 1969 (Fig.18). It is currently rarely indicated where mucosa-to-mucosa can be done. The technique requires the placement of a transhepatic tube, suturing the jejunum to the transhepatic tube and pulling the transhepatic tube to bring the jejunum to the hilum of the liver. Sutures are placed between the serosa and the capsule of the liver. It was advocated for high biliary strictures, thought too high for a sutured hepaticojejunostomy. This technique failed to recognize the ready access to the extrahepatic portion of the left hepatic duct and is no longer recommended routinely because of the high rate of restricture (Pleass and Garden, 1998).

9- Hepaticoduodenostomy: In selected patients especially when the Roux-en-Y limb cannot reach the right upper quadrant, hepaticoduodenostomy has been performed in an end-to-side manner with good results. This anastomosis has the advantage of being accessible to endoscopic instrumentation (Rossi and Tsao 1994). However, when the duodenum is used and a second procedure is necessary, disconnection of this anastomosis can leave a defect in the side of the duodenum that is difficult to repair (Braasch, 1997).

10- Ligamentum teres (round ligament) approach to the left hepatic duct: It is occasionally difficult to expose the left hepatic duct beneath the quadrate lobe. This may be the result of dense adhesions. Initially, the ligamentum teres is elevated, and the bridge of liver tissue joining segment IV to the left liver is divided and the dissection is started to the left at the base of the ligamentum teres (Blumgart, 1994).

11- Hepaticojejunostomy without sutures: Bratucu et al (1998) described a new technique for the procedure of hepaticojejunal anastomosis without suture, which is adequate for the treatment of benign stenosis of the common bile duct. The method realizes anastomosis of the segments without using sutures by simply keeping them in apposition with continuous traction exerted via a Foley-type balloon catheter which stents the anastomosis in an axial manner. The balloon is then inflated and traction is exerted on the catheter, enabling the two segments of the anastomosis to remain in place until complete healing (10 days average) (Fig.19). The results prompt further evaluation of the method.

Exposure of the biliary remnant:

Adhesions to the liver may be dense, particularly if previous biliary surgery was associated with infection. Adequate exposure often requires substantial mobilization of the right and left lobes to adequately approach the hilum. A transverse incision is made at the base of the liver (segment V) from the base of the round ligament to the gallbladder fossa and into the capsule encasing the portahepatis. This is termed detachment of the hilar plate (Fig.20) and permits the liver tissue of segment IV to be swept superiorly top expose the biliary confluence. Once the hilar plate has been incised and the anterior layer removed from the portal structures, it should be possible to find the bile ducts and open it. Operative sonography may be helpful in localizing bile ducts (Edmond and Marvin, 2001).

WHO SHOULD REPAIR BILE DUCT INJURIES?

How and when a bile duct should be repaired is dependant upon the time of recognition of the injury, the severity of the injury, and the surgical expertise available. These factors are especially important for injuries recognized at the time of laparoscopic cholecystectomy. If the bile duct injury is identified at the time of laparoscopic cholecystectomy, and the surgeon has significant experience in biliary surgery, immediate repair is obvious. If the expertise is available within the hospital, surgical consultation with an experienced surgeon should be sought. The rarity of bile duct injuries in one surgeon's practice makes it unlikely that he or she will have the requisite experience for a high hepaticojejunostomy to several bile ducts, unless that surgeon has a referral practice for complex biliary disease (Stain, 1997).

If the diagnosis of bile duct injury is made in the postoperative period, the primary surgeon must weigh his own abilities before a decision is made regarding referral or consultation with a colleague. Laparoscopic bile duct injury has become one of the most litigated malpractice issues. Successful defense of such a claim requires that the diagnosis of bile duct injury was made promptly, and optimal chance at successful repair was given. The primary surgeon should consider several factors before reoperation. If the primary attempt is not successful, the comparison will be made against the published results. The first operative attempt at repair has the highest chance of success, and biliary tract surgeons have better results with greater than 85% early success rate (Davidoff et al, 1992, and Stewart and Way, 1995). In their report of the experience, Stewart and Way (1995) reported 64 operative repairs by the primary surgeon, and only 11% were successful (required no subsequent repairs). A total of 46 repairs were performed on 45 patients by the tertiary care biliary surgeons (first repair, 19; second repair, 25; third repair, one; and fourth repair, one). The initial success for specialized surgeons was 94%, with an additional 4% being treated by dilatation of intrahepatic anastomotic strictures. It might be argued that these data are self-serving, and that the tertiary surgeon only sees the failures, and that most injuries in the community are repaired successfully there.

Chapman et al (1995) reported a series of 130 patients with bile duct strictures after open cholecystectomy. Of the 110 patients treated by stricture repair alone, 79 patients (76%) had an excellent result with no biliary symptoms or need for further intervention during a mean follow up of 7.2 years. Eleven additional patients were symptom-free after anastomotic revision or radiologic intervention. Thus, 90 patients (87%) had excellent or good long-term results when managed by biliary specialists. Late stricture may occur up to 10 years after injury, and ultimate success is dependent upon long-term follow-up.

LONG-TERM OUTCOME AFTER REPAIR OF BILE DUCT INJURIES

Results from centers have shown excellent short-term results after surgical repair and long-term follow-up showed good functional outcome in more than 90% of the patients. The objective functional outcome (5years follow-up) was excellent in 94% of the patients selected for endoscopic treatment.

The results of surgical treatment are dependent on the timing of reconstruction. Despite the good objective outcome, the quality of life, even 5 years after the bile duct injury, appeared to be severely impaired both physically and mentally in comparison to the control patients who underwent LC without bile duct injury. It was frequently noted that patients were disappointed about the occurrence of the injury and in particular about the delay in diagnosis, despite their report of symptoms after the procedure, and the reluctance of the primary surgeon to discuss the procedural error and possible subsequent severe complication or even to acknowledge the error (Lillemoe et al, 2000).

THE ROLE OF BILIARY STENTING AFTER SURGERY FOR BILE DUCT INJURIES

The role of biliary stenting after surgery for the repair of bile duct injuries (Fig.21) is more controversial. The transanastomotic stent is helpful in almost all cases. In the early postoperative period it is useful to decompress the biliary tree if a leak occurs and to provide access for cholangiography. If the injury has involved the common bile duct or the common hepatic duct well distal to the bifurcation where adequate bile duct mucosa could be defined (Bismuth Type 1), the use of long-term biliary stents is not necessary. Regardless of whether a transhepatic catheter or T-tube is used, the catheter can be removed 4-6 weeks after reconstruction (Lillemoe et al, 1990).

How long the stent should remain is controversial. When adequate proximal bile duct is not available for a good mucosa-to-mucosa anastomosis, long-term stenting of the biliary-enteric anastomosis with a silastic transhepatic stent, usually for at least 12 months. Postoperatively, the transhepatic catheter or silastic biliary stent is placed to dependent gravity drainage. Through stents, cholangiography is performed to document anastomotic integrity and the absence of a biliary leakage (Rossi and Tsao, 1994).

Mercado et al (2002) described how to insert a transhepatic stent. A biliary dilator is introduced inside the ductal lumen and exteriorized through the hepatic dome. After exteriorization, a Silastic or latex tube (10F) was fixed to the tip and then delivered through the duct. The distal tip of the stent was placed in the intestinal lumen and the anastomosis was completed.

Sutherland et al (1999) recommended the use of stents only when very small ducts are anastomosed because a neglected stent can be the focus of infection or bleeding which increases postoperative morbidity.

Long-term complications, however, are frequently seen when a bilioenteric anastomosis is combined with trans-anastomotic or transhepatic stenting, particularly with high intrahepatic ducts. Furthermore, it is impossible to eradicate microorganisms from the biliary tree in the presence of a foreign body. As such, stent occlusion and/or migration combined with inspissated, infected bile leads to recurrent bouts of fever and cholangitis in the majority of patients. Treatment typically involves prolonged use of antibiotics, frequent trips to the interventional radiology suite for tube change or manipulation, and at times admission to hospital for control of sepsis. **(**Lichtenstein et al, 2000).

Patients with a trans-anastomotic stent receive follow-up cholangiography through the stent. The stent is scheduled to be removed between the fifth and sixth postoperative months. There are pros and cons for the use of stents. Stents maintain patent anastomosis. During several weeks time, healing of the anastomosis around the stent prevents stenosis (at least to the diameter of the stent) and allows manipulation and/or dilatation of the anastomosis in the postoperative period. Also, stents enable radiologic control of the anastomosis. In the early postoperative period, some patients develop cholestasis with obstruction. Radiologic control rules out obstruction. Another reason for the placement of stents is the added assurance it gives to many surgeons. Although development of complications is infrequent without a stent, the decision to place a stent is an individual one. No convincing evidence-based answer is obtained from some surgeons when asked why a stent was placed (Mercado et al, 2002).

In some instances, it is very difficult to find a duct that has no scar, no inflammatory reaction, and no ischemia (it may be deep in the hepatic parenchyma). Moreover, some of these ducts are small in diameter (<4 mm). If an anastomosis is done in such a duct, a high probability of dysfunction and/or leakage is to be expected. The postoperative edema at the level of the anastomosis, although transitory, is enough to produce obstruction, high intraductal pressure and leakage, subsequent inflammation, and obstruction. In this situation, the stent relieves pressure and maintains a patent anastomosis (Mercado et al, 2002).

Surgical repair remains the treatment of choice for postoperative bile duct stricture. Metallic stents should only be considered for poor surgical candidates, intrahepatic biliary strictures, or failed attempts at surgical repair. Most patients with metallic stents will develop recurrent cholangitis or stent obstruction and require intervention. Chronic inflammation and obstruction may predispose the patient to cholangiocarcinoma (Lopez et al, 2001).

II- INTERVENTIONAL RADIOLOGY AND PERCUTANEOUS TECHNIQUES IN THE MANAGEMENT OF BILE DUCT INJURIES

Non-surgical interventional techniques serve five purposes in the management of postoperative bile duct injuries: 1- definition of the site and cause of the injury, 2- catheter drainage of fluid collections with bacteriologic examination of the fluid for appropriate antibiotic coverage, 3-percutaneous transhepatic drainage of biliary obstruction caused by postoperative stricture or occlusion, 4-palliation of patients who are critically ill to permit improvement in the overall physiologic and hemodynamic status before subsequent reoperative or reconstructive surgery, and 5-provision of readily identifiable anatomic landmarks in patients who will undergo repair of Bismuth type 3 and 4 strictures of the right and left hepatic ducts with hepaticojejunostomy at the hilar plate (Dawson and Muller 1994). Also, preoperative placement of a catheter permits simplified dissection and reliable identification of the strictured ducts at the hilum (Moossa et al, 1992).

Operative management of postoperative bile duct stricture is technically difficult with significant postoperative morbidity and mortality. Moreover in all series, recurrent strictures do develop in a portion of patients. The technical advances in the field of therapeutic radiology and endoscopy, have led to the development of non-operative techniques for the management of postoperative bile duct strictures. The largest non-operative experience in the management of benign bile duct strictures is via the percutaneous transhepatic route. In this technique, access to the proximal biliary tree is gained and the stricture is traversed with a guide wire under fluoroscopic guidance. At this point, dilatation of the stricture is performed using angioplasty-type balloon catheters. The balloon is inflated for at least 30 seconds and the process is repeated until no "waste deformity" is noted during inflation (Lillemoe et al, 1992).

In a multicenter review by Mueller and colleagues (1986), 3-year follow-up showed a 67% patency rate for anastomotic primary bile duct strictures and a 76% patency rate for iatrogenic primary bile duct strictures, yielding an overall 70% success rate. Patency was based on the absence of symptoms and normal bilirubin and alkaline phosphatase levels.

If a biliary stricture has developed from ischemia, periductal bile leakage with secondary inflammatory scarring of the duct or partial clipping of the duct, transhepatic balloon dilatation can be performed. Balloon dilatation of a high-grade obstruction of the bile ducts caused by surgical clip placed at the time of LC, was successful. A balloon catheter was able to be placed through the obstructing clip and inflated, opening the bile duct. Successful stricture dilatation after a single session should be expected in 50% to 70 % of patients, with higher rates of success in anastomotic strictures (Fig.22) and lower rates of success in ischemic strictures. Repeated dilatation can be performed when a percutaneous catheter is left across the stricture Patients with complicated postoperative stricture or prolonged leakage may require stenting for as long as one year (Wright et al ,1993). In patients in whom complete occlusion of the common hepatic duct is present and catheter drainage does not succeed, surgical repair is required (Dawson and Mueller, 1994). An alternative route for percutaneous management of anastomotic biliary strictures is retrograde access, using a subcutaneous modified Roux-en-Y jejunal limb (Fig.23). This technique has been modified by Maroney and Ring (1987), who percutaneously catheterized nonmodified Roux-en-Y limbs and dilated strictures.

Dawson and Mueller (1994) recommend that, all postoperative perihepatic collections must be drained initially by radiologic technique, and only collections that require subsequent surgical intervention undergo repeat laparotomy. They believe that an aggressive interventional radiologic approach to perihepatic and subhepatic collections is warranted because of the lower morbidity of percutaneous treatment and the fact that patients may be discharged with catheter in place, permitting a shorter hospital stay. Percutaneous drainage of bilomas is always preferable to laparotomy (Moossa et al, 1992).

If complications of interventional radiologic procedure develop, the radiologist is uniquely qualified to identify and treat the complication, whether it is tube dislodgment, occlusion of a drainage catheter, or recurrence of a fluid collection or stricture (Dawson and Mueller, 1994).

Percutaneous transhepatic cholangioplasty and biliary stenting are executed in a few stages as the tract through the liver is dilated gradually to pass the optimal size stent. The stent may be completely internalized, with one lumen in the duodenum and the other proximal to the stricture, or may be an internal-external stent, with one lumen outside and one distal to the stricture (Pande et al, 2002).

Biliary leaks can be treated successfully by means of percutaneous transhepatic biliary drainage. The procedure is particularly useful when surgical or endoscopic management has failed (Ernst et al, 1999).

III- ENDOSCOPIC TECHNIQUES FOR THE MANAGEMENT OF BILE DUCT INJURIES

The traditional approach to iatrogenic bile duct injuries and strictures has been Roux-en-Y hepaticojejunostomy. This approach is associated with considerable morbidity and mortality, and most surgical series suggest a 10% to 30% stricture recurrence rate (Kozarek, 1994).

Once bile leaks or ductal injury are suspected, ERCP should be performed to confirm the leak, identify its site and cause, and help define a therapeutic plan. In minor leaks, endoscopic diversion by sphincterotomy or stenting provides a rapid solution. In more significant injuries where ductal integrity is intact, endoscopic dilatation and stenting may play a role in closing leaks and resolving strictures while averting surgery. Where injury is severe, ERCP, often combined with transhepatic cholangiography, helps to rapidly assess the extent of injury and plan a strategy for operative repair (Ponsky, 1996).

ERCP has become increasingly important in identifying bile leaks and their source after biliary surgery. It should be done to confirm the leak and the site of stricture if present and help to define a therapeutic plan. ERCP should be considered the treatment of choice for bile leak. (Al Rashed et al 1996, and El-Ebaidy 1999). This procedure is technically possible only in patients with primary bile duct strictures or strictures at a choledochoduodenal anastomosis (Lillemoe et al, 1992). Sphincterotomy, stent or naso-biliary drainage has a significant role to play in the immediate management of postoperative bile leaks.

Percutaneous stent insertion has been described for unfit patients not considered candidates for surgical intervention. The long-term results of such techniques and the risk of recurrent stricture remain unclear (Abdel Wahab et al 1996, Pleass and Garden, 1998).

- ***Endoscopic management of bile leakage:*** Patients in whom serious postoperative bile leak develops may have variable degree of malaise, nausea, fever, ileus, jaundice, and abdominal pain on presentation. Cystic duct leakage can be handled by ERCP and placement of biliary endoprosthesis (Fig.24), but antibiotic coverage is advised before manipulation (Kozarek and Traverso 1991). Common duct fistulas particularly in conjunction with an associated ductal stenosis is managed by ERCP, endoscopic sphincterotomy and placement of endoprosthesis, depending on the size of the duct and degree of stenosis (Kozarek 1993). After ERCP, patients showed rapid closure of fistulae. Four factors portended a favorable outcome: extrahepatic as opposed to intrahepatic lesions, injuries less than 0.5 cm, distal obstruction that could be treated with sphincterotomy alone and absence of bile peritonitis or intra-abdominal abscess (Kozarek, 1994).
- ***Endoscopic dilatation of biliary stricture:*** Endoscopic management of biliary strictures requires continuity of the biliary tree. A guide wire is passed through the area of stricture and the stricture is dilated with a balloon. Stents are placed after dilatation. Often, stents are left in place for a prolonged period and require multiple exchanges (Rossi and Tsao, 1994).

Therapy consists of hydrostatic balloon dilatation to a size approximating immediately distal to the stenosis. After dilatation, one or two endoprosthesis are placed in an attempt to bypass the site of injury and to prevent recurrent formation of the stricture (Kozarek 1994). Prosthesis is periodically exchanged in conjunction with repeat dilatations of the stricture (Pitt et al, 1989).

Endoscopic techniques offer a temporizing measure in patients with cholangitis and can be used as a more definitive technique in high-risk patients, in patients with difficult proximal strictures, and in patients with portal hypertension and cirrhosis. Endoscopic techniques are associated with long-term results that are similar to those with percutaneous radiologic techniques, but the morbidity related to puncture of the liver is avoided (Rossi and Tsao 1994, and Sherlock and Dooley, 1997).

Surgery should probably be reserved for those patients with complete ductal obstruction or those in whom endoscopic therapy has failed. Endoscopic therapy generally involves a sphincterotomy, which is performed at the first endoscopic session simultaneously with the placement of one or two stents across the area of obstruction. Dilatation of the stricture may be necessary if the stricture is too tight. The insertion of a second stent may be possible only during a second endoscopy session. Thereafter, elective replacement of the stents seems desirable to prevent cholangitis by stent occlusion because polyethylene stents generally clog in 3-4 months (Pande et al, 2002). Results after endoscopic treatment were excellent with a 94% success rate (no recurrent symptoms, no abnormal liver function tests after 5 year) (Gouma and Obertop, 2001).

RESULTS OF REPAIR OF INJURIES AND OUTCOME

Four factors which will determine the success or failure of treatment: the performance of preoperative cholangiography, the choice of surgical repair, the detail of the surgical repair, and the experience of the surgeon performing the repair (Stewart and Way, 1995, and Lillemoe et al, 1997).

Success rates over 90% have been reported after performing biliary reconstruction with a Roux-en-Y hepaticojejunostomy with intermediate follow-up. (Ahrendt and Pitt, 2001)

The type of repair is of significant importance in influencing the outcome. It has been shown repeatedly that primary end-to-end repair of injured bile duct injuries have a very high failure rate (Pelligrini et al 1984; Csendes et al, 1989 b) and it is reasonable to argue that this operation is almost never appropriate if the bile duct has been completely transected (Stewart and Way, 1995).

Ahrendt and Pitt (2001), classified patients at their latest follow-up as having an excellent (no symptoms attributable to their biliary injury or repair), good (mild symptoms not requiring invasive investigation or treatment), or poor result (additional therapeutic procedure after stent removal). Success was defined as an excellent or good result and was achieved in 92% (excellent 79%, good 13%) after surgical management during a mean follow-up of 33 months.

PROGNOSIS AFTER REPAIR OF BILE DUCT INJURIES

The postoperative morbidity for surgical repair of bile duct injuries is high. One retrospective analysis of over 100 bile duct injuries showed that greater than 30% of patients suffered major postoperative complications, although this may often be attributed to the delayed diagnosis of biliary peritonitis in the acute setting (Bottger and Junginger 1991). The common complications encountered are subpherinic and subhepatic collection, wound infections, cholangitis, secondary hemorrhage, biliary fistula and pulmonary complications. The hepatobiliary surgeon may improve outcome by striving to control intra-abdominal sepsis before attempting premature repair of the injury (Pleass and Garden, 1998).

The mortality rate of bile duct injuries is difficult to assess since some patients may die prior to surgical repair and some injuries may go unreported. Prior to the laparoscopic era, 5% of bile duct injuries treated surgically died in the postoperative period (Bottger and Junginger 1991). This compares with a 7.8% mortality following bile duct injuries after LC (Gouma and Go, 1994). With hilar bile duct strictures, a 7% mortality rate has been reported, although this figure falls to 2.4% if cirrhotic patients are excluded from the series (Pleass and Garden, 1998).

The long-term results of repair of bile duct injuries after LC are difficult to assess. Bismuth (1982) has suggested a follow up of at least 5-10 years in asymptomatic patient with normal liver function tests and no restenosis to continue a good result. The restricture rate of bilioenteric anastomosis has been reported to vary between 12% and 25% (Myburgh 1993), with a 10 % related mortality rate within 10 years (Raute et al, 1993).

Development of recurrent stricture following surgical repair of a postcholecystectomy bile duct injury can be related to the technique and timing of the surgical procedure, the complication may therefore be avoidable in some patients. In experienced hands the results of revisional surgery are good but are adversely affected as the number of previous repairs increases (Chaudhary et al, 2002).

EXAMPLES FOR THE SELECTION OF THERAPY

The Treatment of patients with bile duct injuries depends on the type, level and extent of the injury, the timing of diagnosis, the overall status and operative risks of the patient, and the available surgical or interventional radiologic or endoscopic experience (Rossi and Tsao, 1994).

Type of injury:

- ***Cystic duct leakage:*** In most instances, cystic duct leakage can be handled successfully by endoscopic stenting of the common bile duct. More than 75% of cystic duct leaks can be expected to heal with endoscopic biliary drainage (Kozarek et al 1992 and Brook et al 1993). When a sizable subhepatic or intra-abdominal bile collection is present, especially when infected, percutaneous drainage may be required if endoscopic treatment fails (Rossi and Tsao, 1994).

- ***Leakage of bile from the gallbladder bed:*** When leakage of bile from the gallbladder bed become symptomatic, percutaneous drainage is indicated. Either sinography through the percutaneously placed catheter or retrograde cholangiography can document an intact biliary tree and the possible site of leakage (Rossi and Tsao, 1994).

- ***Segmental and unilateral bile duct injuries:*** Segmental bile duct leakage occurs more frequently on the right posterior segmental duct drains low into the common duct. The patient may have an external biliary fistula or collection of bile on presentation or may have pain and elevated alkaline phosphatase level when the duct is occluded. The later form is infrequently identified clinically. External bile leakage from segment duct that continues to drain considerable volume (more than 200 ml of bile) after a month of follow-up observation or is associated with cholangitis requires, in most instances, Roux-en-Y hepaticojejunostomy (Rossi and Tsao, 1994).

Unilateral ductal injury occurs more commonly to the right hepatic duct and is frequently associated with vascular injuries involving the right hepatic artery. Unilateral injuries are seen as external bile leakage and subhepatic collection. In the chronic state, the patient has pain, fever, and elevated alkaline phosphatase level. Jaundice usually absent. Hepaticojejunostomy is the procedure of choice. When recurrent strictures or infections and abscesses occur in the compromised lobe, hepatic resection may be required. Atrophy of the involved lobe can occur with hypertrophy of the contralateral lobe (Rossi and Tsao, 1994).

- ***Bile duct stricture:*** Bile duct stricture represents injuries in which the common duct is narrowed with or without leakage of bile but without considerable loss of tissue. When the occlusion is total, options include excision of stricture followed by end-to-end repair or Roux-en-Y hepaticojejunostomy. When the stricture is not complete and continuity of the extrahepatic bile duct is seen, endoscopic stenting and dilatation are a consideration (Rossi and Tsao 1994). The role of metallic stents in this situation needs further evaluation (Pande et al, 2002).

Surgical management of benign bile duct strictures is necessary for patients with a low surgical risk in whom endoscopic therapy has failed. Surgical management consists of restoration of biliary enteric continuity, which usually is achieved with a defunctionalized Roux-en-Y jejunal loop by means of hepaticojejunostomy, Choledochojejunostomy, or intrahepatic cholangiojejunostomy (Pande et al, 2002).

- ***Transection excision:*** Transection excision represents a common injury secondary to laparoscopic cholecystectomy. Extensive loss of the extrahepatic biliary tree occurs often involving the bifurcation. Roux-en-Y hepaticojejunostomy is the procedure of choice (Rossi and Tsao, 1994).

A MULTIDISCIPLINARY APPROACH TO MAJOR BILE DUCT INJURY

In a study by Yeh et al (1998), the patients received surgical management, interventional radiology and endoscopic treatment. Their study showed that, using a multidisciplinary approach, 75% of the patients attained a promising result through a long-term follow-up, while those with the higher biliary stricture and with an unsuccessful initial surgical repair had a disappointing outcome.

Follow-up after primary non-operative management with balloon dilatation was associated with an overall success rate of 64%. In contrast, primary surgical management with hepaticojejunostomy was associated with a success rate of 92%. Patients undergoing balloon dilatation all had undergone a previous attempt at repair, and in a number of the cases, the balloon dilatation option was aborted in favor of surgery before completion of a full treatment course. Fortunately dilatation failures and surgical failures were all salvaged by secondary management. Therefore, using combined surgical and radiologic management, 100% of patients have achieved a successful outcome (Lillemoe et al, 1997).

CONSERVATIVE MANAGEMENT OF BILE DUCT INJURIES

Approximately 70-80% of patients responds to medical therapy and do not need urgent intervention. Patients not responding to empiric antibiotic therapy within 24 hours or those with hypotension requiring vasopressors, disseminated intravascular coagulation, or multiorgan system failure should be considered for immediate biliary decompression, which can be performed surgically, percutaneously, or endoscopically. Endoscopic or percutaneous decompression often is associated with lower morbidity and should be considered first (Pande et al 2002). Not all late bile duct injuries require intervention. Some patients may remain entirely asymptomatic, the injury being diagnosed by an accidental abdominal US or blood test which demonstrates abnormal liver function tests. Injudicious intervention in such asymptomatic patient may not be necessary or desirable. If the injury has caused atrophy of part of the liver without resulting in sepsis or cholangitis, the patient may merely be observed. Recurrent cholangitis secondary to stricture of the common bile duct or common hepatic duct may result in cirrhosis and portal hypertension with subsequent liver failure. Liver transplantation has been undertaken in patients with both duct and vascular injury in addition to those with secondary biliary cirrhosis (Pleass and Garden, 1998).

BILIARY TRACT INJURY, STRICTURE, AND BILE LEAK AFTER LIVER TRANSPLANTATION

Orthotopic liver transplantation is well established as the most effective therapeutic option for patients with acute and chronic end-stage liver disease. It remains, however, a very complex procedure in an ill patient population and is, therefore, attended by significant morbidity and mortality (Mazariegos et al 1999). Biliary complications continue to remain the Achilles heel of liver transplantation, occurring in an overall incidence of 8% to 15%, with a mortality rate of 10% (O'Connor et al, 1995).

The laboratory diagnosis of biliary complications after liver transplantation depends on elevation in bilirubin, gamma-glutamyltransferase, and alkaline phosphatase levels. The differential diagnosis of elevations in these laboratory findings includes sepsis, graft injury secondary to ischemia, and rejection (Dunham and Aran 1997). Primary imaging modalities are useful in detecting biliary complications after liver transplantation. Sonography is indicated to detect biliary dilatation (Griffith and John 1996), cholangiography (PTC or ERCP) to evaluate for leaks or strictures, and cholescintigraphy using 99mTe-labeled hepatoiminodiacetic acid to look for bile leaks from the cut surface of the liver or from the anastomosis (Kurzawiniski et al, 1997).

Most bile leaks after liver transplantation, are primarily anastomotic complications, T-tube exit site leak, leaks from aberrant ducts or leaks from the surface of the liver in case of split liver transplantation. Management of bile leaks from T-tube exit site is with nasobiliary drainage. Intra-abdominal bile collections can be drained percutaneously. Biliary leaks occurring after choledochojejunostomy most often require operative management (Osorio et al, 1993).

The preferred management strategy for patients with anastomotic obstruction and a choledochocholedochostomy after liver transplantation is conversion to choledochojejunostomy. Balloon dilatation and stenting have also been used with some success (Lewis and Jenkins 1994). Patients who have a stricture of choledochojejunostomy can be initially treated with transhepatic dilatation, with surgical intervention reserved for refractory cases (Donovan 1993). Metallic stents have been used recently to successfully treat intrahepatic strictures after liver transplantation (Khong et al, 1997).

Biliary strictures usually occur 2-6 months after orthotopic liver transplantation (OLT). Anastomotic strictures are more common, with choledochocholedochostomy site stricture being more common than choledochojejunostomy site stricture. (Pande et al, 2002).

THE ROLE OF HEPATIC RESECTION IN THE MANAGEMENT OF BILE DUCT INJURIES

Although hepatic resection is not routinely considered for the treatment of bile duct injury, it can be performed safely and with little or no mortality by experienced centers (Fong et al, 1997).

Segmental liver resection may serve an important role in the management of carefully selected patients with high intrahepatic injuries to avoid long-term transhepatic stenting and complications such as episodic cholangitis and late stricture formation. Hepatic resection may be considered in patients with bile leaks from ducts 3 to 4 mm in diameter. Ligation of the duct in this situation would increase the incidence of hepatic abscess. A resection should also be considered in the presence of a vascular injury associated with the bile duct injury. These complications can lead to significant septic problems or biliary cirrhosis. In these patients with small duct injuries, a resection of the portion of the liver drained by these segmental ducts is a safe alternative to biliary-enteric anastomosis (Gupta et al, 1998, Lichtenstein et al, 2000, and Wakefield et al, 2001).

For higher injuries and injuries involving sectorial ducts, repair may require suture of several ducts, with separate jejunal anastomosis to the Roux limb. In such case, it may be necessary to consider sacrifice of the right hemi-liver in cases of severe bile duct injuries associated with loss of ductal tissue and right hepatic artery injury. It may be unwise to persist at attempt to repair a damaged right duct system since the left duct is readily accessible and left hepaticojejunostomy following right hepatectomy, may be more satisfactory (Pleass and Garden 1998).

When recurrent strictures or infections and abscesses occur in the compromised lobe due to unilateral ductal injury, hepatic resection may be required (Rossi and Tsao, 1994).

In a review of the financial data, there is no significant difference between the cost of a hepaticojejunostomy and that of a hepatic resection. The cost becomes markedly increased, however, with patients who develop complications (e.g., cholangitis) related to hepaticojejunostomy (Lichtenstein et al, 2000).

PREVENTION IS FAR BETTER THAN TREATMENT

Prevention of iatrogenic injury to the bile ducts during either OC or LC relies on a thorough understanding of the anatomy of the region, conditions that predispose to injury, and the mechanisms of injury. Bile duct injury that occurs at LC is of greater severity than with OC. Prevention is the key but should an injury occur; referral to a specialist in biliary reconstructive surgery is indicated (Slater et al, 2002).

The majority of bile duct injuries seen with LC can either be prevented or minimized if the surgeon adheres to a simple and basic rule of biliary surgery; NO structure is ligated or divided until it is absolutely identified! Cholangiography will not prevent bile duct injury, but if performed properly, it will identify an impending injury before the level of injury is extended. And lastly, the incidence of bile duct injury is not related to the laparoscopic technique but to a failure of the surgeon to translate his knowledge and skills from his open experience to the laparoscopic technique (Olsen et al, 1997).

RECOMMENDED STEPS OF DISSECTION AND RETRACTION TO PREVENT POSTOPERATIVE BILE DUCT INJURIES

The following steps are recommended to minimize the chance of iatrogenic injury to the common bile duct.

1- Obtain the maximal cephalic traction of the gallbladder. This step provides reduction of the redundancies of the gallbladder and better visualization of the area of the triangle of Calot (Hunter, 1991).

2- Obtain lateral and inferior retraction of the Hartmann's pouch of the gallbladder, pulling it away from the liver. This maneuver generates a more distinct angle between the cystic and common ducts, permitting better identification of both structures and avoiding their alignment (Reddick et al, 1991).

3- Start the dissection high in the neck of the gallbladder and carry it in a lateral to medial direction. All dissection should be kept close to the gallbladder until the anatomy is well defined (Olsen et al, 1997). The cystic node is a good landmark for the cystic duct at which to start the dissection .The cystic duct should be the first tubular structure found in the triangle of Calot (Martin and Rossi, 1994)

4- Turn Hartmann's pouch medially for posterolateral dissection of the serosa of the gallbladder. This maneuver is helpful to identify the junction of the neck of the gallbladder with the cystic duct. Dissection should proceed along the posterolateral aspect, dividing the serosal attachment of the neck of the gallbladder to the liver. The narrowing of the gallbladder infundibulum into the cystic duct should be defined clearly in its entire circumference (Martin and Rossi, 1994).

5- Free the neck of the gallbladder from its hepatic bed. In the instance of acute inflammation or chronic scarring, it is essential that the junction of the cystic duct and the infundibulum of the gallbladder be dissected and visualized in its entire circumference. High dissection of the neck of the gallbladder, separating it from the hepatic bed, permits an approach similar to that of the anterograde technique of open cholecystectomy. This maneuver permits clear visualization of the gallbladder as it narrow into the cystic duct (Hunter, 1991).

6- Obtain clear visualization of both limbs of the clips. When accurate anatomic identification is obtained, clips should be placed as close to the gallbladder as possible under direct visualization. In instances of a short cystic duct, a tie can be used instead of a clip around the neck of the gallbladder (Martin and Rossi, 1994).

7- Perform cholangiography. Intraoperative cholangiography is helpful to define the anatomy further, detect the presence of calculi, and prevent, recognize, or decrease the severity of an injury (Martin and Rossi, 1994).

8- Keep the dissection close to the gallbladder. When the cystic duct and artery have been divided, the dissection should be continued close to the gallbladder and away from the structures of the hilum of the liver. Excessive use of the electrocautery should be avoided when in close proximity to the hilum of the liver. During laparoscopic cholecystectomy, visual identification of the common bile duct is not essential or recommended (Martin and Rossi, 1994).

9- Convert to OC. Each surgeon should consider his or her limitations and should determine when the degree of difficulty or uncertainty is enough to necessitate converting to OC (Martin and Rossi, 1994).

INTRA-OPERATIVE CHOLANGIOGRAPHY AND THE PREVENTION OF POSTOPERATIVE BILE DUCT INJURIES

The debate over routine versus selective intra-operative cholangiography during OC or LC has continued without definitive resolution (Clair et al, 1993).

Intraoperative cholangiography is warranted for patients with evidence of choledocholithiasis, large cystic duct, and multiple small calculi and for patients with elevated levels of liver function tests. The advent of LC has further muddied the waters regarding this issue. Proponents of routine cholangiography during LC contend that it is helpful in demonstrating variant anatomy and revealing occult injuries at the initial procedure. Furthermore, it is suggested that routine use in LC hastens the learning curve of the procedure (Hunter 1993). If intra-operative cholangiography is performed routinely, the presence and form of bile duct injury can be clearly identified, and the decision to restore the site of injury or to convert to the open technique for biliary reconstruction can be made immediately. (Inui et al 1998). Opponents of routine cholangiography state that laparoscopic cholangiography is technically more difficult and requires equipments that are not uniformly available to all surgeons. It is argued that the procedure is potentially injurious (Brodish et al, 1993).

The majority of patients with bile duct injuries referred to specialist centers were not submitted to preoperative cholangiography (Bergman et al 1996). The injury was severe and usually associated with substantial loss of ductal tissue when preoperative cholangiography was not performed. If the common bile duct is mistakenly identified as the cystic duct, it will be injured in order to perform the operative cholangiogram. If the cholangiography is correctly done and interpreted, major bile duct injury will be avoided. Injury will be recognized and it will be possible to manage the complication appropriately. Peroperative cholangiography should prevent the loss of ductal tissue seen in the classical injury. Early recognition of bile duct injury by cholangiography will minimize morbidity and will not expose the patient to the subsequent risk of biliary peritonitis and jaundice (Pleass and Garden 1998). Operative cholangiography has a protective effect for complications of cholecystectomy (Fletcher et al 1999). Intraoperative cholangiography is helpful for intra-operative discovery of injuries (Archer et al, 2001).

In order for a cholangiogram to be of benefit, a complete study showing the upper biliary tree has to be achieved. Prevention of just one major duct injury can justify the expense of all the routine cholangiogram that a surgeon performs in his career (Olsen et al, 1997).

QUALITY OF LIFE AFTER REPAIR OF BILE DUCT INJURY

During the last several years, quality of life has been an issue of increasing importance in medicine and surgery. There are only limited available quality of life data after the surgical repair of bile duct injuries. (Melton et al 2002). Patients and surgeons expect a successful outcome from laparoscopic cholecystectomy for symptomatic gallbladder stones. The occurrence of an accidental bile duct injury strikes the patient and surgeon with great force, as neither is prepared for this complication, which occurs in around 0.5 per cent of operations (Deziel et al 1993, Richardson et al, 1996).

Often the surgeon is not immediately aware of this disaster, and a delayed diagnosis adds further to the potentially disturbed relationship between doctor and patient. The impact of the unexpected negative outcome on the patient’s quality of life has hardly been given any attention (Gouma and Obertop, 2002). Quality of life is defined as the outcome measure 5 years after repair of a bile duct injury sustained during laparoscopic cholecystectomy. There was no difference in quality of life between patients with minor or major injuries, or between those having endoscopic or open repair (Boerma et al, 2001).

Quality of life is a broad concept that encompasses a patient’s assessment of all aspects of his or her experience. Health-related quality of life encompasses several dimensions of health status that are directly experienced by the person. As it relates to surgical patient after a procedure, health-related quality of life seeks to measure the impact of the disease process and/or procedure on the physical, psychological, and social aspects of the person’s life and feeling of well being (Velanovich 1999). Studies from referral centers seem to have focused on outcome in terms of liver function tests results and scintigraphy, rather in terms of general well being or quality of life. Quality of life is poor after an apparently successful repair of this serious complication of a common operation. More careful and accurate communication between doctor and patient, before and after primary surgery as well as before and after repair surgery, may help to prevent disappointing results. (Gouma and Obertop, 2000).

A successful laparoscopic cholecystectomy is a surgical advance that makes patients and physicians happy. Five-years post procedure, 90 percent of patients with injured bile ducts did have a successful recovery as measured by clinical parameters, but, these patients have an impaired quality of life. Bile duct injury patients and control group patients had similar scores in the physical and social domains, but the bile duct injury patients had significantly lower scores in the psychological domain (Peck, 2001).

THE MORTALITY AND MORBIDITY AFTER BILE DUCT INJURIES

Regardless of etiology, bile duct injuries result in significant mortality and morbidity. Mortality resulted from failure to recognize and appropriately manage complications. Protracted postoperative courses ensued which culminated in the death of these patients. In most series, sepsis leading to multisystem organ failure is the most common cause of death. **(**Lichtenstein et al, 2000), or death may be due to upper gastrointestinal bleeding (Paczynski et al 2002). Inadequate management of bile duct injuries may lead to severe complications, such as biliary peritonitis leading to sepsis and multiple organ failure in the early phase, and biliary cirrhosis during long-term follow-up, eventually leading to the need for liver transplantation (Loinaz et al, 2001).

MEDICOLEGAL PERSPECTIVES OF LAPAROSCOPIC BILE DUCT INJURIES

Although medical negligence litigation casts a pall over virtually all aspects of surgical practice, in no other surgical field has the growth of litigation been as rapid as in laparoscopic cholecystectomy. Since the widespread adoption of laparoscopic cholecystectomy by surgeons in 1990, litigation surrounding bile duct injury alone has surpassed similar litigation for open cholecystectomy by more than 20-fold. In this regard, the Physician Insurers Association of America (PIAA), now undertaking a review of laparoscopic injuries, has tabulated more than 300 lawsuits (150 cases per year) for laparoscopic surgery in the last 2 years. Most of these lawsuits focus on post-LC bile duct injury. By comparison, in the 5 years from 1985 to 1990, only 35 bile duct injuries (7 cases per year) from open cholecystectomy were reported for medical negligence litigation (Kern, 1994).

It is known that most litigation in medical care results from failure of communication between doctor and patient rather than from medical error itself (Fisher 2000).In a literature which confirms the litigious nature of bile duct injuries, the authors stated that one half of cases repaired had proceeded to litigation (Rossi et al, 1992).

CONCLUSIONS AND RECOMMENDATIONS

Bile duct injuries will be always the worst complication of cholecystectomy. Though they will always take place, the incidence and severity can be reduced. Knowledge of how and why they occur can go a long way toward preventing debilitating and life threatening sequelae.

The incidence of bile duct injury seems to be marginally higher after laparoscopic cholecystectomy than after open surgery. Iatrogenic bile duct injuries continue to occur despite increasing experience with laparoscopic cholecystectomy. Careful surgical technique, early recognition, and appropriate management at a specialized hepatobiliary center should decrease the frequency and minimize the morbidity associated with these injuries.

The best treatment for an iatrogenic wound of the biliary tract is prevention by adequate education of surgeons in the performance of a safe technique of cholecystectomy. Great care must be exercised during other biliary tract operations, difficult gastrectomies, pancreatic operations, endoscopic biliary tract investigations and operations in order to preserve the bile ducts. It is very important for every surgeon to be aware of the variants of biliary duct anatomy. It is recommended that, the routine use of intra-operative cholangiography in association with careful dissection of the blood supply to avoid any unexpected bleeding is essential. Injuries recognized during the operation must be repaired immediately by a specific technique suited to the specific injury. On the other hand, injuries recognized in the early postoperative period do not require immediate repair except in the case of bile peritonitis.

A delayed elective reconstruction is associated with fewer complications compared to acute repair under suboptimal circumstances and has a success rate of 90% in experienced centers. Diagnostic work up and treatment of bile duct injuries needs a multidisciplinary approach (gastroenterologists, radiologists, surgeons).

Surgical reconstruction for delayed detected bile duct injuries in the early postoperative phase is associated with a higher risk for complication compared with elective repair after 6-8 weeks.

Precise operative correction is necessary for successful repair of bile duct injuries. The first step in its management is to define the proximal bile duct anatomy, relieve obstruction, and control biliary leak. Surgical reconstruction with Roux-en-Y hepaticojejunostomy with mucosa to mucosa repair seems to be the best way to restore bile flow to the digestive tract.

Once identified, operative repair by hepaticojejunostomy, mucosa-to-mucosa, should be successful in nearly 90% of patients. The first repair of the injury has the best chance of success. Successful repair requires the ability to dissect above the injury to normal bile duct, and perform high hepaticojejunostomies if necessary to individual ducts. End-to-end repair has a high percentage of failure and it is better to be avoided whenever possible.

Non-operative management of postoperative bile duct strictures by percutaneous transhepatic or endoscopic balloon dilatation has been reported to be successful in some patients.

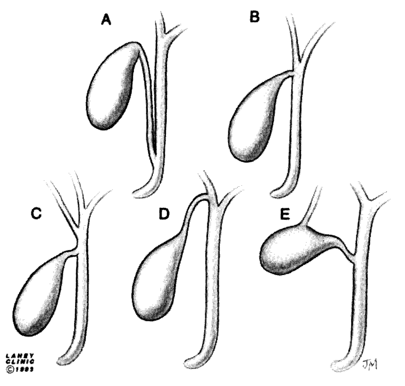

Figure (1): *A-E, Common variants of cystic duct anatomy.*

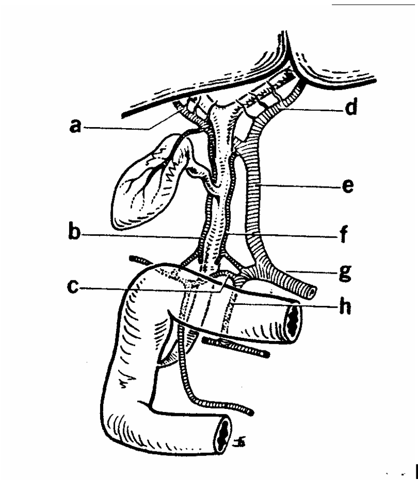

Figure (2): *The bile duct blood supply. Note: The axial arrangement of the vasculature of the supraduodenal portion of the main bile duct and the rich network enclosing the right and left hepatic ducts: right branch of the hepatic artery (a), 9-o'clock artery (b), retroduodenal .artery (c), left branch of the hepatic artery (d), hepatic artery (e), 3-o'clock artery (f), common hepatic artery (g), gastroduodenal artery (h).*

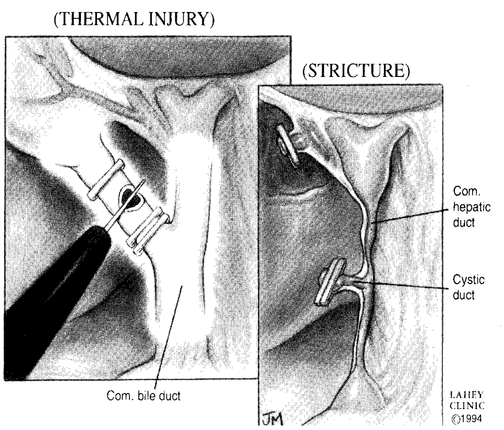

Figure (3): *Diffuse thermal injury with resultant loss of microvascular supply of bile ducts and delayed stricture formation.*

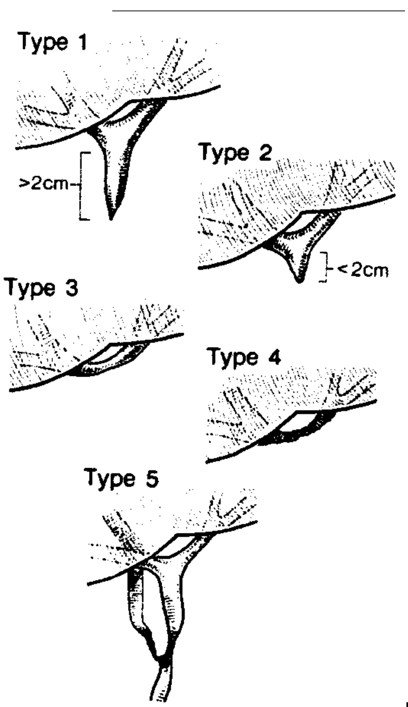

Figure (4): *Classification of bile duct strictures by Bismuth (1982) based on the level of the stricture related to the confluence of the hepatic ducts.*

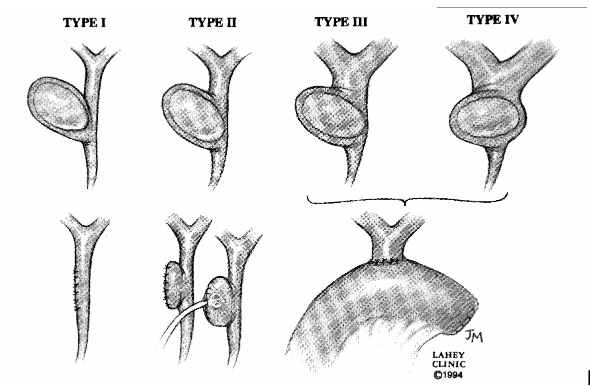

Figure (5): *Classification of Mirizzi's Syndrome and bile duct reconstruction options.*

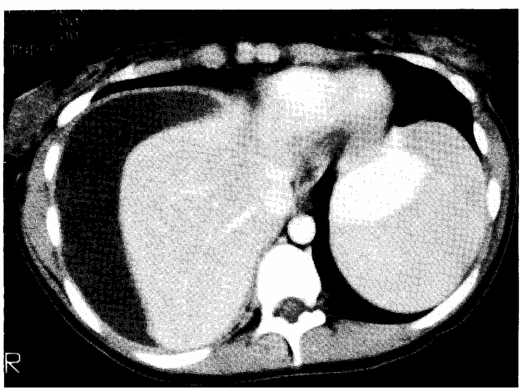

Figure (6): *CT scan demonstrate large biloma lateral to the liver in a patient with leakage from the cystic duct.*

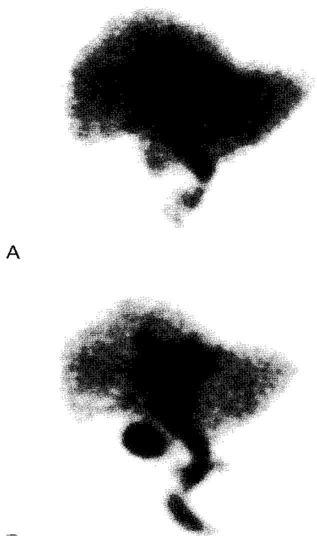

Figure (7): *Common bile duct leakage after cholecystectomy, at 25-minute and 45-minute.*

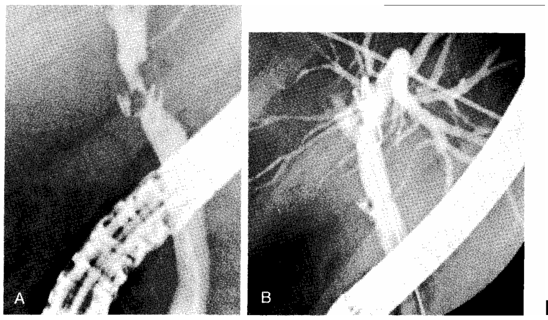

Figure (8): A-*ERCP showing tight stricture of the common bile duct due to surgical clip***. B**-*Balloon dilatation through ERCP was successful.*

Figure (9) *PTC showing long stricture of the mid-common bile duct. Typical appearance of thermal injury caused by electrocautery.*

Figure (10): *PTC showing stricture at a previous choledochojejunostomy*

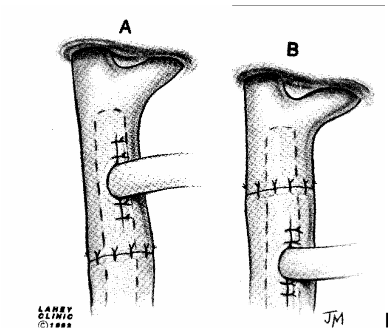

Figure (11): *End-to-end bile duct repair over T-tube*

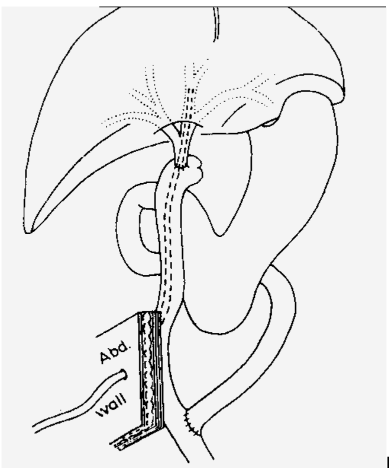

Figure (12): *Hepaticojejunostomy Roux-en-Y, the procedure of choice for patients with major bile duct injuries.*

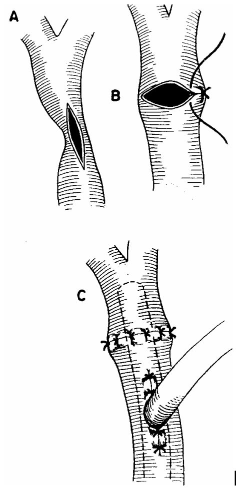

Figure (13): *Heineke-Mikulicz plastic of stricture. A- Longitudinal incision. B- transverse closure. C- Completed and stented anastomosis.*

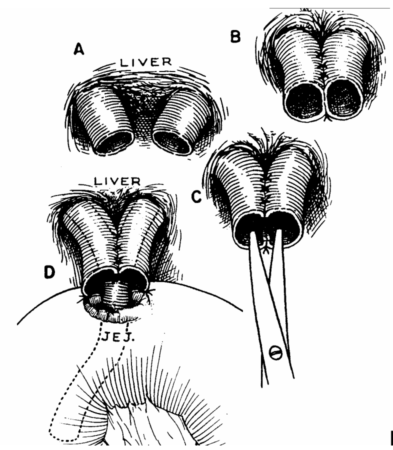

Figure (14): *Construction of hepatic duct bifurcation to permit only one anastomosis.*

Figure (15): *PTC showing choledochojejunostomy with separate left and right ductal anastomosis*

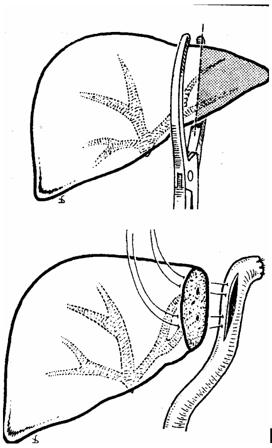

Figure (16): *The Longmire operation. The left lobe of the liver has been completely mobilized by division of the left triangular ligament. A clamp applied across the mobilized lobe allows control of bleeding during removal of a portion of the left lobe to expose the segment II duct and occasionally the segment III duct as well. The jejunal loop may be anastomosed to the surface of the exposed liver as an alternative to direct anastomosis to the duct.*

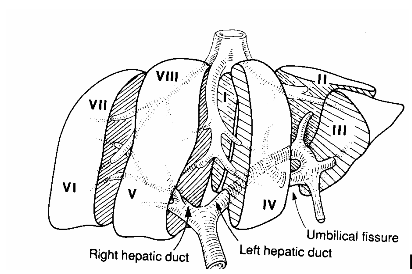

Figure (17): *Segmental structure of the liver and segmental bile ducts.*

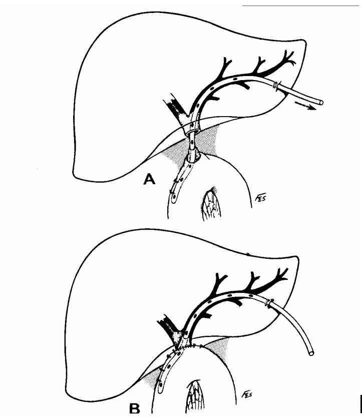

Figure (18): *Smith mucosal graft technique.*

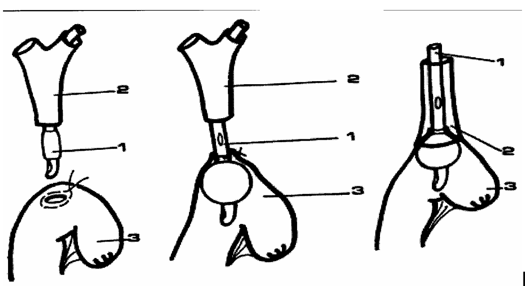

Figure (19): *The successive steps of hepatojejunal anastomosis without sutures.*

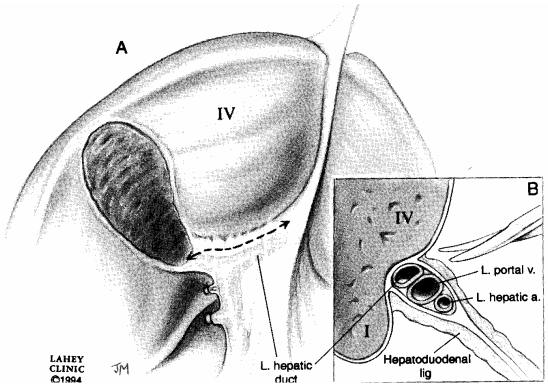

Figure (20): *Mobilization of the hilar plate for high biliary stricture. A- the level of dissection begins at the inferior margin of segment IV, B- Dissection to enter the plane between segment IV and the structures in the hepatic hilum.*

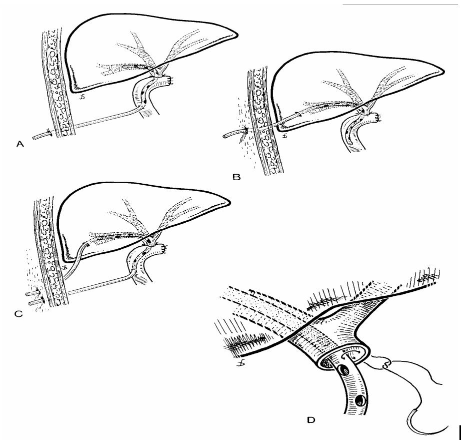

Figure (21): *Variants of passed tubes transjejunally.*

Figure (22): *Successful dilatation through PTC for a stricture in choledochojejunostomy .*

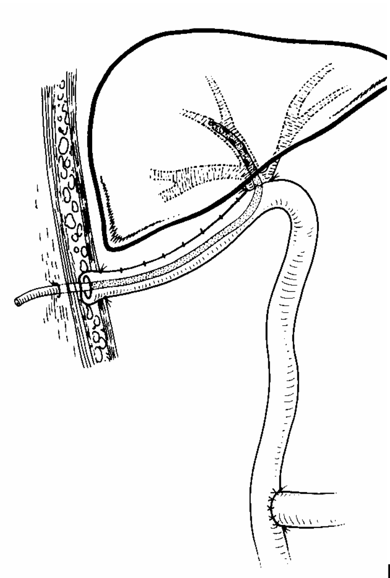

Figure (23): *Roux-en-Y hepaticojejunostomy. The blind end of the jejunal loop is kept deliberately long and is brought to the abdominal wall. It is delivered to the subcutaneous tissue. The anastomosis is splinted with a transjejunal tube that is brought through the blind end of the jejunum and then through the abdominal wall. This tube tract can be used as an avenue for subsequent interventional radiologic or choledochoscopic maneuvers. The Roux-en-Y loop is marked with clips between the peritoneal surface and the anastomosis, and the terminal portion of the loop is marked with a circumferential wire suture. These act as a guide for future radiologic intervention should this be required.*

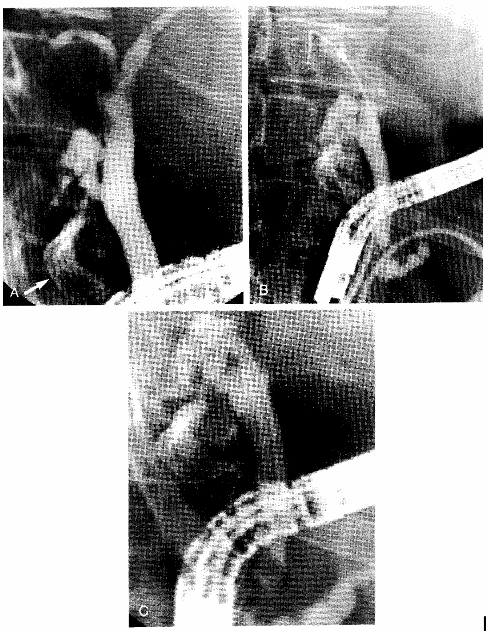

Figure (24): *ERCP showing cystic duct leakage into the gallbladder fossa, insertion of a guidewire, and placement of a stent into the common bile duct.*

REFERENCES

- Abdel Wahab M, El-Ebiedy G, Sultan A, et al: Postcholecystectomy bile duct injuries: Experience with 49 cases managed by different therapeutic modalities. Hepatogastroenterol 1996; 43(11):1141-1147.
- Adkins Jr RB, Chapman W, Reddy VS: Embryology, anatomy, and surgical application of the extrahepatic biliary system. Surg Clin North Am 2000; 80 (1):363-379.
- Ahrendt SA and Pitt HA: Surgical therapy of iatrogenic lesions of biliary tract. World J Surg 2001; 25: 1360-1365.
- Al Rashed RS, Al Mofleh IA, Al Amri SM, et al: Biliary leak: Endoscopic management .Annals Saudi Med.1996; 16(2):126-129.
- Archer SB, Brown DW, Smith CD, et al: Bile Duct Injury During Laparoscopic Cholecystectomy. Ann Surg 2001; 2001; 234:549-559.
- Asbun HJ, Rossi RL, Lowell JA, et al: Bile duct injury during laparoscopic cholecystectomy: Mechanisms of injury, prevention, and management. World J Surg 1993; 17:547-552.
- Azagra JS, De Simone P, Goergen M. Is there a place for laparoscopy in management of postcholecystectomy biliary injuries? .World J Surg 2001; 25(10):1331-1334.
- Bagia JS, North L, and Hunt: Mirizzi syndrome: An extra hazard for laparoscopic cholecystectomy .ANZ J Surg 2001; 71:394-397.
- Barton JR, Fried GM, and Barkun AN et al: Management of bile leaks after laparoscopic cholecystectomy .Br J Surg 1995; 82: 980-984.
- Bergman JJGHM, van den Brink GR, Rauws EAJ et al: Treatment of bile duct lesions after laparoscopic cholecystectomy. Gut 1996; 38: 141-147.
- Bismuth H: .Postoperative strictures of the bile duct. In Blumgart LH (Ed): The biliary tract. Clinical Surgery International, Vol 5.Eidenburg, Churchill Livingstone, 1982.p-p: 209-218.
- Bismuth H and Majino PE: Biliary strictures: Classification based on the principles of surgical treatment. World J Surg 2001; 25: 1241-1244.
- Blumgart LH and Thompson JN: The management of benign stricture of the bile duct. Current Probl Surg 1987; 1:166).
- Blumgart LH: Hilar and intrahepatic biliary enteric anastomosis. Surg Clin North Am 1994; 74(4):845-863.
- Blumgart LH and Matthews JB: Benign biliary strictures. In: Maingot's abdominal Operations. Zinner MJ, Schwartz SI, and Ellis H editor's .10th edition, Ch. 65.Prentice Hall International, Inc.USA, and p-p: 1803-1834.1997.
- Blumgart LH. Biliary tract obstruction: new approach to the old problems. Am J Surg .1978; 135:19-31.
- Boerma D,Rauws EAJ, Keulemans YLA, et al impaired quality of life 5 years after bile duct injury during the laparoscopic cholecystectomy: A prospective analysis. Ann Surg 2001; 234:750-757.
- Bottger T and Junginger T: long-term results after surgical treatment of iatrogenic injury of the bile ducts. Eur J Surg 1991; 157:477-480.
- Braasch JW. Historical perspectives of biliary tract injuries; Surg Clin North Am, 1994, 74(4):731-740.
- Braasch JW: Repair of acute hepatic duct injury and hepatic duct strictures. In: Mastery of surgery, 3rd Edition, Vol I.Nyhus LM, Baker RJ, Fisher JE (Eds), Little Browne Company, Boston ,New York-p: 1110-1117. 1997.
- Branum G, Schmitt C, Baillie et al : Management of major biliary complications after laparoscopic cholecystectomy. Ann Surg 1993; 217: 532-541.
- Bratucu E, Ulmeanu D, Bota D: Hepaticojejunostomy without suture. Digestive Surgery 1998; 15 (6):663-664.
- Brodish RJ and Fink AS: ERCP, cholangiography, and laparoscopic cholecystectomy. The Society of American Gastrointestinal Endoscopic Surgeons (SAGES) opinion survey. Surg Endosc 1993; 7:3-8.
- Brooks Dc, Becker JM, Connors PJ et al: Management of bile leaks following laparoscopic cholecystectomy> Surg Endosc 1993; 7: 292-295.
- Brugge WR, Rosenberg DJ, Alavi A: diagnosis of postoperative bile leaks. Am J Gastroenterology 1994; 89:2178-2183.
- Carroll BJ, Birth M, Phillips EH: Malpractice Claims Involving Bile Duct Injuries During Laparoscopic Cholecystectomy. *Forum* Surgical Specialties 1997; 18 (4):1-10.
- Carter RF and Saypol GM: Transabdominal cholangiography. JAMA, 1952; 148: 253 255.
- Chapman WC, Halevy A, Blumgart LH: Postcholecystectomy bile duct strictures: Management and outcome in 130 patients. Arch Surg 1995; 130:597-604.
- Chartrand-Lefebvre C, Dufresne MP, Lafortune M, et al: Iatrogenic injury to the bile duct: a working classification for radiologists**.** Radiology 1994 Nov; 193(2):523-526.
- Chaudhary A, Chandra A, Negi SS, et al: Reoperative Surgery for Postcholecystectomy Bile Duct Injuries .Digestive Surgery 2002; 19 :(1):22-27.

- Clair DG, Carr-Locke DL, Becker JM, et al: Routine cholangiography is not warranted during laparoscopic cholecystectomy. Arch Surg 1993; 128:551-554.
- Csendes A, Dfaz JC, Burdliles P et al: Late results of immediate primary end-to-end repair in accidental section of the common bile duct .Surg Gynecol Obstet 1989; 168: 125 –130. (a).
- Csendes A, Dfaz JC, Burdiles P et al: Mirizzi syndrome and cholecystobiliary fistula: A unifying classification. Br J Surg 1989; 76:1139-1143. (b).
- Czerniak A, Thompson JN, Soreide et al: The management of fistulas of the biliary tract after injury to the bile ducts during cholecystectomy. Surg Gynecol Obstet 1988; 168: 125-130.
- Davidoff AM, Pappas TN, Murray et al: Mechanisms of major biliary injury during laparoscopic cholecystectomy. Ann Surg 1992; 215: 196-202.
- Dawson SL and Muller PR : Interventional radiology in the management of bile duct injuries. Surg Clin North Am 1994; 74 : 865-877.
- Deziel DJ, Millikan KW, Economou SG et al: complications of laparoscopic cholecystectomy. A national survey of 4,292 hospitals and an analysis of 77,604 cases. Am J Surg 1993; 165:9-14.
- Donovan J: Nonsurgical management of biliary tract disease after liver transplantation. Gastroenterol Clin North Am 1993; 22:317-336.
- Dunham DP and Aran PP :Receiver operating characteristic analysis for biliary complications in liver transplantation. Liver transplant Surg 1997; 3 : 374-378.
- Edmond JC and Marvin MR: reconstruction of the bile duct: Anatomic principles and surgical strategy. In: Mastery of surgery, 4th Edition, Vol 2, Chapter 95, Baker RJ and Fisher JE (Eds), Lippincott Williams& Wilkins , Philadelphia .pp 1110-1117. 2001.
- El-Ebaidy G: Endoscopic management of bile duct fistulas. Mansoura Med J 1999; 29 (3): 245-261.
- Ernst O, Sergent C, Mizrahi D, et al: Biliary Leaks: Treatment by Means of Percutaneous Transhepatic Biliary Drainage .Radiology 1999; 211:345-348.
- Fischer JE: The effect of litigation on surgical practice in USA. Br J Surg 2000; 87:833-834.
- Fletcher DR, Hobbs MST, Tan P et al: Complications of cholecystectomy: Risks of the laparoscopic approach and protective effects of operative cholangiography. A population based study. Ann Surg 1999; 229: 449-457.
- Fong Y, Cohen A, Fortner JG, et al. Liver resection for colorectal metastases. J Clin Oncol 1997; 15:938--46.
- Garden OJ: Iatrogenic bile duct injury to the bile duct. Br J Surg 1991; 78:1412-1413.
- Go PMNYH, Schol FPG, and Gouma DJ : Laparoscopic cholecystectomy in the Netherlands. Br J Surg 1993; 80 : 1180-1183.
- Gouma DJ and Obertop H: Operative bile duct injury .In: Recent advances I Surgery 24, Ch. 11, Taylor I and Johnson CD (Eds). 2001, p-p: 139-149.
- Gouma DJ and Obertop h: Management of bile duct injuries: Treatment and long-term results. Dig Surg 2002; 19: 117–122.
- Gouma DJ and Go PM: Bile duct injury during laparoscopic cholecystectomy and conventional cholecystectomy. J Am Coll Surg 1994; 178: 229-233.
- Gouma DJ, Rauws EA, Keulmans YC, et al: Bile duct injuries after a laparoscopic cholecystectomy. Ned Tijdschr Geneeskd. 1999; 143(12):606-611. (Abstract).
- Grey-Turner RG: Injuries to the main bile duct .Lancet 1944; 1:621-622. (Quoted from Blumghart LH and Thompson JN: The management of benign stricture of the bile duct. Current Probl Surg 1987; 1:166).
- Griffith JF and John PR: imaging of biliary complications following pediatric liver transplantation. Peditr Radiol 1996; 26:338-394.
- Gupta N, Solomon H, Fairchild R, et al. Management and outcome of patients with combined bile duct and hepatic arterial injuries. Arch Surg 1998; 133:176—181.
- Hunter JG: Avoidance of bile duct injury during laparoscopic cholecystectomy. Am J Surg 1991; 162:71-76.
- Hunter JG: Exposure, dissection, and laser versus electrosurgery in laparoscopic cholecystectomy. Am J Surg 1993; 165:492-496.
- Inui H, Kwon AH, Kamiyama Y. Managing bile duct injury during and after laparoscopic cholecystectomy. J Hepatobiliary Pancreat Surg 1998; 5(4):445-449.
- Jarnagin WR and Blumgart LH: Operative repair of bile duct injuries involving the hepatic duct confluence. Arch Surg 1999; 134:769-774.
- Kern KA: Medicolegal perspectives on laparoscopic bile duct injuries .Surg Clin North Am 1994; 74(4):979-984.
- Keulemans YCA, Bergman JJGHM, deWitt LT et al: improvement in the management of bile duct injuries J Am Coll Surg 1998; 187: 246-254.
- Khong PL, Sreeram N, John PR: Metallic stenting of the biliary tree following liver transplant hepatic artery thrombosis in an infant. Pediatr Radiol 1997; 27: 79-81.

- Kozarek R, Gannan R, Baerg R et al: Bile leak after laparoscopic cholecystectomy: Diagnostic and therapeutic application of endoscopic retrograde cholangiopancreatography. Arch Intern Med 1992; 152:1040-1043.
- Kozarek RA and Traverso LW: Endoscopic stent placement for cystic duct leak after laparoscopic cholecystectomy. Gastrointes Endosc 1991; 37:71-73.
- Kozarek RA; Endoscopic management of biliary tract injuries. Gastrointes Endosc Clin North Am 1993; 3: 261-270.
- Kozarek RA; Endoscopic management of biliary tract injuries. Surg Clin North Am 1994; 74(4) : 883-893.
- Kurzawinski TR, Selves L, Farouk M et al: Prospective study of hepatobiliary scintigraphy after orthotopic liver transplantation. Br J Surg 1997; 84:620-623.
- Lewis WD and Jenkins RL: Biliary strictures after liver transplantation .Surg Clin North Am 1994; 74(4):967-978.
- Lichtenstein S, Moorman DW, Malatesta JQ, et al: The Role of Hepatic Resection in the Management of Bile Duct Injuries Following Laparoscopic Cholecystectomy. American surgeon 2000; 66: 372-279.
- Lillemoe KD, Martin SA, Cameron JL, et al: Major Bile Duct Injuries During Laparoscopic Cholecystectomy: Follow-Up After Combined Surgical and Radiologic Management. Ann Surg 1997; 225:459-471.
- Lillemoe KD, Melton GB, Cameron JL, et al: Postoperative bile duct strictures: Management and outcome in the 1990s. Ann Surg 2000; 232: 430-441.
- Lillemoe KD, Pitt HA, Cameron JL: Postoperative bile duct strictures. Surg Clin North Am 1990, 70(6); 1355-1380.
- Lillemoe KD, Pitt HA, Cameron JL: Current management of bile duct stricture. Advances in Surgery 1992; 25:119-174.
- Loinaz C, Gonzalez EM, Jimeneze C, Garcia I, Gomez R: Long-term biliary complications after liver surgery leading to liver transplantation. World J Surg 2001; 25:1260-1263.
- Lopez PR, Cosenza CA, Lois J, et al :Long-term biliary complications after liver surgery leading to liver transplantation. World J Surg 2001;25 :1260-1263.
- Maroney TP and Ring EJ: Percutaneous transjejunal catheterization of Roux-en-Y biliary-jejunal anastomosis. Radiology 1987; 164: 151-153.
- Martin RF and Rossi: Bile duct injuries: Spectrum, Mechanism of injury, and their prevention. Surg Clin North Am 1994; 74(4) :781-803.
- Mathisen O, Soreide O, Bergan A :Laparoscopic cholecystectomy: bile duct and vascular injuries: management and outcome. Scand J Gastroenterol. 2002 ;37(4):476-481.
- Mazariegos GV, Molmenti EP, Kramer DJ: Early complications after orthotopic liver transplantation .Surg Clin North Am 1999; 79 (1) :109-129.
- McCune WS, Shorb PE, Moscovitz H: Endoscopic cannulation of the ampula of Vater: a preliminary report. Ann Surg 1968; 167:752-756
- McMahon AJ, Fullarton G, Baxter JN, et al: Bile duct injury and bile leakage in laparoscopic cholecystectomy. Br J Surg 1995; 82: 307-313.
- McPherson GAD, Benjamin IS, Hodgson HJF et al: Preoperative percutaneous transhepatic biliary drainage: The results of a controlled trial Br J Surg 1984; 74: 371-375.
- Mercado MA, Chan C, Orozco H, et al: To Stent or Not to Stent Bilioenteric Anastomosis After Iatrogenic Injury. Arch Surg. 2002; 137:60-63.
- Mercado MA, Orozco H, Garza L, et al: Biliary Duct Injury: Partial Segment IV Resection for Intrahepatic Reconstruction of Biliary Lesions. Arch Surg. 1999; 134:1008-1010.
- Melton GB, Lillemoe KD, Cameron JL, et al : Major bile duct injuries associated with laparoscopic cholecystectomy. Ann Surg 2002 ; 235: 888-895.
- Moorhead DT and Warren KW: Cganging patterns of surgery of the gallbladder, bile ducts and liver. Surg Clin North Am 1976; 56:657-603.
- Moossa AR, Easter DW, vanSonnenberg E et al: Laparoscopic injuries to the bile duct: A cause of concern .Ann Surg 1992; 215: 203-208.
- Moossa AR, Mayer AD, Stabile B et al: Iatrogenic bile duct injury to the bile duct: Who, how, where? Arch Surg1990; 125: 1028-1031.
- Morgenstern L, Berci G, Pasternak EH : Bile leakage after biliary surgery : A laparoscopic prospective. Surg Endosc 1993:7:432-438.
- Mueller PR, vanSonnenberg E, Ferrucci T, et al :Biliary stricture dilatation : Multicenter review of clinical management in 73 patients. Radiology 1986;160 :17-22.
- Musella, Barbalace, Capparelli, et al: Magnetic resonance imaging in evaluation of the common bile duct. British Journal of Surgery 1988; 85 (1):16-18.
- Myburgh JA: The Hepp-Couinaud approach to stricture of the bile duct. Ann Surg 1993; 218:615-620.

- Nair RG, Dunn DC, Fowler S, et al: Progress with cholecystectomy: improving results in England and Wales. Br J Surg 1997; 84:1396-1398.
- Northover JMA, Hickman R, Watson RGK,et al : Healing of the bile duct anastomosis after transverse choledochotomy or transplantation of the liver in the big. Surg Gynecol Obstet 1985;160 : 33-36.
- Northover JMA and Terblance J: A new look at the arterial supply of the bile duct in man and its surgical implication. Br J Surg 1979; 66: 379-384.
- O, Connor TP, Lewis WD, Jenkins RL: Biliary tract complications after liver transplantation. Arch Surg 1995; 130: 312-317.
- Oi I: Fiberduodenoscopy and endoscopic pancreatocholangiography .Gastrointest Endoscopy 1970; 17:59-62.
- Olsen DO, Asbun HJ, Reddick EJ et al: Laparoscopic cholecystectomy for acute cholecystitis. Probl Gen Surg 1997; 8:426-431.
- Osorio RW, Freise CE, Stock PG et al: Nonoperative management of biliary leaks after orthotopic liver transplantation. Transplantation 1993; 55:1074-1077.
- Paczynski A, Koziarski T, Stanowski E, et al: Extrahepatic bile duct injury during laparoscopic cholecystectomy – a survey of 6873 patients. Med Sci Monit 2002; 8(6):438-440.
- Pande H, Nikoomanesh P, Cheskin L :Bile duct .eMedicine Journal ,June 3, 2002; Volume 3, Number 6: 1- 30.
- Peck P: Special to Doctor’s Guide News ACS: Bile Duct Injury Following Laparoscopic Cholecystectomy Has Long-Term Psychological Impact. .Doctor’s Guide, October 10, 2001.
- Pelligrini CA, Thomas MJ, and Way LW: Recurrent biliary stricture: Patterns of recurrence and outcome of surgical therapy. Am J Surg 1984; 147: 175-180.
- Pitt HA, Kaufman SL, Coleman J et al: Benign postoperative biliary Strictures: Operate or dilate. Ann Surg 1989; 210: 417-427.
- Pleass HCC and Garden OJ: Bile duct injury: prevention and management, In Recent Advances in Surgery 21, Johnson CD and Taylor I (Eds).Churchill Livingston, 1998, p-p: 1-16.
- Ponsky JL: Endoscopic approaches to common bile duct injuries. Surg Clin North Am 1996; 76 (3):505-513.
- Raute M, Podlech P, Jaschke W, Manegold BC, Trede M ; Management of bile duct injuries and strictures following cholecystectomy .World J Surg 1993; 17: 553-562.
- Reddick EJ, Olsen D, Spaw A et al: Safe performance of difficult laparoscopic cholecystectomy. Am J Surg 1991; 161:377-381.
- Regula J, Pachleweski J, Partnik W et al: Endoscopic drainage of the bile ducts. Pol Arch Med Wewn 1991; 85: 256-262.
- Ress AM, Sarr MG, Nagorney DM et al. Spectrum and management of major complications of laparoscopic cholecystectomy. Am J Surg 1993; 165: 655-662.
- Richardson MC, Bell G, Fullarton GM et al: Incidence and nature of bile duct injuries following laparoscopic cholecystectomy: an audit of 5913 cases. Br J Surg 1996; 83:1356-1360.
- Roslyn JJ, Binns GS, and Hughes EFX et al: Open cholecystectomy a contemporary analysis of 42,474 patients. Ann Surg 1993; 218: 129-137.
- Rossi RL, Schirmer WJ, Braasch JW, et al : Laparoscopic bile duct injuries : Risk factors, recognition , and re[pair. Arch Surg 1992; 127: 596-602.
- Rossi RL and Tsao JI : Biliary reconstruction. Surg Clin North Am 1994; 74: 825-841.
- Russell RCG, Williams NS, Bulstrode CJK . The gall bladder and bile ducts. In Bailey & Love, Short practice of surgery. 23rd Edition. Russell RCG, Williams NS, Bulstrode CJK (Eds), Arnold Publishers, London. pp: 965-986, 2000.
- Sachdeva AK, Sigman HH, Danzinger RG: Biliary tract. In Essentials of general surgery. 3rd edition. Lawrence PF, Bell RM, Dayton MT (editors). Ch.16 .Lippincott Williams &wilkins.Philadelphia.New York.P-P299-326, 2000.
- Sawaya DE, Johnson LW, Sittig K, et al: Iatrogenic and Noniatrogenic Extrahepatic Biliary Tract Injuries: A Multi-Institutional Review. American surgeon 2001; 55 :1-17.
- Shallaly GEI and Cuschieri A: Nature, etiology and outcome of bile duct injuries after laparoscopic cholecystectomy. Hepatopancreatobiliary 2000; 2:3-12.
- Sherlock S and Dooley J: Diseases of the liver and biliary system. 10th edition, Ch 32, Benign stricture of the bile ducts. Blackwell Scientific Publications, USA, p-p: 625-632. 1997
- Slater K, Strong RW, Wall DR, et al: Iatrogenic bile duct injury: The scourge of laparoscopic cholecystectomy ANZ Journal of Surgery 2002; 72 (2): 83 – 87.
- Soybel D and Zinner MJ: Complications following gastric operations. In: Maingot’s abdominal Operations. Zinner MJ, Schwartz SI, and Ellis H (Eds} .10th edition, Ch. 32.Prentice Hall International, Inc.USA, 1997, p-p: 1029-1056.
- Stain SC: Repair of bile duct injuries .Chirurgia international 1997; 4 (3): 11-14.

- Stewart L, Way LW. Bile duct injuries during laparoscopic cholecystectomy: factors that influence the results of treatment. Arch Surg 1995; 130:1123-1130.
- Strasberg SM, Hertl M, Soper NJ: An analysis of the problem of biliary injury during laparoscopic cholecystectomy. J Am Coll Surg 1995; 180:101-125.
- Sutherland P, Launois B, Stanescu M, et al: A refined approach to the repair of postcholecystectomy bile duct stricture .Arch Surg 1999; 134:299-302.
- Thomford NR and Hallenbeck GA: New method for the surgical management of strictures of the bile ducts. Surg Forum 1965; 16: 391-393.
- Velanovich V: Using quality of life instruments to assess surgical outcome. Surgery 1999; 126: 1-4.
- Wahl BF: Uber die geschichtliche entwicklung der operationen and der gallenblasen und den gallengangen .Wurzburg, West Germany 1970, E Schmitt and M.Mayer. . (Quoted from Braasch JW. Historical perspectives of biliary tract injuries; Surg Clin North Am, 1994, 74(4) :731-740).
- Wakefield C H, Whigham J, Madhavan K K, et al: Role of hepatectomy in the management of bile duct injuries. British Journal of Surgery 2001; 88 (3) 476 –449.
- Walsh RM, Henderson JM, Vogt DF, et al. Trends in bile duct injuries from laparoscopic cholecystectomy. J Gastrointest Surg 1998; 2:458-462.
- Westcott C and Pappas TN: Benign biliary stricture. In: Current Surgical Therapy. 6^{th} edition.Vol (1), Cameron JL editor, Mosby, New York, London 1998.p-p 425-4434.
- Wherry DC, Marohn MR , Malanoski MP ,et al : An external audit of laparoscopic cholecystectomy in the steady state performed in medical treatment facilities of the department of defense. Ann Surg 1996; 224: 145-154.
- Woods MS, Traverso LW, and Kozarek RA: Characteristics of biliary tract complications during laparoscopic cholecystectomy: A multi-institutional study. Am J Surg 1994; 167: 27-33.
- Wrigt TB, Bertino RB, Bishop AF, et al: The role of interventional radiology for complications of cholecystectomy. Surgery 1993; 13: 119-128.
- Yeh TS, Jan YY, Wang CS, et al: A multidisciplinary approach to major bile duct injury following laparoscopic cholecystectomy. JSLS 1998; 2(2):147-151.