Langenbecks Archiv für Chirurgie

Langenbecks Arch Chir (1987) 370:235–249

Aktuelle Operationstechniken/
Current Operative Techniques

Surgical Approaches to the Left Hepatic Duct

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Surgical decompression in obstructive jaundice due to benign or malignant stricture of the hepatic ducts is usually best obtained by biliary-enteric anastomosis usually to a Roux-en-Y loop of jejunum. It is often possible to form an hepaticojejunostomy between the common hepatic duct and the jejunum below or at the confluence of the major hepatic ducts. When this approach is rendered difficult because the right and left ducts converge within a deep hilus, or impossible because of tumour or dense adhesions perhaps involving a variable length of the hepatic ducts, adequate biliary drainage can only be obtained by intubation or biliary-enteric anastomosis to the right or left hepatic ducts or their intrahepatic branches.

Anatomy

The portal triads of hepatic arterial and portal venous branches and of biliary tributaries are distributed from the hilus of the liver on a sectoral and segmental basis (Fig. 1) [9].

There are wide anatomical variations in the extrahepatic biliary tree and adjacent hepatic arterial and portal venous structures. The important ductal anomalies are nearly all related to the manner of confluence of the right and left hepatic ducts and of the cystic duct with the common hepatic duct and are so frequent that the surgeon must be acquainted with their range and should always expect the unusual.

The most common variation is an abnormal junction between the cystic duct and the main extrahepatic biliary channel. The cystic duct may join the common hepatic duct high and almost at the hilus of the liver. The right hepatic duct as such may be absent and the major ducts draining the anterior and posterior sectors of the right liver may join the left hepatic duct separately to form the common hepatic duct. In some cases the right anterior or right posterior sectoral duct may run a long extrahepatic course to join the common duct and the cystic duct may drain directly into such a duct. However, while these variations are

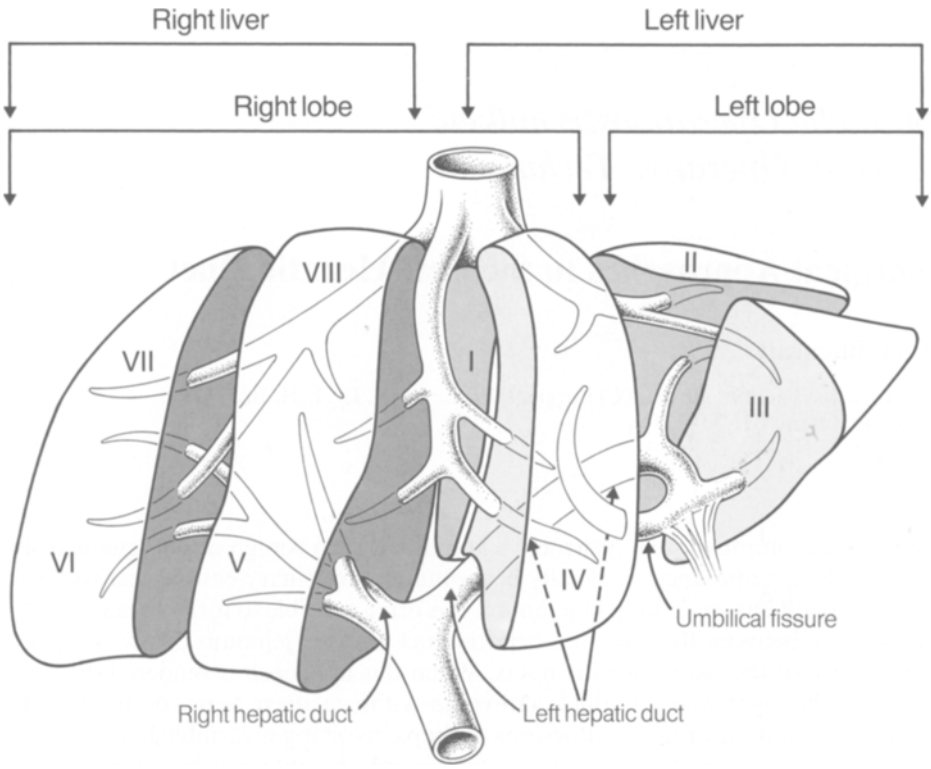

Fig. 1. Exploded diagrammatic sketch of the liver to show its segmental and sectoral pattern. Note that the portal triads are distributed in pedicles containing branches of the bile ducts, hepatic artery and portal vein on an intrasegmental basis. Importantly the hepatic veins run between the sectors. The right hepatic vein courses between the right anterior (Segments V and VIII) and posterior (Segments VI and VII) sectors of the right liver. The middle hepatic vein runs in the principal (Glissonian) plane between the right anterior sector and Segment IV, separating the right from the left liver. The left hepatic vein runs between Segments II and III of the left lobe. The left portal triad courses beneath Segment IV in an extrahepatic plane ensheathed within a peritoneal reflection of the lesser omentum which is fused beneath Segment IV with Glisson's capsule to form the hilar plate. Having traversed to the left it then curves dorsally and caudally in its umbilical portion lying within the umbilical fissure to join with the ligamentum teres. The umbilical portion of the left portal triad separates the left from the right lobe. There is frequently a bridge of liver tissue joining the inferior part of Segment IV and Segment III and obscuring the fusion of the ligamentum teres with the umbilical portion of the left portal vein, but this is not shown. Segment I (the caudate lobe) rises posteriorly adjacent to and hugging the left side of the vena cava

common, there is almost always a consistent anatomy to the left hepatic duct and its branches.

The right hepatic duct has a short extrahepatic portion but the left hepatic duct *always* has an extrahepatic course (Fig. 1) the length of which is reflected by the width of the base of the quadrate lobe. If the quadrate lobe has a broad long base then the left hepatic duct has a longer rather transverse course whereas if the quadrate lobe has a narrower more pyramidal base the left hepatic duct

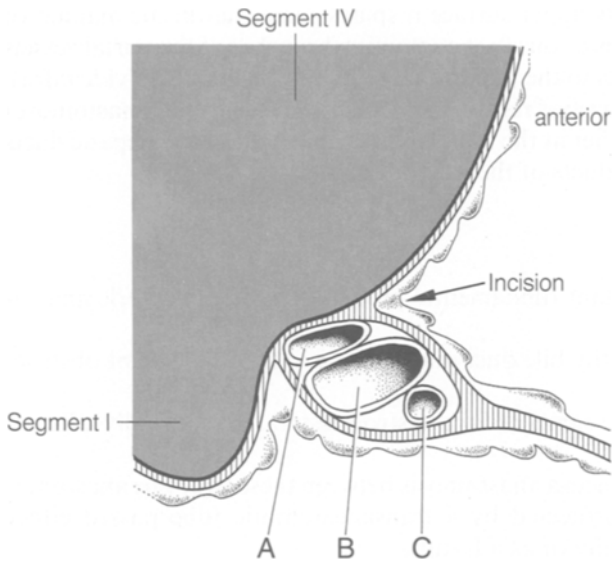

Fig. 2. Sagital section of the liver through Segment IV (the quadrate lobe) and Segment I (the caudate lobe). Note that the left hepatic duct (*A*), the left branch of the portal vein (*B*) and the left hepatic artery (*C*) all lie enclosed within a reflection of the lesser omentum, which fuses on the undersurface of Segment IV in the groove between Segment IV and Segment I with Glisson's capsule. The left portal triad is thus separated from the undersurface of the liver by connective tissue forming the hilar plate (see text). In order to expose the left hepatic duct for surgical access incision must be made at the lower part of the quadrate lobe where Glisson's capsule and the lesser omentum come together (*arrow*)

has a shorter somewhat more oblique course. In the author's experience these features may be predicted on the basis of cholangiographic appearance. The duct traverses to the left together with the left branch of the portal vein within a peritoneal reflection of the gastro-hepatic ligament, fused with Glisson's capsule on the undersurface of the quadrate lobe (Fig. 1, 2). The vessels (including the left branch of the hepatic artery) and the accompanying duct enter the umbilical fissure of the liver, at the limits of which division of vessels to and confluence of ducts from the left lobe (Segments II and III) and the quadrate lobe (Segment IV) occur. The left hepatic duct receives a major tributary from each of these segments which converge in the umbilical fissure dorsocranial to the left portal vein, the Segment III tributary running close to the umbilical portion of the portal vein on its left side. Hepatic ductal tributaries from the quadrate lobe (Segment IV) and hepatic arterial and portal venous branches supplying it recurve to the quadrate lobe (Fig. 1).

The ligamentum teres in the lower edge of the falciform ligament traverses the umbilical fissure of the liver which is usually, but not always, bridged in its lowermost part by a tongue of liver tissue joining the left lobe (lateral to the ligamentum teres) to the base of Segment IV. The ligament joins the umbilical portion of the left portal vein as it curves anteriorly and caudally giving off branches to Segment II and III of the left lobe (Fig. 1). At the base of the

ligamentum teres, and on its upper surface it splays somewhat in the manner of a goose's foot, prolongations of this foot containing branches of the portal vessels traversing over the bile ducts to the quadrate lobe and to the left lobe (vide infra).

The techniques to be described rely on these anatomical features, anastomoses usually being carried out either at the hilus to the major right or left hepatic ducts or to the Segment II or III ducts of the left lobe.

Principles

There are only three important fundamental principles in biliary-enteric anastomoses.

(i) Identification of healthy bile duct mucosa proximal to the site of obstruction.

(ii) The preparation of a segment of the gastrointestinal tract, usually a Roux-en-Y loop of jejunum.

(iii) Direct mucosa-to-mucosa anastomosis between these two. The anastomosis may be "splinted" or protected by a transanastomotic tube passed either transhepatically, transjejunally or as a U-tube.

In some cases, particularly of irresectable carcinoma at the confluence of the bile ducts or to act as a stent following biliary enteric anastomosis, it may be desirable to insert a transhepatic tube which terminates in a subcutaneous reservoir. This allows a sealed system of tubing with no external tube visible. The system is comfortable for the patient, obviates exogenous contamination and yet allows biliary sampling and transtubal radiology in the follow-up period. Originally described by Blumgart et al. [7] the concept was subsequently developed and successfully applied in cases of benign and malignant disease by Voyles [22].

In selected cases in whom difficulty of anastomosis is encountered and where stenosis is anticipated either due to recurrent malignancy or benign stricture, or in order to provide access for the interventional radiological removal of intrahepatic stones, the Roux-en-Y loop may be developed in such a way as to bring it subcutaneously (or to create a jejunal stoma). This approach advocated by Barker et al. (1983) has been successfully used by the author in a planned series of complex benign strictures treated by a combination of surgery and radiological intervention in situations in which either approach alone would have provided only a partial solution to the problem. It should be emphasised, however, that in the usual circumstance where anastomosis is obtained between the mucosa of the bile duct and the jejunum there is usually no need for transanastomotic tubes. The author now advocates a simple sutured anastomosis in the average case, and in a series of over 50 such anastomoses has not encountered any untoward effects resulting from the omission of a tube. Indeed transanastomotic stents carry their own complications and these are obviated by avoiding their use.

However, should such direct anastomosis prove impossible at operation then intubation across the obstruction may be all that can be done. The passage of such tubes may be undertaken in a manner that allows the tube to traverse the obstructed ducts within the liver, the obstructing lesion, and drain into the common hepatic or common bile duct. However, the common bile duct may be

transected and hepaticojejunostomy to the bile duct below the obstructing lesion performed, the tube passing through the hepatic duct and on into the jejunum. In some such cases the surgeon may elect to close the abdomen and proceed later with percutaneous, transhepatic or endoscopic intubation. However, adequate *pre-operative* cholangiography will select most cases in whom intubation is a preferable approach and in whom laparotomy should not be performed.

Incisions

Adequate exposure allowing full visualisation is necessary for good biliary enteric anastomosis.

A right subcostal incision may be adequate but it is usually necessary to extend this incision as a bilateral subcostal (rooftop) incision in order to allow adequate exposure. If a bilateral subcostal incision is employed the use of a broad bladed ("gallows") retractor fixed to an overhead support and elevating the costal margin is valuable. A right rectus split incision is advocated by some and does give good exposure in a proportion of cases but is not really adequate for intrahepatic anastomosis or for clear visualisation of the base of the ligamentum teres.

In cases of right lobe atrophy [10] exposure is particularly difficult, the hilar structures being rotated posteriorly and to the right the portal vein being encountered very early during dissection. In such instances a thoraco-abdominal incision through the right seventh interspace either electively but usually as an extension of a subcostal incision may prove valuable [2].

On opening the abdomen it is important to fully expose the liver and the supracolic compartment of the abdomen. An important early step is division of the ligamentum teres and freeing of the falciform ligament from the abdominal wall back to the diaphragm. The liver is freed from the diaphragm if adhesions are present. If previous surgery has been carried out adhesions are carefully taken down and there should be great care not to damage the bowel and particularly the colon. Dissection of adhesions in the subhepatic area is best commenced from the right, mobilising the colon from its adhesions to the undersurface of the liver and working medially so as to expose the area of the hilus. The duodenum will frequently be found adherent to the base of the liver and requires separation and the colon may be densely adherent to the scar of the gallbladder fossa.

Anastomotic Technique

It is valuable to have an established routine for biliary-enteric anastomosis since although some anastomoses are low and easily carried out, a regular technique which allows anastomosis even in cases of high difficult strictures should be developed.

The opened bile duct having been prepared, a Roux-en-Y loop of jejunum 70 cm in length is prepared and brought up preferably in a retro-colic fashion for side-to-side anastomosis. Should it be considered necessary to cross the anastomosis with a tubal splint this is inserted into the hepatic duct before commencement of the anastomosis. It is useful to fix the tube to the ductal wall

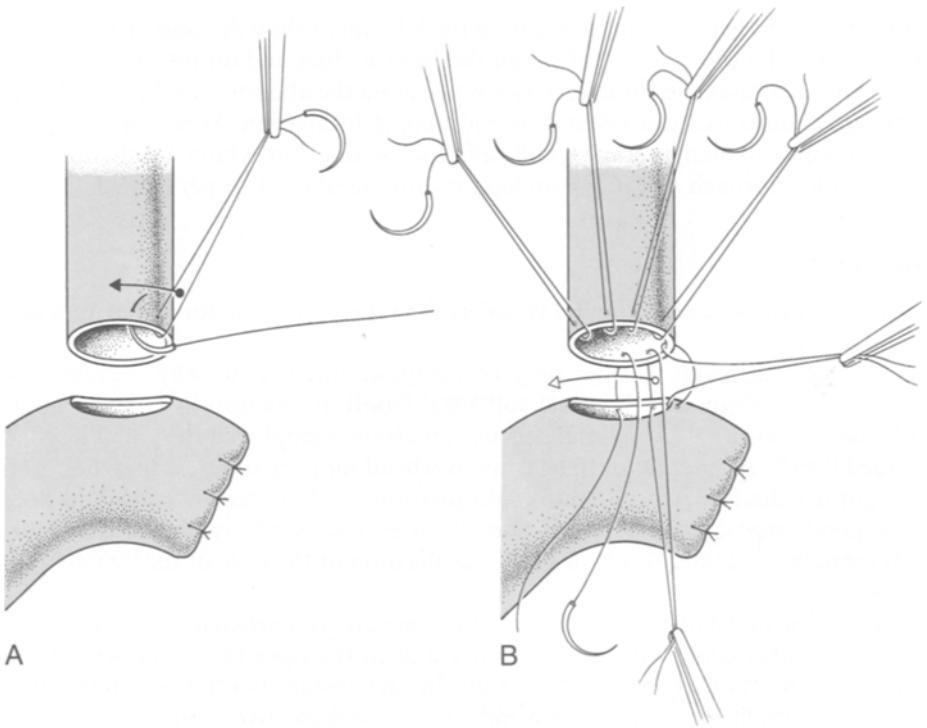

Fig. 3A,B. Biliary enteric anastomosis is commenced. **(A)** The initial stitches are placed in the *anterior* wall of the bile duct, the needles being passed from inside out. The first stitch is placed on the left side of the duct and subsequent stitches are placed working towards the right. **B** The entire row of stitches is placed and held serially. This having been done the anterior layer of the bile duct is elevated using the previously placed sutures. The posterior layer is now placed again starting from the patient's left and working right. The stitches are placed coursing from the jejunal mucosa outwards and then into the bile duct so as to allow subsequent tying of the knots within the anastomotic lumen. The posterior layer is also held serially

using a single 4/0 catgut stuture and this should be introduced in a mattress fashion across the lower duct wall and tied on the outside. This fixation is important since it holds the tube in a pre-determined position and avoids the difficulty which occurs should the tube become dislodged later during the performance of a difficult anastomosis. Side-to-side anastomosis is then performed using the technique described by Voyles and Blumgart [22] and by Blumgart and Kelly [6].

The anterior layer of sutures is placed first and prior to any attempt to place the posterior row. If more than one ductal orifice is visible at the hilus these are best approximated with a row of sutures so that they can be treated as a single duct for anastomotic purposes. If this cannot be done then the *entire anterior row* to all exposed ducts is inserted first so that the separated orifices can be treated as if single. Attempts to complete one anastomosis and then another are difficult or impossible. These sutures (3/0 Vicryl or other absorbable suture material) are introduced starting from the patient's left and working to the right

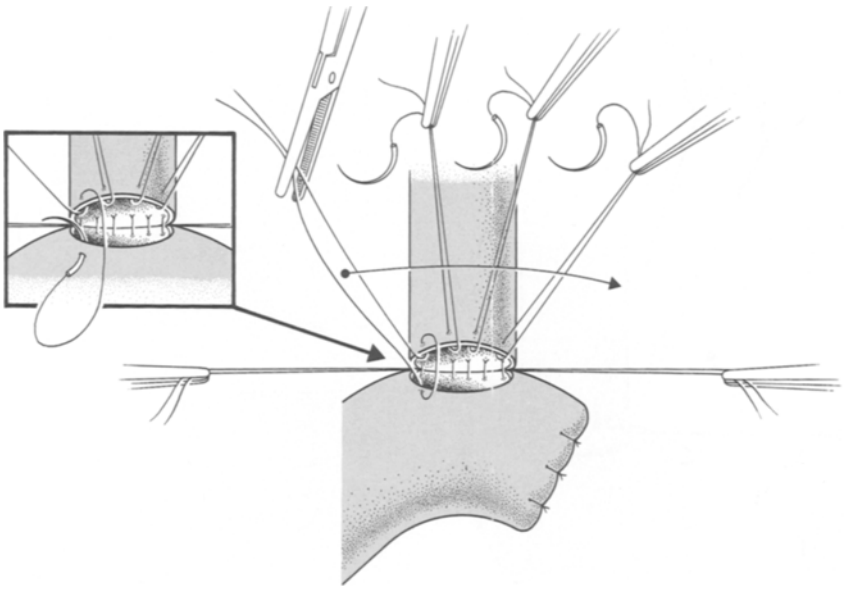

Fig. 4. The posterior layer of sutures is now tied on the inside. The right hand suture is held as a stay, but the others are cut until the left corner suture is reached which is also held as a stay. The previously placed anterior layer of sutures is now passed from outside in through the jejunal wall (*inset*), the sutures are not tied but are again held serially. The process is commenced on the right side and carried to the left

the needles being passed from the inside outwards so as to allow subsequent tying of the knots within the lumen (Fig. 3A). This is done so as to produce the best possible approximation of mucosa-to-mucosa. The needles on this anterior row of sutures are left in place and as each suture is passed it is clipped with a shod clamp and kept in order for subsequent identification (Fig. 3B). The row of sutures so placed is then elevated.

These manoeuvres not only allow precise placement of the anterior row of sutures, which may be very difficult if the posterior layer is inserted first and tied, but also facilitate precise placement of the posterior layer which is now introduced to the jejunum and the bile duct working from the patient's left to right and held taught (Fig. 3B). The jejunal limb is then "railroaded" upwards and the posterior layer of sutures tied serially on the inside in reverse order starting from the right and working left.

The two corner sutures are held on shod clamps but all the others are cut short.

The previously placed anterior row of sutures is now completed as follows. First, starting from the right side, the needles are picked up and passed through the jejunal wall from outside inwards (Fig. 4). The entire row is so placed working towards the left and the needles are now cut from the sutures. The left hand corner having been reached, the corner stay stuture of the posterior layer is cut and the anterior layer then tied serially working now from the left to the right

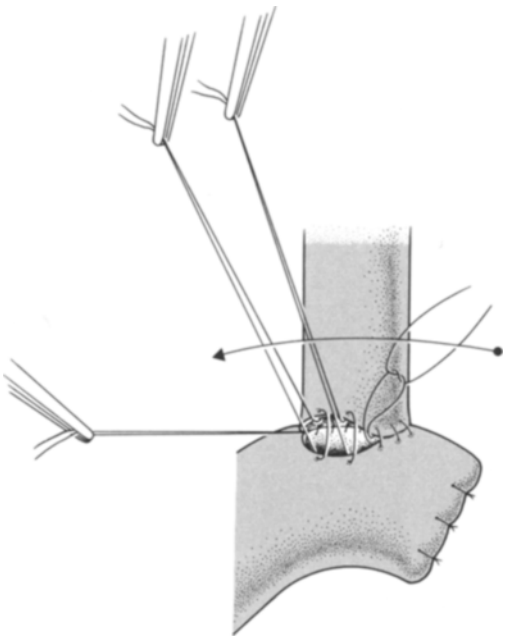

Figure 5. The previously placed corner stay suture on the left is cut and the anterior layer of sutures is now tied so that the knots lie within the lumen. This is commenced on the patient's left and progresses towards the right

(Fig. 5), each knot being placed on the inside until the right corner of the anastomosis is reached, the extreme right hand posterior stay suture being cut before the last anterior suture is tied.

Hepaticojejunostomy

The surgical approach to be described depends either on display of the left hepatic ducts by opening the umbilical fissure elevating the base of the quadrate lobe and lowering the left hepatic ductal system from the undersurface of the quadrate lobe or by exposing the left hepatic ducts by dissection at the base of the ligamentum teres (ligamentum teres approach) [6].

Approach of the Left Hepatic Duct

Early division of the ligamentum teres and freeing of the falciform ligament from the abdominal wall back to the diaphragm is important. A firm tie is placed on the divided ligamentum teres so that it may be elevated and used as a tractor. The liver is elevated so as to display its undersurface. Although often not necessary the bridge of tissue (if present) connecting the left lobe of the liver to the quadrate lobe may now be divided either by fracturing it between finger and thumb or by

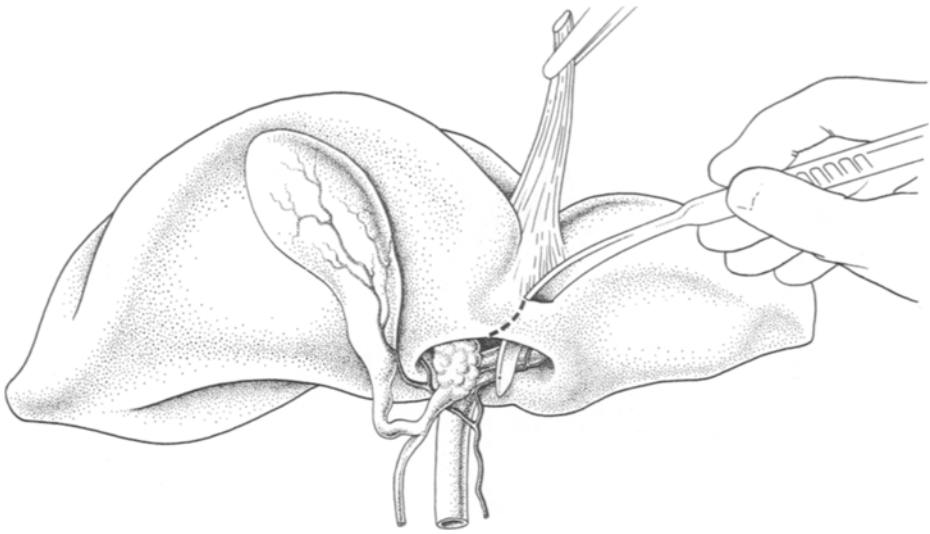

Fig. 6. Method for division of the bridge of tissue which frequently obscures the base of the umbilical fissure. A director can frequently be passed beneath the bridge which can then be divided with a diathermy

cutting it with diathermy (Fig. 6). This bridge of hepatic parenchyma never contains large vessels and control of bleeding is easily obtained. Although not essential for approach to the left hepatic duct this manoeuvre is useful in difficult cases. It exposes the umbilical fissure and allows considerably greater access for dissection at the base of the quadrate lobe.

The base of the quadrate lobe is now identified and dissection proceeded with in the plane between Glisson's capsule and the peritoneal reflection encasing the left portal triad (Figs. 3, 7). This dissection is deepened and the structures of the left portal triad are lowered from the inferior surface of the quadrate lobe and exposed for dissection (lowering of the hilar plate) (Fig. 8) [2, 6, 11]. As this is done dissection can proceed towards the right and the area at the confluence of the hepatic ducts and of the right hepatic duct can be exposed. Even though in benign stricture the lesion may extend to involve the confluence there is usually a bridge of intact ductal mucosa crossing the upper part of the confluence and extending to the right ductal system. If the right duct cannot be adequately exposed in this way it is possible to obtain a better length of the right hepatic duct by incising the liver parenchyma in the line of the gallbladder fossa. This liver split [5], together with the opening of the umbilical fissure described above, allows elevation of the entire quadrate lobe [2]. Occasionally an overhanging mass in the lower portion of the quadrate lobe may require excision in order to improve exposure. A thin bladed curved retractor inserted from above and elevating the quadrate lobe assists exposure.

Stay sutures are placed in the left hepatic duct which is then incised longitudinally.

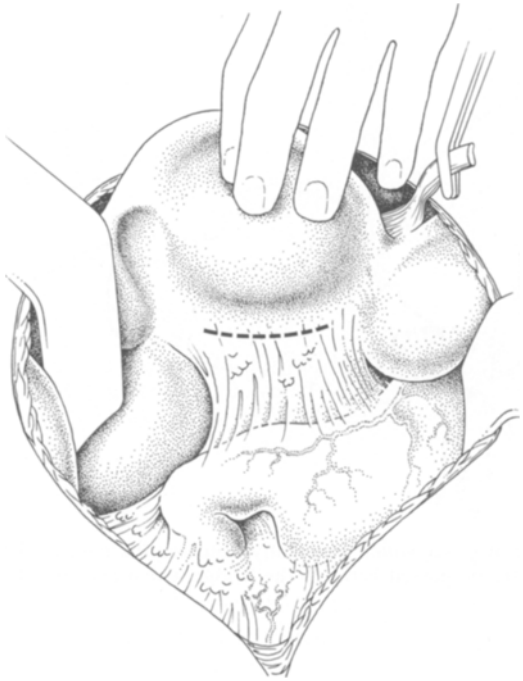

Fig. 7
To show the line of incision in Glisson's capsule for lowering of the hilar plate (see text and Fig. 2)

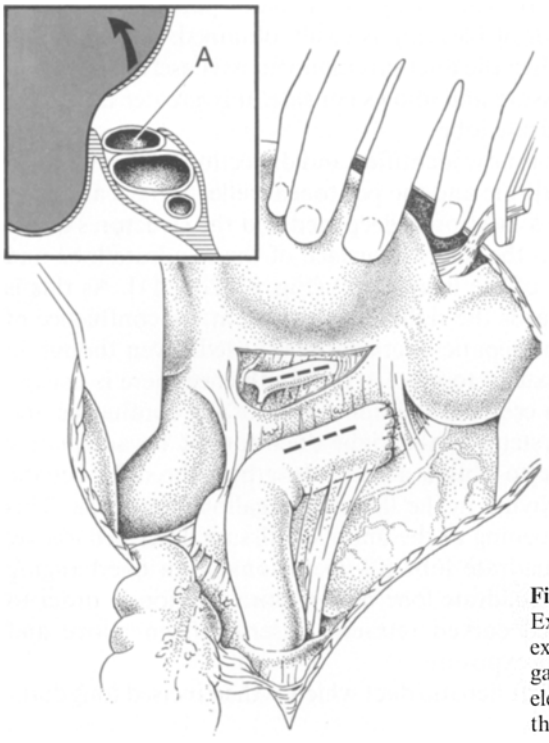

Fig. 8
Exposure of the left hepatic duct with extension to the right at the base of the gallbladder fossa. The inset shows elevation of Segment IV and lowering of the hilar plate (see Fig. 2, 7)

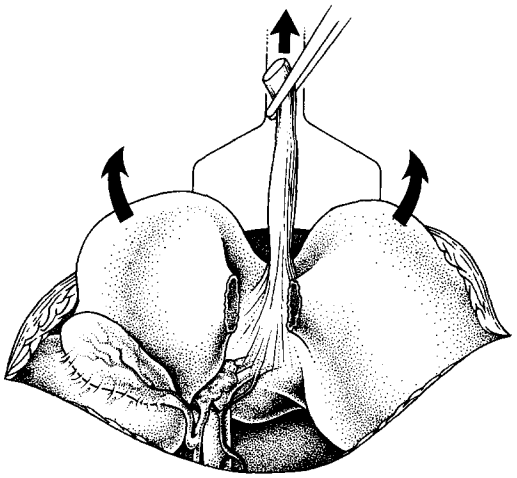

Fig. 9
Exposure of the base of the ligamentum teres in a patient with cholangiocarcinoma at the confluence of hepatic duct. The liver is held upwards as is the ligamentum teres. The bridge of liver tissue at the base of the ligamentum teres has been divided (see Fig. 6)

Ligamentum teres (Round Ligament) Approach

While the vast majority of high benign strictures can be approached and dealt with as described above, it is occasionally difficult to expose the left hepatic duct beneath the quadrate lobe. This may be due to dense adhesions, bleeding may be encountered, or the quadrate lobe may be large and overhanging the area of the left duct. On occasion the extrahepatic length of the left hepatic duct may be relatively short and oblique making approach to it difficult. In carcinoma of the bile duct a tumour extending into the left duct from the confluence area may preclude the use of the main left duct. In any event, palliative anastomosis is best carried out at a reasonable distance from a malignant lesion. In such instances, repair can be affected by dissection of the left hepatic duct within the umbilical fissure and while more often required and useful in malignant disease [3] and particularly in cancer of the hepatic duct confluence and gallbladder the method is also useful in selected cases of benign stricture.

Initially the ligamentum teres is elevated and the bridge of liver tissue joining Segment IV to the left liver is divided as described above (Figs. 6, 9). While the liver is then held up so that its inferior surface can be seen the ligamentum teres is pulled downwards and dissected from the liver (Fig. 10). When this is done and the upper surface of the ligament is displayed, the extensions passing into the liver at the base of the ligament are exposed. If dissection is commenced *to the left* of the upper surface of the base of the ligamentum teres then the Segment III duct itself is finally exposed above and behind the portal vein (Fig. 11). This must be done with care since the extensions contain vascular portal branches and bleeding can ensue if dissection is careless. The use of a small aneurysm needle facilitates ligation. If exposure is inadequate then a small "split" of the liver substance can be made by dividing liver tissue just to the left of the falciform ligament.

Downward traction is continued on the ligamentum and the tissue above it and overlying the duct is cleared. Needle aspiration may assist identification of

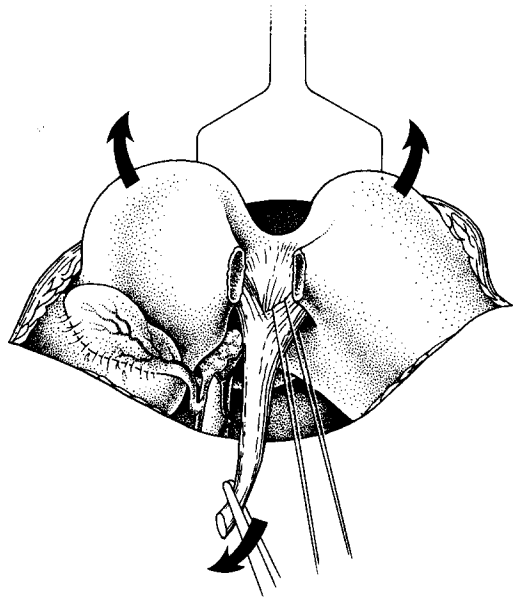

Fig. 10
Exposure of the Segment III duct. The liver is held up but the ligamentum teres has now been pulled downwards. At the base of the umbilical fissure the vascular prolongation originating from the termination of the umbilical portion of the *left* branch of the portal vein is divided between ligatures

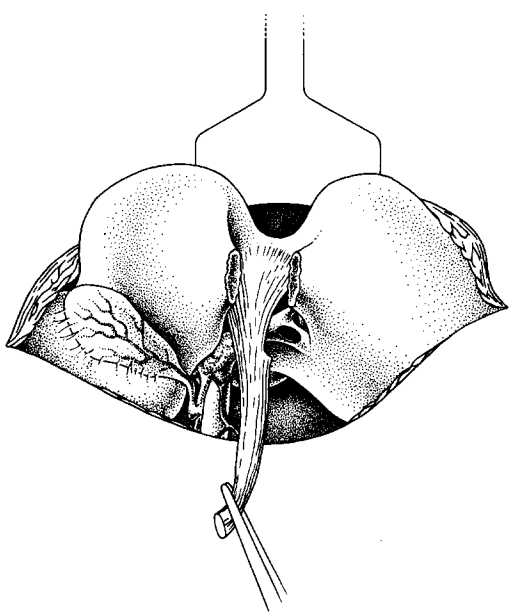

Fig. 11
The Segment III duct is exposed and is opened to allow anastomosis to a Roux-en-Y limb of jejunum

the bile duct. The duct is then opened longitudinally at or usually just beyond the point of its division into the Segment II and Segment III ducts (Fig. 11). Stay sutures are placed and the duct is incised. Anastomosis to a loop of jejunum is then carried out by the techniques described above (Figs. 3–5). The procedure is not useful if there is left lobar atrophy and not necessary if the confluence and

left hepatic duct is not involved by tumour and can be approached directly. In addition the procedure may be difficult in patients in whom long-standing obstruction has led to severe secondary biliary fibrosis rendering the liver substance rigid and difficult to manoeuvre.

Longmire Procedure

In 1948 Longmire and Sandford described an approach to the Segment II duct of the left lobe of the liver in cases where approaches to the hilus is not possible. This procedure remains occasionally valuable but should not be employed when the left duct can be exposed below the quadrate lobe or within the umbilical fissure (vide supra). At present the author reserves the Longmire-Sandford operation for such patients in whom there is unilobar right lobe atrophy accompanied by left lobe hypertrophy rendering subhepatic dissection of the main left duct or its branches difficult, or in patients in whom the umbilical fissure and the left hepatic duct are involved with malignant disease.

A portion of the left lobe of the liver is removed so as to expose the dilated intrahepatic ducts of Segment II (and sometimes Segment III). One of the difficulties of the procedure, is that the vessels of the portal triad run in close approximation with the ducts so that some bleeding is inevitable and difficult to control without compromising the duct lumina. This is particularly so if the liver is fibrotic.

The left lobe of the liver is mobilised by division of the left triangular ligament so allowing its delivery towards and into the wound. It is the author's preference in the performance of this operation to apply a liver clamp to the left lobe just to the left of the ligamentum teres.

The peripheral portion of the left lobe is then simply resected in order to reveal the exposed ducts and vessels. Slight release of the pressure of the clamp allows identification of the vessels which can then be suture ligated.

This having been done a Roux-en-Y loop of jejunum may be prepared and brought up for anastomosis. This can usually be done by suture of the Segment II duct to the jejunum over a transanastomotic tube. However, identification of a suitable size duct may be difficult. In such cases the Roux loop may be opened over a considerable length and sutured to Glisson's capsule, although this is not easy. Such suture may be carried out utilising mattress sutures passed through the jejunal wall and through the exposed liver substance.

Alternatively exposure of the Segment II duct which runs close to the postero-inferior surface of the left lobe of the liver can also be made by incising the duct longitudinally. The procedure is as follows; firstly the left lobe is mobilised as described above. The tissue of the left lobe is then incised in a cephalo-caudal direction posteriorly, the incision being gradually deepened until the left duct is encountered.

Once encountered the duct is then entered with a probe and incised longitudinally through the liver substance. Haemostasis is secured and a Roux-en-Y loop of jejunum is brought up for anastomosis.

Segement III Hepaticojejunostomy

Occasionally wedge excision of Segment III allows exposure of the Segment III duct with subsequent hepaticojejunostomy.

Results and Conclusion

Roux-en-Y hepaticojejunostomy is the favoured approach for the restoration of biliary-enteric continuity. Despite some reports of stenosis at the anastomosis [8, 13, 14] there is no evidence that this problem is due to the use of the Roux loop rather than a consequence of the primary disease. Similarly cholangitis appearing after Roux-en-Y formation is almost always associated with stenosis, intrahepatic stones or persistent intraductal disease [4, 6]. The author has performed over 300 Roux-en-Y hepaticojejunostomies for benign and malignant disease and can confirm the efficacy and low complication rate using this approach. However, peptic ulceration can develop after this operation in some 7–13% of cases [12, 16, 20, 23]. For this reason some have suggested an interposed loop of jejunum between the bile ducts and the duodenum [17–19, 24], but this approach has not been generally adopted, the advent of the new histamine H_2 antagonists introducing a method of therapy for those who develop peptic ulceration and indeed these drugs could be used prophylactically for patients shown to have a high acid output pre-operatively [12]. Patients with proven duodenal ulceration should be considered for a definitive ulcer operation at the time of biliary repair.

Precise sutured hepaticojejunostomy can usually be carried out either after exposure of the left hepatic duct beneath the quadrate lobe by lowering of the hilar plate or within the umbilical fissure by utilising the ligamentum teres approach.

Left hepaticojejunostomy by the Longmire-Sandford [15] operation or a similar right sided intrahepatic hepaticojejunostomy are only indicated in special circumstances and usually in unilateral atrophy/hypertrophy of the liver or where both the hilus and umbilical fissure are compromised by tumour.

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