Principles of liver surgery

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Abstract

Liver resectional surgery has become increasingly popular and patient outcomes continue to improve. In order to optimize postoperative outcomes several key principles of liver surgery require careful consideration. Major resection of the liver requires assessment of the future liver remnant to ensure adequate postoperative functioning, particularly when underlying liver disease is present. Appropriate extent of resection is mandated in order to achieve optimum long-term outcome, and the underlying pathology and liver parenchyma must be considered when trying to achieve this. Surgical technique can be adjusted to reduce perioperative morbidity. Techniques focused on reduction of intra-operative blood loss are low central venous pressure (CVP) resection and inflow occlusion via intermittent portal triad clamping and these can contribute to help minimize blood loss and improve outcome. Recently, laparoscopic liver resection is increasing in popularity and has achieved good short-term results and is likely to be used more widely in the future.

Keywords Anatomy; central venous pressure (CVP); liver parenchyma; operative approach; portal vein embolization (PVE); resection margin

Introduction

The first liver resection was performed in 1952 by Lortat Jacob for the resection of colorectal liver metastases. It has since become a routine procedure worldwide with increasing numbers of resections being performed annually. It has historically been associated with a high morbidity and mortality, however, particularly over recent years the mortality rate has dropped to less than 5% although morbidity remains high at 15–50%.[1] Liver resection offers the only curative option for a number of primary and secondary liver cancers and long-term survival is becoming increasingly common. Below are described some of the main principles that guide the decisions around liver resectional surgery to optimize patient short and long term outcomes.

Anatomy

Intimate knowledge of the anatomy of the liver is mandatory when performing resectional liver surgery. This requires careful consideration because several different classifications of the anatomy are in use resulting in varying terminology being applied to describe the organ.

The liver is a vascular organ and has both the portal vein and hepatic artery supplying the blood into the liver. There are also three veins, the right, middle and left hepatic veins that drain the blood from the liver into the inferior vena cava and back into the heart. As well as this, a system of bile ducts drains bile from the hepatocytes into the duodenum via the biliary tree and common bile duct.

The ability of liver tissue to function is dependent on receiving inflow from the portal vein and hepatic artery and having bile and blood drained away by the biliary tree and hepatic veins respectively. The liver is divided into segments according to the functional branching of the hepatic inflow and biliary drainage combined in a biliary triad. The standard description of the liver was first described by Couinaud[2] who defined the segmental anatomy according to the distribution of the portal vein branches.

The liver is divided up first of all into two hemilivers: the left and the right. The hemilivers are divided into segments. The segments are divided up according to the portal vein branches as well as their arterial inflow and biliary drainage. There are eight segments in total that are numbered from one to eight. Segments one to four comprise the left hemiliver and segments five to eight make up the right hemiliver. The two hemilivers are divided by the middle hepatic vein.

Each hemiliver is further divided into sections. It is important to distinguish 'sections', which is derived from the Brisbane terminology[3] and 'sectors' which is how Couinaud originally described it, because these terms can mean different things. The following description is the Brisbane terminology which is more surgically relevant although does stray from Couinard's anatomical definition. The right liver is divided into the anterior (segments five and eight) and posterior (segments six and seven) sections. The right hepatic vein divides the right anterior and posterior sections. The left hemiliver is divided into the medial and lateral sections. The left medial section comprises segment four and the left lateral section is made up of segments two and three. These sections are divided by the left hepatic vein.

The remaining segment of the left hemiliver is segment one or the caudate lobe, which lies between the IVC and the portal vein and has its own drainage via short hepatic veins into the IVC.

Patient selection

Prior to liver resection, it is of paramount importance to determine which patients are likely to benefit from liver resection and which are not. A summary of factors associated with morbidity after liver resection is illustrated in Table 1. Due to the potential risks of liver surgery, only those patients who could potentially benefit from the operation should be considered for resection. This involves consideration of the disease process and whether surgical intervention is the option that will give the best outcome in combination with the underlying medical condition of the patient and their likelihood of being able to tolerate major surgery. All of these factors must also be considered in concert with the wishes of the patient and optimized where possible.

Patient factors

Age, comorbidity, deranged liver function and clotting[4] have all been found to be independent risk factors for morbidity and mortality following liver surgery.

Preoperative work up prior to liver resection is important in order to optimize patient outcomes. Simple clinical history and

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Factors associated with increased risk of postoperative complications in patients undergoing liver resection

Liver parenchyma	Fibrosis/cirrhosis
	Steatosis
	Chemotherapy-associated liver injury
	Biliary obstruction cholestasis
General	Infection
	Poor nutrition
Surgical	Increasing magnitude of resection
	Major haemorrhage
	Simultaneous resection of extrahepatic disease

Table 1

examination will screen patients for potentially complicating medical conditions that need to be assessed prior to surgery.

Standard preoperative investigations will include haematological and biochemistry assessment, namely FBC, U&E, LFTs and clotting screen. Anaesthetic assessment potentially requiring pulmonary function tests, ECG, echocardiography and exercise testing can determine patient risk stratification.

The underlying liver

The condition of the underlying liver parenchyma is also a consideration when assessing patients prior to liver surgery. Patients with underlying cirrhosis are at potentially increased risks of complications and mortality. Cirrhosis is a particular concern when operating on patients with hepatocellular carcinoma (HCC) due to the direct relationship between the two. The model of end-stage liver disease (MELD) is a strong predictor of outcome following liver resection for patients with cirrhosis and high MELD scores are associated with mortality rates of up to 14% after liver resection.[5]

Chemotherapy-associated liver injury is a potential concern prior to liver resection particularly for patients with colorectal liver metastases who might have had either adjuvant chemotherapy following the bowel operation or neoadjuvant chemotherapy for a primarily unresectable or resectable liver tumour. Many of the chemotherapy regimens used can lead to pathological evidence of steatosis, steatohepatitis and sinusoidal obstruction syndrome, termed 'blue liver' which can lead to higher rates of postoperative complications.

Assessment of liver parenchyma can be made from radiological investigations such as the appearance of the liver on CT or MRI scan as well as by virtue of historical biopsies or laparoscopic assessment. However, often consideration and preemption of the possibility of poor functional reserve should be factored into the preoperative work up.

Tests of liver synthetic function such as PT, albumin and LFTs are not necessarily specific for liver function prior to surgery and therefore for are not particularly useful in predicting liver failure. Other tests, known as dynamic liver function tests, are able to accurately determine preoperative liver function. These tests assess the ability of the liver to take up a substance and excrete it (indocyanine green) or metabolize a product to its by-products (lidocaine and sorbitol). However, they are not routinely used.

Further consideration should be considered to any obstruction of the biliary system prior to resection. Obstructed biliary systems are associated with poor postoperative outcomes following resection and efforts should be made to relieve obstruction (most commonly secondary to hilar cholangiocarcinoma) prior to surgery in an effort to reduce complications such as abscess formation, bile leak and liver failure.

Should an extended resection be deemed necessary to provide oncological clearance of the liver, consideration regarding the future liver remnant must be made. Preoperative CT scanning can be used to estimate the volume of the remaining liver. Should this prove to be the less than the stipulated 25% to maintain function in healthy liver (more if the liver is cirrhotic or potentially damaged by chemotherapy), portal vein embolization (described below), may be indicated.

Imaging

The diagnosis and characterization of liver tumours are ideally performed by CT scanning and MRI (see 'Malignant liver tumours' on pages 655–660 of this issue). CT PET scanning can also be used in the detection of hepatic disease. All these modalities have been shown to be as effective as each other when detecting lesions although MRI has a higher specificity for correctly diagnosing lesions of less than 1 cm[6] and is beneficial when determining resectability as it can provide further detail on vascular invasion and biliary involvement of tumours.

Once a lesion has been diagnosed and malignancy is suspected preoperative staging is required to prevent surgery on patients who will not benefit from it. The aim of staging is to determine the extent of the disease and establish if extra-hepatic disease is present.

Operation selection

Deciding which operation to perform is paramount to successful long-term and short-term outcomes. Resectability is defined as the removal of a tumour with R0 resection (surgical resection margin clear of tumour), leaving two segments with corresponding inflow, outflow and biliary drainage.[7]

Deciding on which operative strategy to take involves consideration of size and location of tumour. Small peripheral tumours are often amenable to localized non-anatomical resection without requiring disruption to the inflow or drainage of the anatomical segment (referred to as an atypical resection). Appropriate atypical resection can achieve satisfactory oncological results with complete pathological resection and satisfactory hepatic function of the remaining segment. Larger or more centrally located tumours are not amenable to atypical resection and require formal anatomical resection of the involved segments (see Figure 1 for the common anatomical resections).

Consideration of the underlying tumour pathology must be made when considering surgical approach. When considering HCC, the performance of an anatomical resection has been shown by meta-analysis to offer superior overall survival and disease free survival than non-anatomical atypical resections.[8] In contrast to this no difference was observed in survival rates when anatomical and non-anatomical resections are compared for CLM resections.[9]