Principles of liver resection

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Abstract

Liver resection offers the only potentially curative treatment for many primary and secondary hepatic malignancies. With ongoing advances, the indications for surgery continue to expand; however perioperative risk remains significant as increasingly complex cases are considered. The overriding principle is to achieve complete resection of disease with preservation of an adequate functional liver remnant. Successful outcomes rely on intricate knowledge of functional anatomy and demand meticulous attention to patient selection, surgical technique and perioperative care. This article reviews the essential considerations in contemporary hepatobiliary surgery.

Keywords Anatomy; hepatectomy; liver resection; patient selection; perioperative care; surgical techniques

Introduction

Despite advances in multimodal cancer treatment, hepatic resection continues to offer the only curative option for a multitude of primary and secondary neoplasms. Indications and techniques continue to be refined, resulting in a dramatic risk reduction compared to the first descriptions of liver surgery over a century ago. Although major morbidity rates remain around 20%, these figures are likely the consequence of increasingly complex resections, and mortality rates are now less than 5%. The following article describes the essential considerations for successful liver surgery.

Anatomy

The liver is the largest solid organ in the abdomen. Residing in the right upper quadrant, it has diaphragmatic relationships on all sides except for its inferior aspect, which faces towards the supracolic viscera. Most gross anatomy textbooks describe liver morphology in detail; however it is the organ's functional anatomy that is of prime concern to hepatobiliary surgeons.

Although visibly divided into right and left lobes, the liver is more usefully appreciated according to its unique dual arterial and portal venous blood supply (inflow), corresponding biliary drainage, and venous outflow. A number of classifications have been proposed, resulting in unfortunate confusion because of similar terms and different meanings. Couinaud is most famously known for his original description of liver anatomy according to portal venous inflow, but the Brisbane 2000 terminology[1] is more relevant to the surgeon.

Devised by international consensus in 2000, the Brisbane system divides the liver into decreasingly sized functional units according to the pattern of dual blood supply and biliary drainage (together referred to as the portal triad). The liver is first divided into right and left hemilivers by extra-hepatic division of the main portal triad structures coursing in the hepatoduodenal ligament. Further division of the branches provides sections and subsequent segments for each hemiliver. Segments constitute the smallest functional units of the liver, each having their own portal triad and venous outflow, and are numbered I to VIII in an unusual anticlockwise manner (Figure 1).

Anatomy on the right side is more straightforward compared to the left. The right portal triad splits into anterior and posterior divisions, which supply the correspondingly named anterior and posterior sections. Further splitting of the anterior and posterior sectional branches then separates each section into two segments, thus providing two sections and four segments for the right hemiliver. The anterior section contains segments V and VIII and the posterior section contains segments VI and VII.

The left portal triad divides differently to the right, having a perpendicular branching pattern from the main left pedicle, similar to that of a main road feeding side streets. Two second-order branches arise from the left side of the main left pedicle and individually supply segment II (receiving the first branch) and segment III (receiving the second branch), which together constitute the lateral section. Two second-order branches also arise from the right side of the main left pedicle to supply a single segment, which is subdivided into segment IVA (receiving the first branch), and segment IVB (receiving the second branch). The medial section therefore constitutes only one segment. The main left portal pedicle terminates at the falciform ligament, which is the vestigial thrombosed remnant of the umbilical vein.

Venous drainage is provided by three hepatic veins. The right hepatic vein bisects the right hemiliver by coursing between the

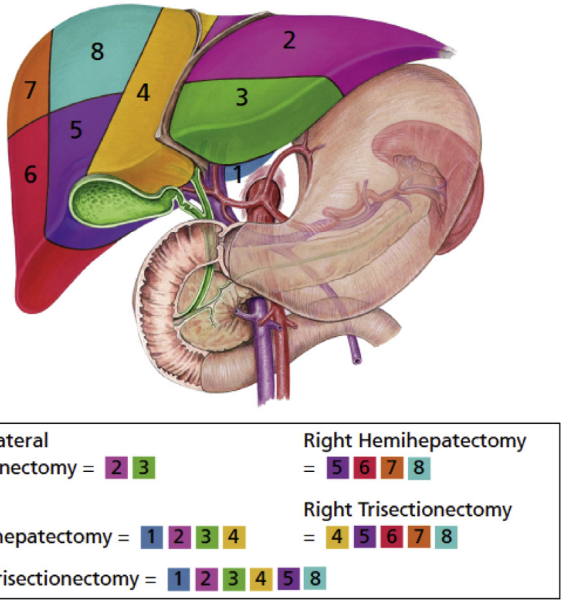

Figure 1 Resectional liver anatomy.

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anterior and posterior sections, provides outflow for all right-sided segments, and drains directly into the inferior vena cava (IVC) superiorly. The middle vein runs along the dividing line between the two hemilivers (Cantlie's line, the principal plane), provides outflow for the adjoining segments IV, V and VIII, and fuses with the left hepatic vein prior to draining into the IVC. In contrast to the right hepatic vein, the left hepatic vein runs in the lateral section between segments II and III (not between sections), provides outflow to these segments, and fuses with the middle hepatic vein before draining into the IVC.

Segment I (caudate lobe) is atypical, lying sandwiched between the IVC and the main portal venous pedicles. Blood supply and biliary drainage is bilateral, albeit predominantly left-sided, with venous outflow directly into the IVC.

Variations in the prevailing anatomical patterns are generally not the exception but the rule, and may be helpful or a hindrance. Further detail is beyond the scope of this text, but the successful liver surgeon must be persistently alert to their existence.

Selection for surgery

Liver surgery remains a significant undertaking, even in the setting of minor resection (less than four segments), emphasizing the importance of appropriate patient selection. Relevant considerations can be separated into patient-related, lesion-related, background liver-related and advanced technical factors.

Patient factors

Established independent risk factors for morbidity and mortality following liver resection include male gender, increasing age, number of co-morbidities, sepsis, deranged liver function tests and abnormal clotting. Obesity is ever increasing and provides an important consideration because of its association with both systemic and liver-specific disease, in addition to its direct impact on the technical aspects of liver surgery. Obesity-associated diabetes and cardiovascular disease (metabolic syndrome) decreases operability (the ability of the patient to safely undergo surgery from a medical standpoint), whilst background hepatic steatosis/steatohepatitis impairs liver function and decreases resectability (the ability of the surgeon to remove the hepatic lesion leaving an adequate liver remnant).

Fitness for surgery is assessed mainly on clinical grounds, with objective exercise testing reserved where doubt exists. Precedence is often helpful, particularly in those with secondary malignant lesions such as colorectal liver metastases (CRLM). Many of these patients will have undergone previous major surgery, and their postoperative recovery following resection of the primary tumour provides the liver surgeon with an opportune functional indicator.

Lesion factors

Indications for hepatic resection continue to be refined as outcomes and techniques improve, but can be broadly divided according to malignant and benign processes. The decision to operate based on risk/benefit balance is often more straightforward in the setting of malignancy, which can be further separated into primary and secondary disease (Table 1). Hepatocellular carcinoma (HCC) is the fourth most common cancer worldwide and provides the most frequent indication for resection of primary disease, however cirrhosis in such patients is frequent and must be taken into account when deciding treatment regimens (discussed below). Cholangiocarcinoma (CCA) represents the second most common primary liver cancer, and may occur sporadically or in the setting of primary sclerosing cholangitis (PSC). Surgery provides the only curative option, and requires liver resection when the disease occurs either intrahepatically or in the hilum (Klatskin tumours, the most common site). Colorectal cancer represents the most common indication for resection of secondary disease, and remains the most common indication overall in Western countries. Over half of all colorectal cancer diagnoses result in liver metastases, of which half are present on initial staging. Resectability rates continue to improve with the evolution of surgical techniques and multimodal therapy (discussed below). Decision-making is becoming increasingly complex for all common malignant conditions of the liver, and as such detailed descriptions of the nuances for each is beyond the scope of this overview. Suffice to say, multidisciplinary team (MDT) discussion is a recognized standard of care for all such cases in order to ensure the correct tailored approach is applied on an individual basis. In general terms, benign lesions are resected when symptomatic, where there is doubt over diagnosis, or where malignant potential exists (Table 1).

Indications for liver resection

Malignant		
Primary	**Secondary**	**Potential**
Hepatocellular carcinoma	Colorectal liver metastases	Cystadenoma
Cholangiocarcinoma	Neuroendocrine tumours	Ciliated foregut cyst
Fibrolamella carcinoma	Selected other solid metastases, e.g. breast, anal SCC, Melanoma	Choledochal cyst/Caroli disease
Neuroendocrine tumours		Indeterminate lesions
Angiosarcoma		
Epithelioid Haemangioendothelioma		

Benign		
Symptomatic	**Infective/ Inflammatory**	**Other**
Adenoma	Hydatid cyst	Trauma
Simple cyst	Hepatic Pseudotumour	Unilateral Hepatolithiasis
Selected polycystic liver disease		

SCC, squamous cell carcinoma.

Table 1

Resection extent

The principal goal for most malignant disease processes is to achieve complete resection, with the exception of selected patients undergoing debulking surgery to alleviate systemic

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