Postoperative management after hepatic surgery

Introduction

The structural design and unique innate property of the liver to regenerate functioning parenchyma after tissue loss forms an important basis of hepatic resection surgery. Early experience was associated with significant mortality and morbidity but now is reported at <2% and 25–30% respectively in high volume centres (Rees et al, 2008; Cescon et al, 2009). Outcomes have improved as a result of advances in the understanding of hepatic anatomy, improved surgical techniques and enhanced perioperative management.

Patients are generally cared for in specialist higher-level ward settings with multidisciplinary input during the initial postoperative period, but then care is transferred, usually after 24–48 hours or so, to a standard ward environment.

The junior surgical trainee will be presented with such patients either electively as part of a hepatobiliary firm or via the on-call service, and it is therefore important to understand the key points in managing patients who have undergone hepatic resection surgery. This article gives an overview of the relevant nomenclature of hepatic surgery, an approach to the postoperative management, and awareness of complications to give greater confidence in managing this complex subgroup of general surgical patients.

Indications for hepatic resection surgery

In the UK the commonest indication for hepatic resection surgery is colorectal liver metastasis. Resection is also performed for other benign and primary malignant hepatobiliary tumours, donation for transplantation and trauma. Most resections performed are on liver with otherwise normal or mildly diseased parenchyma such as post-chemotherapy fatty livers. Less frequently in the UK, hepatic resection surgery is performed in cirrhotic patients with hepatocellular carcinoma, and this is associated with a higher complication rate.

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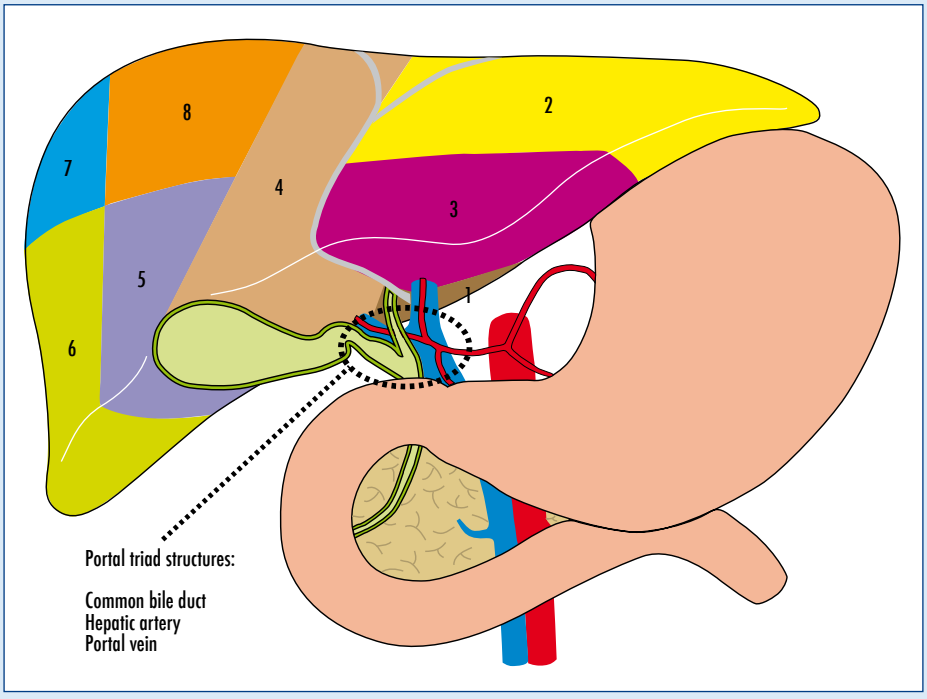
Liver anatomy and surgical nomenclature

Unlike other general surgical operations where the nature of the procedure is readily grasped, hepatic resection surgery requires some knowledge of hepatic anatomy, and specific nomenclature is applied to such resections. The surgically applied anatomy of the liver is different to the traditional (morphological) teaching in undergraduate medical school. The core principle relates to the Couinaud classification of liver anatomy (Couinaud, 1999).

In this system the liver is divided into eight functionally independent segments (*Figure 1*), each with its own vascular inflow, outflow and biliary drainage. In the centre of each segment there is a branch of the portal vein, hepatic artery and bile duct. In the periphery of each segment is the vascular outflow via the hepatic veins which link to form the right, middle and left hepatic veins and, in turn, drain into the inferior vena cava. Crucially, the segmental portal and hepatic blood supply, together with the biliary drainage, are unique, and allow for contiguous segments to be resected without compromising the vascular supply to the adjacent tissue.

In addition, the liver is separated into four sectors by the hepatic veins (*Figure 2*). Briefly, the right hepatic vein divides the right lobe into anterior and posterior segments, the middle hepatic vein divides the liver into right and left lobes (hemi-livers) and the left hepatic vein divides the left lobe into medial and lateral sectors.

Figure 1. Couinaud classification of hepatic segmental anatomy. The liver is made up of eight segments: segment 1 is the caudate lobe and is closely related in position to the inferior vena cava posteriorly, segments 1–4 make up the left hemi-liver, segments 5–8 make up the right hemi-liver. Couinaud divided the liver into functional left and right hemi-livers, and the plane between the two runs in Cantlie's line. This line runs from the middle of the gall bladder fossa anteriorly to the inferior vena cava posteriorly.



This knowledge forms the basis of the consensus nomenclature outlined by the Brisbane 2000 terminology guidelines for hepatic resections (Pang, 2002). *Table 1* details the operation titles and number of segments. While complex, it is more important for the junior trainee to be aware of what constitutes a minor and major hepatic resection, as the extent of resection is associated with mortality and morbidity. A major resection was traditionally defined as more than three segments but more recently has been established as more than four segments (Reddy et al, 2011a).

Figure 2. Sectorial anatomy of the liver based on the hepatic veins. The liver is divided into a right and left hemi-liver by the middle hepatic vein (lies in Cantlie's line). The right hemi-liver is divided into anterior and posterior sections by the course of the right hepatic vein. The left hemi-liver is divided into lateral and medial sections by the left hepatic vein.

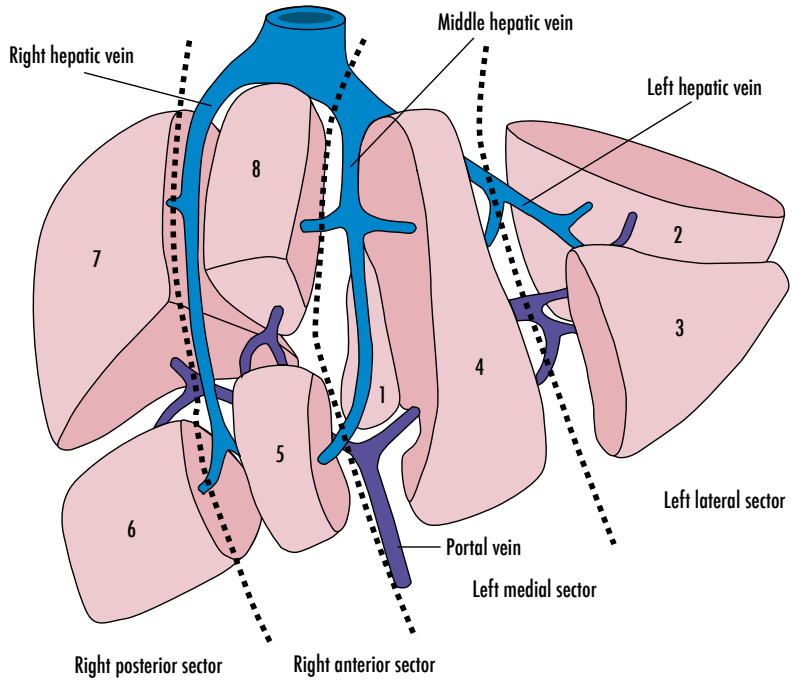


Table 1. Brisbane consensus nomenclature for describing hepatic resection surgery based on liver segmental and sectorial anatomy

Anatomical term	Couinaud segments	Term for hepatic resection surgery	Major or minor resection
Right hemi liver	5, 6, 7, 8	Right hemihepatectomy or right hemihepatectomy	Major
Left hemi liver	2, 3, 4 (+/- 1)	Left hemihepatectomy or left hemihepatectomy	Major
Right anterior sector	5, 8	Right anterior sectionectomy	Minor
Right posterior sector	6, 7	Right posterior sectionectomy	Minor
Left medial sector	4	Left medial sectionectomy or resection segment 4 or segmentectomy 4	Minor
Left lateral sector	2, 3	Left lateral sectionetomy or bisegmentecomy 2, 3	Minor
	4, 5, 6, 7, 8 (+/- 1)	*Right trisectionectomy or extended right hemihepatectomy or extended right hepatectomy	Major
	2, 3, 4, 5, 8 (+/- 1)	*Left trisectionectomy or extended left hemihepatectomy or extended left hepatectomy	Major

*These operations do not have an 'anatomical' name currently in practice. 'Non-anatomical' resections are also performed either as the main index procedure or in combination with the above anatomical hepatic resection surgery. A non-anatomical resection refers to a situation in which there is a small tumour that is excised with a negative margin but leaving a remnant segment – a so-called 'chip-shot' or metastectomy. From Pang (2002)

Approach to postoperative management

Many units are now incorporating hepatic resection surgery patients into enhanced recovery programmes with early targets for introduction of enteral diet, mobilization, prompt removal of invasive monitoring devices, reduction in the use of opiate analgesia and judicious use of intravenous fluids. These measures mean that most patients will expect to stay less than a week. The increasing use of laparoscopic techniques has also contributed to the reduction in hospital stay, especially for minor resections.

Assessment of liver function

Liver enzymes

Perhaps one of the most challenging aspects for the junior trainee in the postoperative period is making sense of liver function tests.

A transient early rise in serum hepatic transaminase and alkaline phosphatase levels as a result of hepatocellular damage is common, but a persistent elevation may indicate ongoing hepatic ischaemia. Such a problem is more likely in those in whom vascular reconstructions are performed. This is an indication for urgent notification of senior staff and a Doppler study is useful in looking at the patency of the hepatic artery and portal veins. Early intervention by means of re-operation or interventional radiology may be appropriate.

A sustained rise in bilirubin levels coupled with elevated alkaline phosphatase levels should prompt a search for a cause of biliary obstruction. This is uncommon after a minor liver resection and is usually seen after a major resection in which a biliary reconstruction has been performed. Ultrasound is the first-line investigation to look for evidence of dilated biliary radicles. Further investigations and management can be arranged depending upon the findings of initial studies.

Synthetic function

Changes in platelet count, prothrombin (international normalized ratio) and acti-

vated partial thromboplastin times, which are markers of coagulation status, may also be deranged and reflect the magnitude of resection. Specifically, a postoperative rise in international normalized ratio between days 1–5 as well as a decrease in platelet count and fibrinogen are common and thought to be the result of a combination of decreased synthetic function of the remnant liver and consumptive coagulopathy (De Pietri et al, 2010). This is usually self-limiting, particularly in the setting of normal liver parenchyma, and does not need correction with fresh frozen plasma or platelet infusions.

While there are no established guidelines on the use of fresh frozen plasma to prevent coagulopathy some centres do use prophylactic fresh frozen plasma if the international normalized ratio >2, in particular in cirrhotic patients. This is administered in combination with other products including vitamin K and human recombinant factor VIIa.

Fluid and electrolytes

Changes in liver function are coupled with fluid and electrolyte imbalances in the postoperative setting. The principles of goal-directed therapy in maintaining adequate fluid balance, haemodynamics and renal function (urine output >0.5 ml/kg/hr) should be followed (Powell-Tuck et al, 2011). However, there are some important caveats in hepatic resection surgery. In the setting of cirrhosis, colloids or human albumin solutions are preferred to crystalloids, with sodium restriction, judicious use of diuretics, and selective paracentesis. Under normal circumstances liver gluconeogenesis consumes a large proportion of body lactate but in the post-hepatic resection surgery setting serum lactate levels can rise, as it is not efficiently metabolized. There are a number of reports implicating elevated lactate levels and base excess on worse outcomes after hepatic resection surgery and some centres advocate the use of non-lactate-containing solutions (Watanabe et al, 2007).

Hypoglycaemia, hyperglycaemia, hypocalcaemia and hypophosphataemia particularly after major resection should not be ignored and require correction. Strict control of glucose levels improves outcomes and most intensive care units and high dependency units have dedicated protocols. Phosphate is an important component of efficient cell energy metabolism. A decreased level can affect many systems and functions including respiratory failure, cardiac and neurological dysfunction, and insulin resistance (Geerse et al, 2010). Replacement can be with phosphate infusions, potassium phosphate solutions and oral and parenteral replacement. The exact mechanism behind the pathogenesis of hypophosphataemia and optimal target levels after hepatic resection remain unclear at present. Calcium levels should be corrected with calcium gluconate or calcium chloride to optimize coagulation status.

Drains

Unit guidelines will dictate when drains are to be removed but some advocate the '3x3' rule (drain-fluid bilirubin level below 3 mg/dl on day 3 after operation) as criterion for removal of prophylactically-placed abdominal drains after hepatic resection (Yamazaki et al, 2012). A Cochrane review has shown that routine abdominal drainage for uncomplicated liver resection is not needed and use of a closed drain system is associated with fewer infectious complications and a shorter hospital stay than open systems (Gurusamy et al, 2007).

Nutrition

After major hepatic resection surgery patients enter a catabolic state and require early nutritional support to optimize liver regeneration, prevent infections and promote general recovery. Those undergoing minor resection with normal parenchyma will often only require re-introduction of normal diet the next day. A systematic review of nutrition following hepatic resection surgery confirmed that early enteral nutrition is associated with a lower incidence of wound infections and complications than parenteral and remains the favoured route of nutritional support (Richter et al, 2006).

Thromboprophylaxis

The prevalence of venous thromboembolism after surgery, particularly in oncological patients, cannot be overemphasized. In hepatic resection surgery there has been reluctance to prescribe pharmacological thromboprophylaxis because of concerns regarding bleeding and so-called 'auto-anticoagulation'. However, venous thromboembolism can still occur even in the presence of elevated international normalized ratio and activated partial thromboplastin time following hepatic resection surgery (Senzolo et al, 2009). Indeed, evidence now confirms patients are more hypercoagulable and the use of pharmacological thromboprophylaxis lowers the incidence of symptomatic venous thromboembolism after major hepatic resection surgery without increasing the rate of blood transfusion (Reddy et al, 2011b).

The majority of patients undergoing hepatic resection surgery will have an epidural catheter placed and so low molecular weight heparins should be started on the day of surgery unless there are explicit instructions not to from the operating team. During surgery, pneumatic compression devices are used to reduce the risk of thrombosis and use of compression stockings should be continued postoperatively.

Analgesia

It is crucial that to ensure the patient has adequate analgesia as poor control leads to prolonged bed rest, inefficient respiratory effort, a poor appetite and a general slowing down of recovery. There are many options that can be tailored to the patient, including intravenous opioids, paracetamol, epidural and local anaesthetic transabdominal blocks. Patients can then be switched to regular and as required oral analgesics according to the World Health Organization analgesic ladder (Mercadante and Fulfaro, 2005).

As the liver is important in drug metabolism and detoxification, the potential risks of each modality should be considered in the context of liver parenchyma status, magnitude of resection, and concomitant liver and renal failure. Opiates have traditionally been the mainstay of analgesia but can be associated with respiratory depression, excessive sedation and exacerbation of hepatic encephalopathy. As such, patients on opiates require close observation, in particular after major resections or hepatic resection surgery in the presence of cirrhosis. Better alternatives to simple morphine in cirrhotics include hydromorphone and fentanyl as they are less affected by renal impairment, and are better secreted by the kidney. Intramuscular routes should be avoided, as bioavailability is variable.

Recognizing postoperative complications

Mortality rates in most published series are now about 0–2%, but with reported morbidity rates of 25–45% it is important to be alert to potential complications after hepatic resection surgery in all patients. Risk factors for complications include age >65 years, American Society of Anesthesiologists score >3, larger extent of resection (multiple tumours, bilobar disease), blood transfusion and involved resection margins (Farid et al, 2010). Up to 30% can suffer 'major' complications, specifically bleeding, liver, kidney or respiratory failure and sepsis, and these account for the majority of deaths post surgery (Farid et al, 2010).

Hepatic failure

Around 3–5% of patients may develop liver failure after resection and will usually show signs and symptoms from 48–72 hours (Rees et al, 2008). These are usually patients undergoing major resections, or resections carried out in the presence of cirrhosis. Liver failure definitions vary but an accepted description is one or more of the following:

1. Persistent hyperbilirubinaemia (serum bilirubin level >4.1 mg/dl; to convert to µmol/litre, multiply by 17.104)
2. Coagulopathy (international normalized ratio >2.5, despite early attempted correction with clotting factors)
3. Abdominal ascites (drainage volumes >500 ml/day)
4. Encephalopathy with hyperbilirubinaemia and exclusion of other acute confusional states (Jarnagin et al, 2002).

Another practical definition of postoperative liver failure after hepatic resection is a prothrombin time <50% and serum bilirubin >50 µmol/litre (the '50-50' criteria). This has been shown to predict mortality when measured at day 3 and 5 (Paugam-Burtz et al, 2009).

Patients with significantly impaired hepatic function may exhibit hepatic encephalopathy. The West Haven criteria (*Table 2*) grades hepatic encephalopathy from I to IV and is widely used (Ferenci et al, 2002). It is based on changes of consciousness, intellectual function and behaviour, and is useful in monitoring patient progress. Ammonia levels should be measured if hepatic encephalopathy is suspected and lactulose prescribed to help 'draw ammonia out'.

When confronted with a picture of liver failure, it is important to attempt to determine the underlying cause, as some elements are correctable. Causes of liver failure are usually multifactorial and include: bleeding, sepsis, hepatic ischaemia, portal vein thrombosis, venous outflow obstruction, and a poorly functioning liver remnant. Intensivists, senior surgeons and hepatologists lead the management.

The mainstay of treatment is supportive with blood products administered to support synthetic function, aggressive investigation and treatment for infection, and radiological investigation to ensure patency of major vascular and biliary structures. Exogenous antioxidants such as N-acetylcysteine (Parvolex) have been used by some to try and reduce the damage by oxygen free radicals associated with ischaemic reperfusion injury of the liver. However, this remains to be accepted as universal practice and currently lacks a strong evidence base.

Bleeding and transfusion requirements

Intra- and postoperative bleeding, and the requirement for blood transfusion are associated with increased morbidity, mortality and poorer long-term disease-specific outcomes. The operating surgeon and anaesthetist incorporate multiple techniques including low intraoperative central venous pressure, dynamic intraoperative coagulation monitoring, intermittent vascular inflow occlusion, drugs (aprotin, tranexamic acid), and haemostatic products on the cut surface of the liver to reduce the occurrence of these complications. As a result median blood loss in overall hepatic resection surgery has significantly reduced and is reported to be less than 700–800 ml (McNally et al, 2012). Indeed, the median transfusion rate in the majority of contemporary series is zero.

Blood loss during surgery should be clearly documented on the operative note. Unit protocols drive the specific haemoglobin criteria for transfusion and should be referred to when assessing the patient in this early stage. During the postoperative phase, patients will have regular haemoglobin and haematocrit measurements. It would be expected that patients would stabilize during the initial 24–48 hours and any deterioration following this should trigger referral to senior colleagues and a request for imaging studies. Patients actively haemorrhaging may require re-exploration or radiological embolization of bleeding vessels.

Postoperative sepsis

As evidence grows implicating postoperative complications, in particular infection, in poorer disease-free survival, an important aim must be to proactively attempt to minimize infections, and when present to identify and implement treatment promptly (Garwood et al, 2004; Farid et al, 2010). Risk factors associated with infection include obesity, major resections requiring blood transfusions, comorbidity (diabetes, chronic obstructive pulmonary disease) and postoperative bile leak (Garwood et al, 2004).

Standard effective interventions to minimize infections include ensuring adequate chest physiotherapy, early patient mobilization, removal of indwelling devices and institution of broad-spectrum antibiotic therapy where indicated.

Bile leaks

Bile leakage is an important complication occurring after liver surgery and the reported incidence ranges between 4.8% and 7.6% in large series (Yamashita et al,

Table 2. Abridged version of West Haven criteria

Hepatic encephalopathy grade	Mental state
I	Mild confusion, slowing of ability to do mental tasks, e.g. serial 7s
II	Drowsiness, inappropriate behaviour
III	Somnolent but rousable, marked confusion
IV	Coma

From Ferenci et al (2002)

2001). It is less common in surgery for colorectal liver metastasis. The International Study Group of Liver Surgery has proposed a uniform definition of bile leakage and a grading system according to severity, based on drain fluid bilirubin concentration of greater than three times the serum bilirubin concentration on day 3 after surgery or the need for additional interventions (Koch et al, 2011). Management of bile leaks includes treatment of associated infection, defining the location of leak and the consideration of insertion of biliary stents and/or reconstructive surgery.

Conclusions

No consensus exists for postoperative management of patients who have undergone hepatic resection surgery as each centre will have different guidelines reflecting preferences of senior staff with regard to the finer points of management. It is important to deliver early nutrition, effective analgesia and promote good respiratory function. Furthermore close observation in the early postoperative period is required to identify and aggressively manage bleeding, infection and prevent the development of liver failure.

The junior trainee needs a basic grounding and the ability to appreciate exactly what resection has been performed in a patient to allow meaningful assessment. This will help know when to alert senior staff appropriately and expediently in this challenging dynamic subgroup of patients. **BJHM**

Conflict of interest: none.

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KEY POINTS

- Hepatic resection surgery is carried out mainly for colorectal liver metastasis in the UK.
- Understanding applied surgical anatomy and the nomenclature used to describe an operation allows a trainee doctor to appreciate the extent of the resection undertaken.
- Successful postoperative management requires attention to detail: observation of trends in liver function, balanced fluid and electrolyte replacement, and adherence to specific local protocols are paramount.
- Early introduction of nutrition, effective analgesia and physiotherapy is critical no matter the extent of hepatic resection surgery.
- Avoidance, detection and aggressive treatment of infection are important in all patients undergoing hepatic resection surgery.
- Venous thromboembolism is common in patients undergoing hepatic resection surgery and requires thromboprophylaxis unless explicitly stated by the operating team.
- Have a low threshold for alerting seniors for this complex sub-group of general surgical patients.