Anaesthesia for Hepatic Resection Surgery

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KEYWORDS

• ERAS • Enhanced recovery • Hepatic resection surgery
• Pancreatic resection surgery • Whipple's procedure

KEY POINTS

- There has been significant improvement in outcomes after liver resection in the last 20 years
- Improved outcomes are due to a combination of patient selection, prehabilitation, techniques to increase functional liver remnant, anesthetic and surgical technique, refinement of ERAS pathways, and neoadjuvant chemotherapy,
- The role of minimally invasive surgery and robotically assisted surgery continues to expand and be impactful in improving outcomes
- Analgesia techniques to facilitate rapid restoration of function while minimizing opioids are evolving as are techniques to minimize intraoperative hemorrhage

Abbreviations	
ERAS	Enhanced Recovery After Surgery

INTRODUCTION

Approximately 150,000 individuals are expected to experience colorectal cancer (CRC) in the United States in 2020 and over half of these patients will go on to develop liver metastases in the future. Although only 20% of these will be suitable for curative hepatic resection there has been a tremendous improvement in overall outcomes following CLRMs in the past 2 decades with a doubling in 5-year overall survival (OS) rates from 30% in the 1980s and 1990s to 60% in the 21st century.[1]

These advances have been a combination of improvements in patient selection, operative procedures, and perioperative management.[2]

Hepatic resection remains the only curative option for CLRMs and current perioperative mortality rates are less than 5% and as low as 1% in high-volume centers. The highest

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Anesthesiology Clin 40 (2022) 91–105
https://doi.org/10.1016/j.anclin.2021.11.004 anesthesiology.theclinics.com

mortality is seen in those with underlying liver dysfunction. Morbidity ranges widely—reported between 16% and 67%—with a recent systematic review demonstrating an association between postoperative complications and shorter overall, as well as disease-free, survival (DFS).[3] The incidence and severity of postoperative complications are highest in cirrhotic patients. Major complications in this group include bile leak, coagulopathy, postoperative bleeding, and liver failure. Effective preoperative assessment, risk stratification, and optimization are vital in reducing morbidity and mortality.

Treatment options for isolated CLRMs comprise regional approaches with or without systemic chemotherapy. The regional approaches range from potentially curative surgical resection to several other options when surgical resection is unsuitable that is, thermal ablation, regional hepatic intraarterial chemotherapy, chemoembolization, radioembolization, and radiation therapy (RT), including stereotactic RT.

INDICATIONS FOR HEPATIC RESECTION SURGERY

Resection of isolated CRLMs is the most common indication—two-thirds of patients' CRLMs will already have extra-hepatic spread at presentation. Other indications are for primary benign and malignant hepatobiliary tumors and occasionally for hepatic trauma although the latter is usually managed conservatively.

HISTORY OF SURGICAL TECHNIQUES

The first partial hepatectomy was performed by Luis in 1886 for a large adenoma in a female patient who unfortunately died from hemorrhage 6 hours after surgery. Paquelin's cautery—consisting of burning flammable liquids such as benzene at high temperatures within the operative site—had been used to resect and cauterize the tumor site.

In 1889, Keen reported a series of 73 cases involving wedge excisions of the liver with a mortality of 15% and in 1908 Dr Pringle, a surgeon in Glasgow, reported the use of obstruction of the portal vein and hepatic artery to control bleeding during surgery for trauma of the liver with one of the 4 operated patients surviving. Wendell followed this in 1911 with the first reported successful right hepatic lobe resection. Although credited to a French team in 1951—due to publication timing in English-speaking journals—it seems the first known case of right hepatic lobectomy with hilar dissection may have been by the Japanese surgeon Hondo in 1949. It was not until the 1950's that Couinaud among others developed the current concept of segmental anatomy of the liver which formed the basis for segmental hepatectomy. The rapid reductions in mortality seen in the 1980s are credited to a better understanding of the safe limits of resection regarding liver function using indocyanine green (ICG) clearance, intraoperative ultrasound allowing real-time assessment of hepatic vascular anatomy and the development of portal vein embolization (PVE) to prevent liver failure after large resections. The 21st century has seen the development and growth of laparoscopic hepatectomy from 1991, when Reich reported the first case, through to 2011 when a large registry of hepatectomies from Japan reported 63% as laparoscopic, with 90-day mortality rates as low as 0.67%. Recent years have seen the advent of robotic surgery with some reports indicating it may be better suited to right hepatectomy than laparoscopic surgery regarding the duration of surgery and conversion rate, although this remains controversial.[4]

ANATOMY

The highly vascular nature of the liver—receiving 25% of cardiac output with 80% supplied by the portal vein and 20% by the hepatic artery—provides the greatest

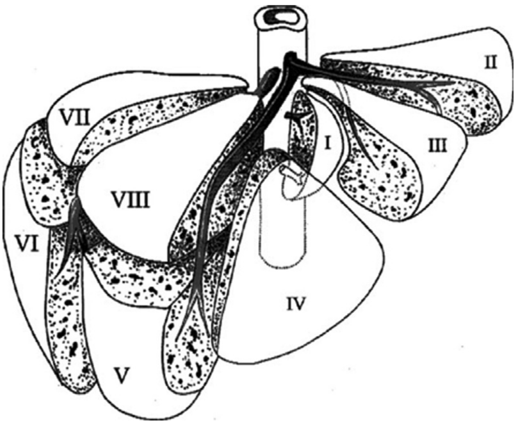

Fig. 1. Couinard's segmental picture of the liver. The representative appearance of the hepatic segments separated within the liver.

intraoperative challenge to hepatic resection surgery. The porta hepatis contains all the structures entering the liver.

Fig.1 depicts the 2 lobar segments (left and right) subdivided into 5 liver sectors with further subdivision into the 8 liver segments defined by their blood supply and biliary drainage as described by Couinaud. These segments are contiguous regarding blood supply and biliary drainage allowing resection without disruption or damage to neighboring segments.

Unique to the liver is its ability to regenerate. This phenomenon starts within 48 hours of resection reaching a significant volume within weeks to months and allows for large resections without consequent liver failure via hyperplasia of the liver remnant. The same principle leads to the increase in FLR when PVE is used preoperatively.

PREOPERATIVE MANAGEMENT

Patient Selection

This involves the assessment of the following:

1. *Patient factors*: patients must have an appropriate biological age and adequate cardiopulmonary function to endure the considerable inflammatory and neuroendocrine response. Additionally, the impact of comorbid diseases and recovery from any neoadjuvant chemotherapy all need to be taken into account.
2. *Tumor factors*: the biology of the tumor provides important prognostic information and various clinicopathologic based scoring systems have been validated with 4 in current use for predicting recurrence.[5] These help to guide whether surgery is the appropriate treatment and whether the patient might benefit from neoadjuvant chemotherapy.[6,7] The biology of the primary colon cancer also influences the prognosis in CLRM.[8]
3. *Anatomic factors*: resectable CLRMs have been defined by modern consensus as tumors that can be completely resected while leaving a functional volume of residual liver or functional liver remnant (FLR). Imaging studies define the location of the lesions, the resectable margin (ideally >1 cm), and the FLR. An FLR of less than 20% is unsuitable due to the high rate of postoperative liver failure and mortality. The FLR threshold required is greater than 30% if preoperative chemotherapy has been administered and greater than 40% if preexisting liver dysfunction

(NASH or cirrhosis) is present. These patients could be considered for PVE in an attempt to increase their FLR to meet the necessary threshold for resection. There is evidence for reduced rates of postoperative liver failure and improved survival following preoperative PVE. The American Hepato-Pancreato-Biliary Association, the Society for Surgery of the Alimentary Tract, and the Society of Surgical Oncology published consensus guidelines covering FLR and PVE in 2006.[9]

Assessment of Cardiopulmonary Function

Cardiopulmonary exercise testing (CPET) is widely used in the United Kingdom (UK) to provide an objective assessment of exercise capacity along with useful diagnostic information regarding likely causes of any exercise intolerance. There have been multiple studies validating the association between the measurement of peak oxygen consumption (peak Vo_2), oxygen consumption at anaerobic threshold (AT), and ventilatory efficiency (Ve/VCO2) including a systematic review by Smith and colleagues in 2009.[10] Specific to assessment for hepatic resection surgery Junejo and colleagues reported that an AT less than 10 mLs O2/kg/min predicted in-hospital death with 100% sensitive and 76% specificity.[11]

Some centers favor the use of the Carlisle model[12–14] which starts with baseline mortality risk using actuarial data (in the UK, based on the latest Office of National Statistics data) and then individualizing this prediction of baseline mortality risk and median survival by the weighting of any key comorbidities and biochemical markers that are independently associated with lifespan, the peak Vo_2 (which is a validated predictor of lifespan) and the VeVCO2. This model does not account for the 5-year survival in different types of cancer (including the effect of individual tumor biology, cancer volume, and staging) and, in the case of hepatic resection surgery, the liver function, hence the CPET result needs to be combined with the surgical team's knowledge of the latter 2 factors to enable a complete risk stratification. Once complete, this allows informed and shared decision making with the patient as well as better planning, preparation, and optimization.

Alternative options for the objective assessment of cardiopulmonary function in the absence of CPET include the “Six-Minute Walk Test” and the “Incremental Shuttle Walk Test.”

Identifying and assessing frailty is increasingly being recognized as an important factor when predicting both postoperative and long-term survival[15] with both validated subjective scoring systems and objective surrogates, for example, the “Get up and go” test (time standing up from sitting in a chair) and handgrip strength measurement in use.[16]

Assessment of Liver Function

The presence of severe underlying liver disease (cirrhosis or nonalcoholic steatohepatitis (NASH)—the latter possibly as a complication of neoadjuvant chemotherapy) is a contraindication. If the underlying liver disease is less severe the surgery could be considered depending on the anticipated FLR and other comorbidities. This requires imaging-based volumetric assessment of the FLR together with an estimation of liver synthetic function. The Child–Pugh score is generally used for the latter (**Table1**.). Child–Pugh A and Child–Pugh B cases with an FLR greater than 40% can be considered.

In some centers, ICG clearance is used to assess liver function with normal clearance at 15 minutes (ICG_{15}) of 90%. A clearance of less than 60% indicates a high likelihood of postoperative liver failure and mortality. ICG is a dye dilution that is selectively taken up by hepatocytes following intravenous injection in an ATP-dependent process

Table 1
Child–Pugh classification of severity of cirrhosis

Parameter	1 Point	2 Points	3 Points
Ascites	Absent	Slight	Moderate
Bilirubin	<2 mg/dL (<34.2 micromol/L)	2–3 mg/dL (34.2–51.3 micromol/L)	>3 mg/dL (>51.3 micromol/L)
Albumin	>3.5 g/dL (35 g/L)	2.8–3.5 g/dL (28–35 g/L)	<2.8 g/dL (<28 g/L)
Prothrombin time:			
Seconds over control	<4	4–6	>6
INR	<1.7	1.7–2.3	>2.3
Encephalopathy	None	Grade 1–2	Grade 3–4

Modified Child–Pugh classification of the severity of liver disease according to the degree of ascites, the serum concentrations of bilirubin and albumin, the prothrombin time, and the degree of encephalopathy. A total Child–Turcotte–Pugh score of 5 to 6 is considered Child–Pugh class A (well-compensated disease); 7 to 9 is class B (significant functional compromise); and 10 to 15 is class C (decompensated disease). These classes correlate with one- and 2-year patient survival: class A: 100% and 85%; class B: 80% and 60%; and class C: 45% and 35%.
Abbreviation: INR, international normalized ratio.

and is not metabolized or undergo enterohepatic recirculation therefore its rate of disappearance from the plasma (measured by transcutaneous pulse-densitometry within 6–8 minutes) represents liver blood flow, parenchymal cellular function, and biliary excretion.

Models using machine learning algorithms are an exciting development and are likely to further refine the accuracy of risk prediction in the future, comparing outcomes with all the data mentioned above along with liver function data and relevant preoperative biochemistry. A recent study from Washington University demonstrated accuracy for predicting postoperative complications using a combination of preoperative test results, comorbidities, and intraoperative variables input into a deep learning algorithm.[17]

Prehabilitation and Optimization

These are programs involving generic preoperative lifestyle interventions such as nutritional supplements, exercise programs, stress reduction, and smoking cessation before surgery.

It has been estimated by the American Society for Enhanced Recovery and Perioperative Quality that 2 out of 3 patients undergoing GI surgery are malnourished and have a threefold greater risk of perioperative complication and fivefold greater risk of death.[18]

A 2018 systematic review of preoperative nutrition (whey protein) either alone or in combination with an exercise program in colorectal surgery patients reported a 2-day reduction in hospital stay in the prehabilitation group.[19]

A further enhancement to correcting malnourishment and sarcopenia is the concept of immunonutrition (IM) usually consisting of combinations of the amino acid arginine, omega-3 fatty acids, and sometimes further protein enhancement via BCAAs (branched-chain amino acids). There have been 3 recent systematic reviews of perioperative IM for hepatic resection with Wong and colleagues[20] concluding from ten RCTs that IM reduces wound infection rates and hospital stay, recommending it be included as a component in ERAS for liver surgery; McKay et al[21] reported large heterogeneity in results with one cohort study showing a 26.9% reduction in postoperative complications using BCAAs and another showing a 25.4% reduction in postoperative ascites with preoperative IM. Guan and colleagues[22] included 11 RCTs with 1136 patients in a metanalysis concluding that IM is safe and feasible significantly reducing overall postoperative complications, postoperative liver failure, and hospital stay. Currently, IM is not widely implemented but seems worth consideration within ERAS guidelines for hepatic resection.

An RCT from 2016 investigating prehabilitation in hepatic resection surgery demonstrated an improvement in cardiopulmonary function and quality of life with CPET plus a 4-week high-intensity exercise program.[23] The same research group had previously demonstrated a significant reduction in exercise capacity following neoadjuvant chemotherapy (NACR) for CRC comparing CPET variables at baseline and following NACR. The intervention group in this RCT experienced a significant increase in CPET measured exercise capacity following a 6-week high-intensity exercise program with the control group still not recovering to their pre-NACR fitness.[24] This may be relevant in hepatic resection whereby many patients undergo NACR and a 3 to 4-week window exists before their surgery to implement such a program.

Preoperative hemoglobin optimization, largely via intravenous iron infusion, has been implemented widely in the UK as a prehabilitation component in major surgery. While the recently published PREVENTT study[25] reported no outcome improvements in anemic patients receiving intravenous iron therapy preoperatively this study did not include hepatic resection surgery patients and did not reflect current anemia pathways, with the intervention delivered too close to surgery and limited to one treatment dose and thus few patients achieved target hemoglobin. Munoz and colleagues[26] previously reported the incidence of preoperative hemoglobin less than $130g.L^{-1}$ in patients undergoing hepatic resection for CRLMs as 37%. As this is surgery whereby the major intraoperative risk is blood loss and any consequent blood transfusion significantly worsens perioperative outcomes, preoperative optimization of hemoglobin is crucial. This may also allow safer normovolemic hemodilution intraoperatively for larger resections.

An issue specific to hepatic resection surgery is the impact of intrahepatic fat (either NAFLD or NACR-induced) which may be further worsened by inflammation that is, steatohepatitis (NASH)—termed chemotherapy-associated steatohepatitis (CASH) if new and deemed secondary to NACR. These conditions have been independently associated with postoperative morbidity but may be rapidly modifiable using dietary interventions in the window between NACR and surgery.[27]

INTRAOPERATIVE MANAGEMENT

Surgical Technique

Surgical approaches include open surgery, laparoscopic-assisted surgery, and robotic-assisted surgery and there is a large variation between surgeons, centers, and countries regarding the preferred approach. Laparoscopic approaches remain largely limited to minor resections that is, involving less than 3 Couinaud segments. To date several large propensity score-matched cohort comparisons have shown longer or similar operative time, less intraoperative blood loss or transfusion requirement, shorter hospital stays, lower or comparable morbidity, and equivalent mortality compared with open surgery.[28–30] The first RCT comparing open and laparoscopic-assisted hepatic resection conducted at the Oslo University Hospital[31] reported a lower complication rate (19% vs 31%) and a shorter hospital stay in the laparoscopic group with similar blood loss, operative time and resection models. Mortality was low and not significantly different between groups. The perceived advantages of laparoscopy are better-magnified views and less bleeding due to the pneumoperitoneum compressing low-pressure vessels during transection. Although the latter is borne out in the cohort studies this advantage was not seen in the RCT.

There are three phases to the operation with differing anesthesia goals:

1. Initial phase:
   a. mobilization of the liver,
   b. ultrasound localization of the lesions with confirmation of resectability,
   c. if confirmed, followed by cholecystectomy and dissection of the porta hepatis.
2. Resection phase.
3. Hemostasis and closure.

Anesthetic Technique

Anesthesia for hepatic resection surgery has some unique aspects primarily focused on strategies to limit blood loss during the resection alongside minimizing reperfusion injury to the liver to reduce the risk of postoperative liver failure.

Monitoring Recommendations

- Large bore venous access
  - optional placement of a pulmonary artery catheter introducer alongside a central venous catheter (CVC) could be considered for large complex resections to aid rapid volume loading if necessary and for easy venesection if performing normovolemic hemodilution
- Availability of a rapid infusion system
- Arterial line (also aids regular blood sugar and lactate monitoring)
- CVC – allows CVP targeting and norepinephrine infusion
- Minimally invasive CO monitoring using esophageal Doppler or arterial pressure-based systems—primarily for goal-directed fluid therapy during the postresection phase of surgery

Anesthesia

- Avoid halothane due to hepatotoxicity
- Atracurium/cisatracurium preferred as they are unaffected by liver dysfunction
- Intravenous fluid administration is limited until the posttransection phase—vasopressor infusions are titrated to maintain optimal perfusion pressure
- Ensure normothermia throughout for optimal coagulation using intravenous fluid warmers, forced air warming blankets, or warming gel mats

Analgesia Options

Administration of simple analgesia perioperatively is limited due to the hepatotoxicity of paracetamol. It may be considered for smaller resections with good underlying liver function following endorsement from the surgical team.

As this group is at risk of renal dysfunction and impaired coagulation the use of nonsteroidal anti-inflammatory drugs is discouraged.

Several metanalyses have found an opioid-sparing effect for perioperative gabapentinoids and low dose ketamine (eg, 0.5 mg/kg)—with the latter also leading to lower pain scores and these may comprise one of the elements of a multimodal package.[32]

In open liver resection, thoracic epidural analgesia (TEA) remains the mainstay of analgesia (and may also reduce bleeding via lowering the CVP). However, more recently continuous wound infusion catheters (CWIC) have shown potential to become the standard approach. There have been 3 recent RCTs comparing TEA to CWIC with Revie and colleagues[33] reporting a shorter hospital stay for CWIC despite superior analgesia in the TEA group; Hughes and colleagues[34] also found shorter recovery times in CWIC and the multi-centre POP-UP study[35] which included hepatic and pancreatic resections found CWIC noninferior to TEA within an ERAS protocol with significantly less vasopressor consumption perioperatively and shorter infusion duration postoperatively in the CWIC group. CWIC also avoids the concern around epidural catheter removal if postoperative coagulopathy develops.

For laparoscopic surgery, intrathecal opiate (morphine or diamorphine) is effective with a recent metanalysis including 40 studies (2500 patients) examining the use of intrathecal opioids in abdominal surgery[36] finding a reduced consumption of postoperative intravenous opiate, lower pain scores, longer time to first analgesic request, and shorter hospital stay with intrathecal opioids. The only adverse events were an increase in pruritis in the intrathecal opiate group and a dose-dependent increase in respiratory depression which disappeared when 2 outlying studies which used excessive doses (greater than 800mcg) were removed. Apart from 6 studies the doses used ranged from 100mcg to 400mcg with 300mcg being the most common. The authors recommend for safety using less than 500mcg. The metanalysis included several hepatic resection studies which all showed safety and benefit for intrathecal opiate.[37–39] Indeed intrathecal opiate may even be adequate for open liver resection with a 2020 study reporting reduced opiate requirements and improved analgesia compared with conventional multimodal analgesia alone.[40]

Anecdotally and requiring research this author finds a hybrid approach for open liver resection which combines the benefits of intrathecal opiate and CWIC very effective.

Intrathecal opiate analgesia may be further enhanced by combining it with intravenous lidocaine infusions perioperatively with evidence for suggesting it may reduce opiate requirements, improve analgesia, shorten hospital stay and reduce ileus rates along with ameliorating postoperative inflammation.[41–50] This approach is routinely used in our institution for laparoscopic approaches whereby CWIC or TEA is not required. Caution is required and intravenous lidocaine either avoided or the dose reduced if there is any underlying liver dysfunction or a large resection with a higher risk of postoperative liver failure is planned.

Strategies for Reducing Bleeding

There is a paucity of high-quality evidence for the efficacy of the different techniques for reducing blood loss, transfusion requirements, and consequent mortality as concluded by a 2016 COCHRANE review.[51]

Several older observational studies indicated that maintaining a CVP < 5 mm Hg was associated with reduced blood loss, length of stay, morbidity, and mortality.[52–55] This must be balanced against the risks of cardiovascular compromise and air embolus. Despite a COCHRANE review[56] not finding any effect on outcomes when analyzing randomized trials, it remains a standard practice in most units.

The following have been used in isolation or together, depending on local practice and individual cases, to achieve low CVP targets:

- Anti-Trendelenburg 15°[57]
- Fluid restriction to 1 mL/kg/h
- TEA or intrathecal analgesia
- GTN infusion at 5 to 15 mcg/min[58]
- Minimization of PEEP/reduced ventilation
- Mannitol 0.5 g/kg and furosemide 10 mg

Acute normovolemic hemodilution is a technique whereby the patient undergoes venesection following induction of anesthesia—the volume removed depending on preoperative hemoglobin and cardiovascular stability—and normovolemia is reestablished with albumin administration. The blood removed is then retransfused during the postresection phase. The COCHRANE review reported less blood loss during resection when combining this with low CVP than low CVP alone.[51]

Surgical options for reducing blood loss comprise the vascular occlusion techniques depicted in **Fig. 2** which isolate the hepatic circulation from the systemic circulation and may be broadly divided into temporary hepatic inflow occlusion (Pringle maneuver) and total vascular exclusion (TVE). The Pringle maneuver can be applied continuously or intermittently with a limit of an hour or less. It results in a 10% decrease in cardiac output, a 40% increase in SVR, and a 40% increase in mean arterial pressure. It carries an increased risk of air embolus, which may be reduced by positioning the patient at 15° Trendelenburg. Repeated intermittent 5 to 10-minute occlusions with several minutes of reperfusion in between are favored. There is growing evidence for a reduction in blood loss, transfusion risk, and associated reperfusion injury and postoperative liver failure using a Pringle maneuver.[59–63]

Prophylactic tranexamic acid may be considered to reduce bleeding and transfusion rates. While the evidence for its use largely extrapolated from other settings[64–66] one study randomizing over 200 liver resection cases between tranexamic acid and placebo demonstrated reduced blood loss and transfusion rates in the treatment group.[67]

Intraoperative Strategies to Minimize Postoperative Liver Failure

The incidence of postoperative liver failure may be reduced by avoiding the administration of any hepatotoxic drugs perioperatively, minimizing intraoperative bleeding, and consequent blood transfusion, minimizing vascular occlusion times thereby reducing reperfusion injury to the liver and maintaining an optimal hemodynamic

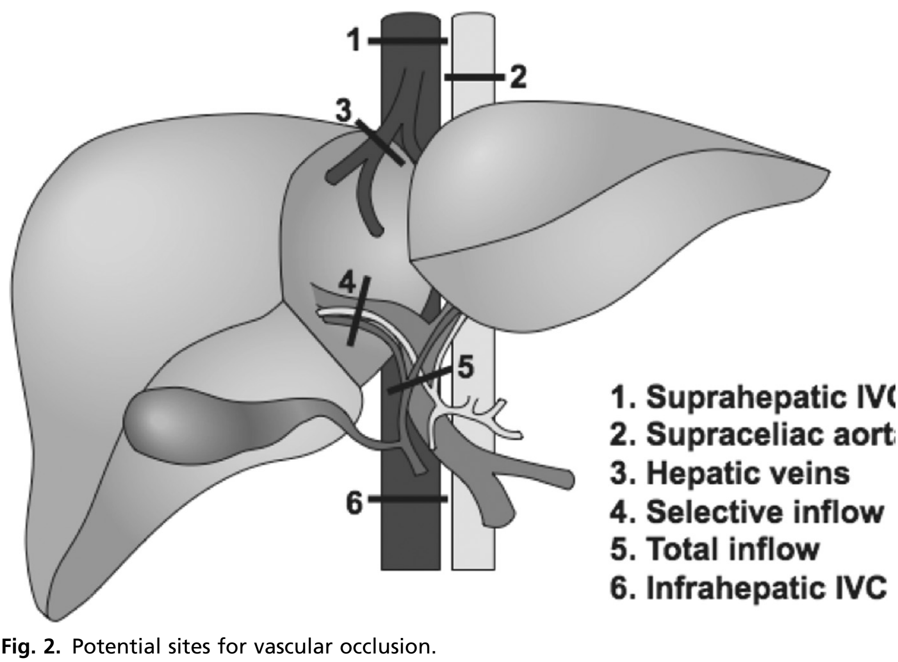

Fig. 2. Potential sites for vascular occlusion.

balance that is, providing a low CVP, while avoiding excessive hypovolemia and ensuring an adequate perfusion pressure. Good communication between surgical and anesthesia teams regarding surgical manipulation and filling status is crucial to ensuring good outcomes. Individualized targets and planned surgical manipulation should be discussed at the WHO team brief before surgery.

Preoperative glucocorticoids can be considered although the evidence is conflicting with 2 meta-analyses both analyzing the same 5 RCTs reaching different conclusions.[68,69] Reductions in IL6 and bilirubin levels were statistically significant on day one postoperatively and nonsignificant trends toward lower prothrombin times however this did not translate into lower overall complication rates, or a shorter hospital stay. Therefore, it seems to be a safe intervention that reduces short-term inflammation, however, the clinical benefit seems to be limited.

POSTOPERATIVE MANAGEMENT

The majority of hepatic resections with normal underlying liver function have an uneventful postoperative course, without the high ileus rates and difficulty reestablishing enteral feeding seen in other types of major abdominal surgery. The focus should be on ERAS with early mobilization and nutrition and a short hospital stay.

Cases with underlying liver dysfunction or very large resections have greater risks of postoperative complications that is, bile leak, ascites, liver failure, pulmonary complications, and thrombotic complications.

Ascites is common leading to increased fluid shifts and complicating fluid and electrolyte management. Hypophosphatemia is common and occasionally sodium and water retention with edema formation secondary to hyperaldosteronism are seen.

The most concerning complication are liver failure which may be complicated by:

- Hypoglycemia - requiring glucose infusion.
- Encephalopathy - supported by lactulose and minimizing opiates.
- Coagulopathy is usually corrected with FFP as required; larger volume blood loss may require targeted blood product and/or tranexamic acid administration guided by thromboelastographic monitoring.

The nature of the electrolyte disturbance, glucose requirement, and amount of ascites and edema together with the intravascular volume status will determine the type and volume of fluid administration required, with 20% albumin often the best option.

N-acetylcysteine infusions are often used until liver function normalizes although the evidence is mixed, and some trials report worsened liver function.[70–72]

ENHANCED RECOVERY AFTER SURGERY

The ERAS society published perioperative care guidelines[73] for hepatic resection surgery in 2016 although the 23 items selected for the multimodal pathway were largely transplanted from existing ERAS guidelines for colorectal surgery and may not all apply to liver surgery. Encouragingly, a recent systematic review[74] demonstrated that these pathways are effective in this type of surgery for reducing hospital stay (2.2-day reduction in the ERAS group), complications (only in the laparoscopic surgery sub-group), and hospital cost without any increase in mortality or readmission rates. Only 4 of the 27 studies included compared compliance rates which were greater in the ERAS groups (65% to 73.8% vs 20% to 48.7%). Further research is required to determine which ERAS elements are the most important for achieving improved outcomes.

FUTURE DIRECTIONS

Likely future developments will be in the areas of machine learning algorithms and AI to improve patient selection, interventions to address hepatic steatosis preoperatively within effective prehabilitation programs, three-dimensional simulation, and navigation technology,[4] improved intraoperative imaging, and refinement of laparoscopic-assisted and robotic approaches.

SUMMARY

Outcomes for liver resection surgery have improved significantly in the past decade due to better patient selection, patient preparation, improved anesthetic and surgical techniques to reduce intraoperative bleeding and the implementation of ERAS programs.

CLINICS CARE POINTS

- Patient selection, optimization of medical conditions, and prehabilitation.
- Reducing blood loss during resection.
- Opioid sparing analgesia approach that restores function.
- Avoidance and management of postoperative liver failure.
- Mobilization and early nutrition for most patients.

DISCLOSURE

The authors have no conflicts of interest to disclose.

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