Guidance document: risk assessment of patients with cirrhosis prior to elective non-hepatic surgery

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ABSTRACT

As a result of the increasing incidence of cirrhosis in the UK, more patients with chronic liver disease are being considered for elective non-hepatic surgery. A historical reluctance to offer surgery to such patients stems from general perceptions of poor postoperative outcomes. While this is true for those with decompensated cirrhosis, selected patients with compensated early-stage cirrhosis can have good outcomes after careful risk assessment. Well-recognised risks include those of general anaesthesia, bleeding, infections, impaired wound healing, acute kidney injury and cardiovascular compromise. Intra-abdominal or cardiothoracic surgery are particularly high-risk interventions. Clinical assessment supplemented by blood tests, imaging, liver stiffness measurement, endoscopy and assessment of portal pressure (derived from the hepatic venous pressure gradient) can facilitate risk stratification. Traditional prognostic scoring systems including the Child-Turcotte-Pugh and Model for End-stage Liver Disease are helpful but may overestimate surgical risk. Specific prognostic scores like Mayo Risk Score, VOCAL-Penn and ADOPT-LC can add precision to risk assessment. Measures to mitigate risk include careful management of varices, nutritional optimisation and where possible addressing any ongoing aetiological drivers such as alcohol consumption. The role of portal decompression such as transjugular intrahepatic portosystemic shunting can be considered in selected high-risk patients, but further prospective study of this approach is required. It is of paramount importance that patients are discussed in a multidisciplinary forum, and that patients are carefully counselled about potential risks and benefits.

INTRODUCTION

The increasing incidence of cirrhosis in the UK[1] has driven the rise in such patients requiring non-hepatic surgery as an emergency (eg, irreducible umbilical hernia) or electively (eg, cardiac or colon cancer surgery). There has been a long-standing reticence to operate on such patients due to their perceived poor outcomes, which has potentially disadvantaged this patient group.

Surgical outcomes vary considerably according to the type of surgery, type of anaesthesia and importantly the stage of liver disease, with clinically significant portal hypertension ((CSPH) defined as a hepatic venous pressure gradient (HVPG) $\geq$10 mm Hg) heralding the development of varices, and further progression to decompensation.[2] Additionally, comorbidities such as obesity, diabetes and cardiovascular disease present further anaesthetic and surgical challenges for the growing cohort of patients with non-alcoholic fatty liver disease-related cirrhosis.

The assessment of surgical risk in patients with cirrhosis is increasingly important but limited by a lack of prospective controlled data and significant heterogeneity in risk assessment pathways. Although AGA guidance on this topic has been published,[3] there is no clear guidance in the UK. This position statement aims to summarise the current evidence and advise members of BSG and BASL on the current options for presurgical assessment and future directions. This guidance document has been reviewed by the BASL Portal Hypertension Special Interest Group Steering Committee, BSG Liver Section, and BSG Clinical Services and Standards Committee.

Guidance statements

1. Patients with cirrhosis are considered high-risk candidates for non-hepatic surgery, in particular intra-abdominal and cardiothoracic procedures. The risk is highest inChild-Turcotte-Pugh (CTP)-B and C disease and correlates with the degree of portal hypertension.
2. The preoperative assessment of patients with cirrhosis being considered for non-hepatic surgery is complex and a case-by-case decision is advised.
3. Multidisciplinary assessment including hepatology, anaesthetics and surgery is advised, with involvement of other disciplines (eg, radiology, haematology or nutrition/physiotherapy) where appropriate.
4. In eligible patients, particularly those with decompensated cirrhosis, consideration should be given to deferring elective surgery until after liver transplantation where applicable. Where liver transplantation is not an option in decompensated cirrhosis, referral to palliative care services should be considered unless aetiology of cirrhosis is modifiable for example, alcohol abstinence, antiviral therapy.
5. The current bespoke prognostic scoring systems such as Mayo Risk Score, VOCAL-Penn and Adequate Operative Treatment for Liver Cirrhosis (ADOPT-LC) can be considered to aid multidisciplinary team decisions, in addition to CTP and Model for End-stage Liver Disease (MELD) score.
6. Measuring HVPG can provide additional important information and may be considered as an adjunct to other prognostic paraments where available.
7. In compensated cirrhosis, transjugular intrahepatic portosystemic shunting (TIPSS) prior to surgery can be considered in those at high risk as quantified by the presence of varices, prognostics scoring systems and/or HVPG. However, further comparative multicentre studies are urgently needed, to guide selection of patient most likely to benefit
8. Algorithm for assessment of patients with cirrhosis undergoing elective surgery is presented in figure 1.

Pre-surgery assessment

Presurgery evaluation requires that we consider specific harms that may either complicate surgery or recovery from surgery. These risks should be assessed and explained to the patient, with appropriate steps put in place to mitigate where possible.

History, physical examination and blood tests may reveal findings suggestive of chronic liver disease. There should be a low threshold to consider further investigations such as imaging and liver stiffness measurement where there is clinical suspicion of liver disease since patients with compensated advanced chronic liver disease can present with normal liver function tests and absence of overt clinical stigmata of chronic liver disease. A multidisciplinary assessment is strongly advised with input from hepatology, anaesthetics, surgery and other disciplines where appropriate such as radiology, haematology, nutrition and physiotherapy. The risks include: (1) general anaesthesia which could be mitigated by the use of regional techniques; (2)

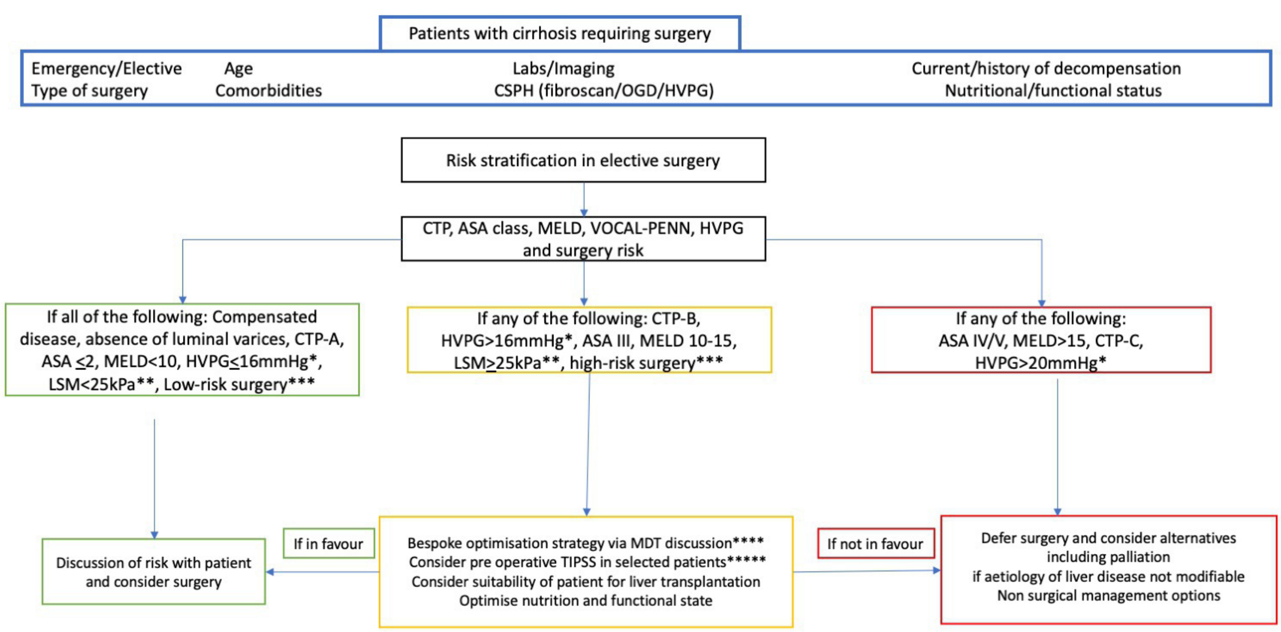

Figure 1 Algorithm for assessment of patients with cirrhosis undergoing elective surgery. *HVPG measurement is preferable where available. **LSM applicable only in compensated cirrhosis. ***High-risk surgery includes cardiovascular, thoracic and open abdominal surgery. ***Low-risk surgery comprises of minimally invasive, abdominal wall and orthopaedic surgery. ****Includes addressing individual risk factors such as alcohol intake, increased BMI, measures to improve ASA status and portal decompression, for example, TIPSS in suitable patients. *****Only available in selected centres. ASA, American society of Anesthesiology score; BMI, body mass index; CSPH, clinically significant portal hypertension; CTP, Child-Turcotte-Pugh score; HVPG, hepatic venous pressure gradient; LSM; liver stiffness measurement; MDT, multidisciplinary team discussion; MELD, Model for End-Stage Liver Disease; OGD, oesophagogastroduodenoscopy; TIPSS, transjugular intrahepatic portosystemic shunting.

implied bleeding risk using traditional indices such as international normalised ratio (INR), activated partial thromboplastin time (APTT) and platelet count, which in this population do not reflect deranged haemostatic mechanisms, making an assessment of bleeding risk challenging[4]; (3) infection which can precipitate decompensation[5]; (4) compromised nutritional status with malnutrition and sarcopenia hampering postoperative recovery and wound healing[6]; (5) acute kidney injury precipitated by hypovolaemia due to depleted albumin, contrast agents, infection or anaesthesia[6]; (6) cardiovascular compromise due to stress of surgery unmasking undiagnosed cardiomyopathy.[7 8] Decompensated cirrhosis (defined by ascites, encephalopathy, variceal bleeding, and/or jaundice) results in a much higher risk of poor outcomes, with increased propensity to precipitate acute on chronic liver failure post-surgery.[9] In this group, an individualised decision on whether surgery can be deferred until after liver transplantation for eligible candidates should be considered. Decompensated patients with non-hepatic malignancy can be particularly challenging since pre-emptive liver transplantation is normally contraindicated. Elective surgery is absolutely contraindicated in acute liver failure, acute viral or alcoholic hepatitis and American Society of Anesthesiologists (ASA) Physical Status class V. Intra-abdominal or cardiothoracic surgical procedures are considered higher risk—the former due to the potential presence of portal hypertension, and the latter due to the adverse impact of reduced cardiac output in patients who are already vasodilated, with low blood pressure and reliant on their compensatory high cardiac output state.[10]

Specific prognostic models

Most studies of prognostic models are observational or retrospective and limited by significant heterogeneity with regard to the type of surgery, severity of liver disease and whether surgery was elective or emergency. Traditional prognostic scoring systems including CTP and MELD, have an established role but can overestimate surgical risk.[11] Bespoke prognostic models have also been proposed which can provide a greater precision (table 1). These include the Mayo Risk Score,[12] VOCAL-Penn[13] and ADOPT-LC score[14] (table 1). These are all based on retrospective data, some dating back 25 years, and do not quantify the degree of portal hypertension. A recent multicentre prospective study[15] found that ASA class (HR III vs II=2.98 (95% CI 0.7 to 13.2), HR IV vs II=9.97 (95% CI 2.0 to 50.4), p=0.008), high-risk surgery (HR=3.65 (95% CI 1.4 to 9.3), p=0.006) and HVPG (HR=1.14 (95% CI 1.05 to 1.25), p=0.003) were strongly predictive of 1 year mortality (C-statistic >0.8). HVPG is invasive and not widely available, but given that values >16 mm Hg (and especially ≥20 mm Hg (HR=5.67 (95% CI 2.4 to 13.2)) are independently associated with high risk of 1-year postsurgical mortality, its use, particularly in patients with compensated cirrhosis or with previous decompensation, may be considered where available.

Risk associated with different types of non-hepatic surgery

Patients with liver disease have high morbidity and mortality across the spectrum of surgical procedures.[16] Operative risk is dependent on severity of liver disease, type and mode of surgical procedure, concomitant medical conditions, nutritional and performance status of the individual, and peri- and postoperative expertise.[17 18] Studies on the outcome of patients undergoing surgery are highly variable with the majority of studies being retrospective and single-centre, and lacking detail of liver disease and appropriate quality controls[17 19–22] (table 2). Emergency surgery confers an estimated 4–10 fold higher postoperative mortality.[10 23–26] A systematic review by de Goede *et al* quotes general surgical risk for 30-day mortality and morbidity to be 11.6% and 30.1%, respectively.[27] Presence of portal hypertension further heightens the mortality with colectomy, abdominal aortic aneurysm repair or coronary artery bypass grafting (CABG) having a 12.3-fold, 14.3-fold, 7.8-fold and 22.7-fold higher risk, respectively, when compared with patients without cirrhosis.[27]

Laparoscopic versus open surgery

Laparoscopic surgery was deemed a relative contraindication in cirrhosis due to risk of rupturing abdominal varices but multiple studies have demonstrated favourable outcomes following this approach.[28–37] It's safety in CTP-C patients is not yet proven, hence surgery in such patients may be limited to conservative measures. In the context of cirrhosis, laparoscopic cholecystectomy has been the most common procedure assessed. In a meta-analysis of randomised controlled trials comparing laparoscopic and open cholecystectomy (n=234 patients (97% CTP-A or B)), there were no postoperative deaths and the laparoscopic approach was associated with fewer postoperative complications (p=0.03), shorter hospital stay (p<0.001) and quicker resumption of normal diet (p<0.001).[29] Laparoscopic inguinal hernia repair can be performed safely[32] and there are also favourable outcomes when comparing laparoscopic to open appendectomy.[38]

Colorectal surgery

Colorectal surgery in cirrhosis is considered high risk with morbidity and 30-day mortality quoted between 21.5%–26% and 48%–77%, respectively.[39–43] The risk is higher in the presence of portal hypertension due to altered intraoperative haemodynamics, ascites and

Table 1 Prognostic scores used to predict post operative outcomes in patients with chronic liver disease

Score	Components			
Child-Turcotte-Pugh (CTP)	Score	1	2	3
	Albumin (g/L)	>35	28–35	<28
	Bilirubin(µmol/L)	<34	34–50	>50
	Clotting (INR)	<1.7	1.7–2.2	>2.2
	Ascites	None	Diuretic responsive	Diuretic resistant
	Encephalopathy	None	Grade 1 or 2	Grade 3 or 4
	Class	A	B	C
	Total score	5–6	7–9	10–15
Model for End-Stage Liver Disease (MELD)	Creatinine (µmol/L)			
	Bilirubin (µmol/L)			
	Clotting (INR)			
	Dialysis at least twice in past week			
	Formula = (0.957 x ln (Serum Cr) + 0.378 x ln (serum Bilirubin) + 1.120 x ln (INR)+0.643) x 10 (if haemodialysis, value for creatinine is automatically set to 4.0)			
ASA	ASA I—Normal healthy patient			
	ASA II—Patient with mild systemic disease			
	ASA III—Patient severe systemic disease that is not a constant threat to life			
	ASA IV—Patient with severe systemic disease that is a constant threat to life			
	ASA V—Moribund patient not expected to survive with or without surgery			
ADOPT-LC	Age (years)			
	Charlson Comorbidity index			
	CTP Class			
	Anaesthesia duration			
Mayo Postoperative Mortality Risk Score (https://www.mayoclinic.org/medical-professionals/transplant-medicine/calculators/post-operative-mortality-risk-in-patients-with-cirrhosis/itt-20434721)	Age			
	ASA Score			
	Bilirubin (mg/dL)			
	Creatinine (mg/dL)			
	INR			
	Aetiology of cirrhosis			
VOCAL-Penn (https://www.vocalpennscore.com/)	Age (Years)	BMI >30		
	Albumin (g/L)	NAFLD aetiology		
	Bilirubin (µmol/L)	ASA score		
	Platelet count ($\times 10^9$/L)	Emergency surgery		
	Surgery type			

ADOPT-LC, Adequate Operative Treatment for Liver Cirrhosis; ASA, American Society of Anesthesiologists; BMI, body mass index; INR, international normalised ratio; NAFLD, non-alcoholic fatty liver disease.

coagulopathy.[10 40] Ascites heightens the risk of wound complications such as dehiscence.[44] A meta-analysis demonstrated that, compared with a non-cirrhotic group, patients with cirrhosis who underwent primary colorectal cancer surgery had more major complications, a higher reoperation rate and increased short-term mortality[45] (table 2). Additional risk factors for mortality included older age, elevated bilirubin, prolonged prothrombin time, higher CTP class, MELD score >15, intraoperative transfusions and comorbidities (cardiovascular disease, chronic kidney disease, paraplegia and malnutrition).[39 46–48] Nonetheless, improvements in surgical technique and perioperative care have led to reduced mortality rates over the last two decades. Mortality was reported to be 13% in a study of 72 cirrhosis patients undergoing colorectal surgery in 2003.[46] However, in a more recent study, Lee *et al* reported mortality of 3.1% 161 patients undergoing colorectal surgery.[48]

Hernia repairs

The incidence of abdominal wall hernia in patients with cirrhosis is 16%, which rises to 24% in patients with ascites.[49] Half of these are umbilical hernias and 60% of patients experience recurrence following repair.[49] Mortality is quoted to be 6% for umbilical hernia repair, which is higher in the emergency setting.[50] However, a randomised controlled trial concluded that elective repair of an umbilical hernia is safe in cirrhosis patients, even in patients with a relatively high MELD score (table 2). The presence of ascites appears to be strongly predictive of hernia recurrence.[51 52]

Table 2 Studies with mortality and morbidity data in relation to non-hepatic surgery in patients with cirrhosis and portal hypertension, categorised by type of surgery

Type of surgery	Reference and date	Type and details of study	Salient findings
Colorectal surgery	Gervaz *et al*[46] 2003	Retrospective analysis of 72 colorectal adenocarcinoma operations between 1976 and 2001 on cirrhosis patients.	► Post-operative death—13% ► Risk factors predictive of postoperative mortality include elevated bilirubin (p=0.01) and prolonged prothrombin time (p=0.009). ► CTP-A patients had significantly better survival rates than combined group of CTP-B and C patients (p=0.008)
	Csikesz *et al*[10] 2009	Retrospective analysis of national database between 1998 and 2005; 22 569 patients with cirrhosis (of whom 4214 had portal hypertension)	► Higher mortality for patients undergoing colectomy compared with controls (HR 3.7, 95% CI 2.6 to 5.2) ► Presence of portal hypertension confers even higher risk (HR 14.3, 95% CI 9.7 to 21.0)
	Nguyen *et al*[39] 2009	Population based study (1998–2005) identifying 4042 patients	► Patients with cirrhosis and cirrhosis with portal hypertension had higher in-hospital mortality in comparison to patients without cirrhosis (14% and 29% vs 5%, respectively, p<0.0001) ► Approximately four-fold higher rate of in-hospital mortality for emergency and urgent procedures in comparison to elective procedures in liver cirrhosis patients ► Higher mortality rate of cirrhotic patients with portal hypertension undergoing surgery (HR: 5.8; 95% CI 4.9 to 7.6). ► Independent risk factors for mortality were cirrhosis, portal hypertension, old age, colectomy and comorbidities which included cardiovascular disease, chronic kidney disease, paraplegia and malnutrition.
	Ghaferi *et al*[47] 2010	Prospective, clinical database between 2005 and 2007 identifying 1565 patients with chronic liver disease undergoing colorectal resections	► Chronic liver disease patients were identified using clinical characteristic: ascites, oesophageal varices or total bilirubin >34 umol/L. ► 6.5-fold increased risk of mortality following colorectal operations in chronic liver disease patients. ► MELD score >15 associated with higher rates of mortality and complications (Ascites, infection, bleeding anastomotic leaks and stoma issues including leaks, difficulty closing and peristomal variceal bleeding).
	Montomoli *et al*[87] 2013	Population-based study between 1996 and 2009 identifying 39 840 patients undergoing colorectal surgery with 158 (0.4%) having cirrhosis	► Higher 30-day mortality (24.1%) corresponding to adjusted RR of 2.59 (95% CI 1.86 to 3.61)
	Lee *et al*[48] 2017	Retrospective analysis of 161 cirrhosis patient undergoing surgery for colorectal cancer (CRC)	► MELD score >8 influenced overall survival (p<0.001)
	Lee *et al*[88] 2018	Retrospective, observational, population-based study between 2005 and 2014 identifying 7463 patients with CRC who underwent colorectal surgery.	► Increased risk of in-hospital mortality (adjusted OR 2.05, p<0.001) ► No significant increase in postoperative complications (adjusted OR 0.91, p=0.192)
	Cheng *et al*[45] 2021	Meta-analysis identifying 2485 patients from 5 studies	► Cirrhotic group experienced more major complications (OR 5.15; p=0.005), higher rates of return to theatre (OR: 2.04; p=0.03), higher short-term mortality (OR: 2.8; p<0.00001) and shorter survival (HR 2.96, p<0.00001)
Peptic ulcer disease	Lehnert and Herfarth[64] 1993	Retrospective analysis (1972–1991), 69 patients undergoing surgery (90%—emergency) for gastroduodenal disease	► Overall mortality—54% with bleeding and multiorgan failure being leading causes of death (70%).
Gastric cancer surgery	Isozaki *et al*[65] 1997	Retrospective analysis of 39 patients with liver cirrhosis undergoing curative surgery for gastric cancer between 1978 and 1994	► Postoperative complications were observed in 10 (25.6%) of patients with 4 (10.3%) hospital deaths.
	Guo *et al*[66] 2014	Retrospective analysis of 58 patients with cirrhosis undergoing radical gastrectomy between 2001 and 2012.	► Forty-four patients received subtotal gastrectomy and 14 received total gastrectomy accompanied by D1 (26 patients) or D2 (32 patients) lymphadenectomy. ► Severe postoperative complications occurred in 58.6% of patients and occurred more frequently in CTP-B (p=0.03) or if underwent D2 lymphadenectomy (p=0.015). ► Postoperative mortality occurred more frequently in CTP-B patients (p=0.033). ► 100% mortality was experienced in CTP-C.
Oesophageal surgery	Valmasoni *et al*[89] 2017	Retrospective analysis of oesophageal cancer database identifying 3445 oesophageal cancer patients, 73 with cirrhosis undergoing surgery.	► Cirrhosis patients experienced more respiratory events (p=0.013), infections (p=0.005) and severe anastomotic complications (p=0.046) ► MELD >9 associated with decreased 5 year survival (p=0.004) and MELD score or nine or lower showed outcomes similar to that of non-cirrhotic patients.
	Cheng *et al*[90] 2020	Retrospective, propensity-matched study (cirrhotic (n=50) and non-cirrhotic patients (n=100))	► Patients with cirrhosis experience higher rates of postoperative complications including postoperative pneumonia (22 vs 9%, p=0.027), pleural effusion (38 vs 20%, p=0.018), chylothorax (10 vs 1%, p=0.016) and had longer intensive care unit (ICU) stay (mean: 6.10 vs 2.58 days, p=0.002) compared with controls
	Schizas *et al*[68] 2020	Meta-analysis of 12 observational studies including 1938 patients (238 with cirrhosis)	► 30-day mortality higher in cirrhosis (OR 3.04, 95% CI 1.71 to 5.39) although this was not observed at 90 days (OR 2.84, 95% CI 0.94 to 8.93) or long term (mean follow up - 24-months) (OR 1.70, 95% CI 0.53 to 5.51). ► Anastomotic leak occurred at a higher rate in patients with cirrhosis (OR 2.81, 95% CI 1.05 to 7.49). ► CTP-A patients were associated with a significantly lower 30-day mortality compared with CTP-B (OR 0.14, 95% CI 0.04 to 0.54).
Bariatric surgery	Lee *et al*[91] 2021	Retrospective, 1:1 propensity-matched case control study of 957 patients with and without cirrhosis undergoing bariatric surgery.	► No difference in mortality (OR 1.73; p=0.33) ► Comparing decompensated (n=117) and compensated (n=957) cirrhosis, increased mortality was observed (7.69 vs 0.94%, p<0.001).

Continued

Table 2 Continued

Type of surgery	Reference and date	Type and details of study	Salient findings
	Mavilia *et al*[92] 2020	Retrospective study of 20 096 chronic liver disease (using ICD coding) patients undergoing bariatric surgery	Chronic liver disease patients experience high inpatient mortality (adjusted OR 1.47, 95% CI 1.24 to 1.73) but significantly less surgical revision, improper wound healing and postoperative infection following bariatric surgery
	Agarwal *et al*[71] 2021	Systematic review and meta-analysis including 18 studies and 471 patients with obesity and liver cirrhosis undergoing bariatric surgery (mainly LSG and RYGB)	▶ 397/423 patients with defined CTP class were CTP-A ▶ The weighted pooled proportion of overall complications was 22.14% and all-cause 90-day mortality was 0%. ▶ Significant increase in postoperative complications (p<0.001) but no difference in all-cause 90-day mortality (p=0.1165) compared with controls.
Appendectomy	Rashid *et al*[73] 2022	Meta-analysis of 923 patients with cirrhosis undergoing appendectomy	▶ 30-day mortality 9% vs 0.3% in cirrhosis and non-cirrhosis patients, respectively. ▶ Laparoscopic appendectomy appeared safer with a mortality of 0.5% in comparison to open appendectomy with mortality of 3.2%)
Umbilical hernia	Snitkjær *et al*[50] 2022	Systematic review of 13 prospective, 10 retrospective studies including 3229 patients	▶ Evidence was graded as very low quality for all outcomes. ▶ Mortality quoted to be 6% (n=191). ▶ Patients with cirrhosis are eight times more like to die after surgery compared with patients without cirrhosis
	De Goede *et al*[52] 2021	Randomised controlled trial (CRUCIAL trial) with 2 years of follow-up recruiting 34 patients with umbilical hernia in liver cirrhosis and ascites	▶ Randomised controlled trial (16—elective repair, 18—conservative management) ▶ After 24 months, 8 (50%) assigned to elective repair, in comparison to 14 (77.8%) assigned to conservative treatment had no significant difference in morbidity.
	Grey *et al*[93] 2008	Retrospective analysis of 1421 cases, 127 (8.9%) cirrhotics	▶ Elective repair in cirrhosis is associated with similar outcomes in patients without cirrhosis. ▶ Cirrhotic patients were more likely to undergo emergency repair (26% vs 4.8%; p<0.0001), concomitant bowel resection (8.8% vs 0.8%; p<0.0001), return to theatre (7.9% vs 2.5%, p=0.0006) and increased length of stay (4 vs 2 days; p=0.01)
	Eker *et al*[94] 2011	Prospective study	▶ In total, 30 patients (6 CTP-A, 19 CTP-B and 5 CTP-C) with a median MELD score was 12 (IQR 8–16). ▶ Elective umbilical hernia is safe with no post-operative intensive care admissions and only 2 of 30 patients died; neither of deaths were attributable to umbilical hernia repair.
	Carbonell *et al*[95] 2005	Nationwide retrospective cohort study 32 033 patients (30, 836 non-cirrhotic and 1197 cirrhotics)	▶ Cirrhotics had a higher age distribution (p<0.0001) underwent ICU admission more commonly (15.9% vs 6%; p<0.0001), had a longer length of stay (5.4 vs 3.7 days), and higher morbidity (16.5% vs 13.8%; p=0.008), and mortality (2.5% vs 0.2%; p<0.0001) compared with non-cirrhotics. ▶ Mortality was seven-fold higher in patients undergoing emergency repair (3.8% vs 0.5%; p<0.0001)
	Marsman *et al*[96] 2007	Retrospective study between 1990 and 2004 34 cirrhosis patients	▶ Elective hernia repair was successful in 12 out of 17 patients without complications and recurrence. 3/17 wound related problems and 4/17 had recurrence. ▶ Conservative management was only successful in 23%; 10/13 attended hospitals for incarceration of which 6 required emergency hernia repairs. Two patients managed conservatively died from complications of umbilical hernia.
	Pinheiro *et al*[97] 2020	Prospective cohort study 246 patients with cirrhosis	▶ A total of 246 patients (57 underwent elective hernia repair and 189 who opted for 'wait and see' approach) were included in the study. Of the latter, 43 (22.7%) patients required emergency hernia repair due to complications such as ascites leakage due to skin rupture in hernia site (n=28), incarceration (n=7), small bowel strangulation (n=5), and extensive skin necrosis or ulceration (n=3). ▶ MELD score >11 (HR 7.8; p=0.011) and emergency hernia repair (HR 5.35; p=0.005) were identified as risk factors for 30-day mortality.
Inguinal hernia	Oh *et al*[98] 2011	Retrospective study over 10-year period 780 patients having inguinal hernia repair. 129 patients with cirrhosis	▶ Morbidity (9.1–16.7%) is not significantly higher than patients without cirrhosis ▶ Overall mortality ranging from <1% to 2.7% ▶ Cumulative recurrence rates were not significantly different between cirrhosis and non-cirrhosis group (p=0.87)
	Patti *et al*[99] 2008	Prospective evaluation of QOL by questionnaire including 32 patients.	▶ Inguinal hernioplasty in patients with cirrhosis is a safe procedure and improves quality of life.
Cardiovascular	Chou *et al*[54] 2017	Nationwide, population-based study from Taiwan between 1997 and 2001 including 1030 Liver patients and 1040 matched controls without cirrhosis.	▶ 1 year survival was 68 vs 81% (p<0.001) in cirrhosis for CABG and valve surgery
	Hayashida *et al*[55] 2004	Retrospective study between 1989 and 2003 of 18 patients with cirrhosis undergoing cardiac operations	▶ Overall postoperative mortality—17% ▶ CTP-A—no increased mortality when undergoing elective cardiac surgery ▶ CTP-B and C—mortality rate 50%–100% after cardiopulmonary bypass
	Jacob *et al*[100] 2015	Systematic review (19 studies) of short-term and overall mortality in patients with liver cirrhosis classified by CTP score undergoing cardiac surgery.	▶ CTP score reporting 30-day mortality noted to be 9%, 37% and 52% for CTP class A, B and C, respectively. ▶ One-year mortality was reported to be 27.2%, 66.2% and 78.9%, respectively, for CTP class A, B and C, respectively.
	Araujo *et al*[56] 2017	Retrospective, propensity-matched, case–control study of 1197 patients with liver dysfunction undergoing cardiac surgery (n=755 CABG, n=442 valve surgery)	▶ Increased mortality was observed for both CABG (OR 5.19, p<0.0001) and valve surgery (OR 7.49, p<0.0001) in comparison to controls. ▶ Higher rates of complications (bleeding, respiratory, renal, infections) in patients with liver dysfunction and CABG.

Continued

Table 2 Continued

Type of surgery	Reference and date	Type and details of study	Salient findings
	Hseih *et al*[57] 2015	Meta-analysis (22 studies, 939 patients—CABG, valve surgery and cardiopulmonary bypass)	▶ Nineteen of the studies evaluated mortality with 354 patients in CTP-A, 205 in CTP-B and 33 in CTP-C. ▶ Mean mortality rates were 20.58%, 43.58% and 56.48% for patients in class A, B and C, respectively (p<0.01 for comparisons between each class). ▶ Major postoperative morbidity with rates up to 60%, 100% and 100% for CTP-A, B and C, respectively.
	Steffen *et al*[53] 2017	Retrospective, propensity-matched study between 1998 and 2011 identifying 2769 patients with cirrhosis undergoing surgical aortic valve replacement	▶ Aortic valve surgery in-hospital mortality was 16 vs 5% in controls (OR 3.6, p<0.0001) and greater rate of complications (55% vs 45% for controls). ▶ Risk factors of mortality included congestive cardiac failure, fluid and electrolyte disturbances, pulmonary circulation disorder and weight loss.
AAA repair	Marrocco-Trischitta *et al*[63] 2011	Retrospective, single centre study between 2001 and 2006 identifying 24 patients with Liver cirrhosis undergoing elective open repair of infrarenal AAA.	▶ CTP-B and MELD≥10—associated with reduced survival ▶ Significant difference in 2-year survival (77.4% vs 97.8%; p=0.03)
Elective Hip and knee arthroplasty	Cohen *et al*[74] 2005	Retrospective analysis of outcomes of primary total hip arthroplasty and total knee arthroplasty in cirrhotic patients.	▶ Complication rates, decompensation and/or death in up to 80% of cirrhosis patients after emergency THA due to a fracture. ▶ Primary THA or TKA can be safely performed electively in CTP-A and CTP-B patients
	Bell *et al*[101] 2020	Retrospective study identifying 18 129 cirrhotic patients undergoing TKA and compared with control of 1716439 TKA patients.	▶ Cirrhosis was associated with increased rate of major complications (3.7% vs 2.3%; OR 1.23, 95% CI 1.13 to 1.33; p<0.001) Higher risk of periprosthetic joint infection compared with controls, minor medical complications (13.5% vs 7.4%; OR 1.52, 95% CI 1.45 to 1.59, p<0.001), transfusion (2.8% vs 1.4%; OR 1.66, 95% CI 1.51 to 1.81, p<0.001), encephalopathy (1.0% vs 0.2%; OR 3.00, 95% CI 2.55 to 3.51, p<0.001), DIC (<0.001) within 90 days ▶ Alcohol and viral aetiologies were associated with increased rate of major complications.
	Onochie *et al*[78] 2019	Systematic review identifying eight studies on 28514 THA's	▶ Increased postoperative infection rates of 0.5% (p<0.001) and perioperative mortality of 4.1% (p<0.001). ▶ Frequent need for revision surgery at 4% (p<0.001). ▶ Aetiology of need for revision surgery included periprosthetic infection (70%), aseptic loosening (13%), instability (13%), periprosthetic fracture (2%) and linear wear (2%).

AAA, abdominal aortic aneurysm; CABG, coronary artery bypass grafting; CTP, child-turcotte-pugh; ICD, international classification of diseases; LC, laparoscopic cholecystectomy; LSG, laparoscopic sleeve gastrectomy; MELD, model for end-stage liver disease; OC, open cholecystectomy; RR, relative risk; RYGB, roux-en-y gastric bypass; THA, total hip arthroplasty; TKA, total knee arthroplasty.

Cardiovascular surgery

Morbidity and mortality in patients with cirrhosis undergoing cardiovascular surgery is increased with higher risk of infectious, respiratory and renal complications alongside longer hospital stay.[53–56] CABG and valvular surgery carry approximately fivefold and sevenfold increased risk of mortality in cirrhosis, respectively.[56] A meta-analysis (CABG, valvular surgery and cardiopulmonary bypass) quoted 1-year mortality at 20.6%, 43.6% and 56.5% for patients with CTP A, B and C, respectively.[57] Both CTP and MELD score reliably predict mortality,[58] and cardiopulmonary bypass is not recommended in patients with an MELD >13.5 or CTP ≥8.[59 60] Despite these data, cardiac surgery risk prediction models do not consider liver dysfunction as a surgical risk factor.[61] Surgical aortic valve replacement carries higher mortality in comparison to transcatheter aortic valve replacement (TAVR), therefore, TAVR is recommended in cirrhotic patients.[62] There are limited data on abdominal aortic aneurysm repair but CTP-B and MELD ≥10 are associated with reduced survival.[63]

Upper gastrointestinal and bariatric surgery

Upper gastrointestinal surgery outcomes in patients with cirrhosis are variable. Emergency surgery for complicated peptic ulcer disease (perforation and bleeding) is associated with a high mortality rate (23%–64%).[64] For gastric cancer operations, morbidity and mortality in cirrhosis patients is 25.6% and 10.3%, respectively.[65] Surgery carries acceptable risks for CTP-A and CTP-B cirrhotic patients; thus gastrectomy with D2 or more lymph node dissection can be safely carried out in CTP-A patients, whereas only D1 lymph node dissection is recommended in CTP-B patients. Radical gastrectomy is likely to be fatal in CTP-C patients, with mortality rates of 100% reported.[66 67]

Oesophagectomy in cirrhosis patients carries a high risk of developing pulmonary complications (postoperative pneumonia, pleural effusions and chylothorax), ascites, anastomotic leaks during the first month, in addition to longer intensive care stays in comparison to patients without cirrhosis.[68 69] Patients who are CTP-A have significantly lower mortality in comparison to CTP-B patients, and CTP-C disease remains a contraindication to oesophagectomy.[68] MELD score >9 was associated with significantly lower 5-year survival and a score ≤9 was associated with similar outcomes to non-cirrhotic controls.[70]

Bariatric surgery is considered safe to be undertaken in an experienced centre. A meta-analysis and systematic review concluded that postoperative and liver-related complications were higher among patients with cirrhosis when compared with non-cirrhotic individuals. Significantly lower postoperative complications were noted with sleeve gastrectomy compared with Roux-en-Y gastric bypass.[71]

Appendicectomy

The lifetime risk of appendicitis is 8.6% in males and 6.7% in females, making it the most common surgical emergency worldwide.[72] A meta-analysis showed that 30-day mortality for cirrhosis patients undergoing

Table 3 Studies on pre-operative tips in cirrhosis patients

Study	Patients and surgery types	Procedure and study details	Findings
Lahat *et al*[83] 2018 Systematic review	19 studies—all retrospective 64 patients (largest series 18 patients)	Planned surgery for ▶ Gastrointestinal cancer in 38 (59%) patients ▶ Benign digestive/pelvic surgery in 21 (33%) patients	▶ TIPS successful in all patients ▶ Encephalopathy –4.7% (controlled in all cases with treatment) ▶ All patients could be operated within a median delay of 30 days from TIPS (mortality rate: 8%) 1-year survival—80%
Fares *et al*[102] 2018 Retrospective study (2005–2013)	28 patients included Digestive (43%) Liver resections (25%) Abdominal wall surgery (21%) and Interventional Gastrointestinal endoscopy (11%)	Primary endpoint: ▶ Rate of failure (defined by inability to proceed to the planned intervention after TIPS placement or persistent decompensation 3 months after intervention) Secondary endpoints: ▶ Rate of complications ▶ Parameters associated with failure ▶ 1-year survival	▶ Median time between TIPS and surgery—24 days ▶ 1-year survival—70% ▶ Procedure failure—6 (21%) patients (4/6 patients with HCC: two because of tumour progression before surgery) ▶ Persistent decompensation—2 patients ▶ Hepatic surgery, history of encephalopathy and viral-related cirrhosis were associated with failure.
Tabchouri *et al*[84] 2019 Retrospective study (2005–2016)	66 patients (compared with no TIPS group n=68)	Colorectal surgery performed in 54% patients TIPS patients had higher CTP score, received more beta-blockers. 85% of patients in TIPS group underwent planned surgery	▶ In TIPS group, 56 (85%) patients underwent planned surgery ▶ Encephalopathy—15% ▶ In TIPS and no-TIPS group, severe postoperative complications (18% vs 23%, p=0.392) and 90-day mortality (7.5% v 7.8%, p=0.64) were similar.
Goel *et al*[82] 2021 Retrospective study	Twenty-one patients undergoing prophylactic TIPS before non-hepatic surgery were identified.	Primary outcome Discharged patients without hepatic decompensation after the planned surgery.	▶ TIPS successful in all patients. ▶ 57% patients achieved primary outcome. ▶ Reduction in portal pressure gradient from 21.5 (11–35) to 16 (7–25) mm Hg (p<0.001). ▶ Post-TIPS complications in 7 (33%) patients with 4 patients experiencing encephalopathy ▶ Post-TIPS portal pressure gradient was significantly higher in patients with adverse primary outcome. ▶ 1, 6 and 12 months survival was 90%, 80% and 76%, respectively.
Chang *et al*[103] 2022 Retrospective study	In total, 926 patients (363 with cirrhosis undergoing surgery and 563 patients with TIPS) were included.	Propensity score matching (1:1) of preoperative TIPS (TIPS group) with patients without preoperative TIPS (no-TIPS group). Primary endpoint ▶ Development of ACLF within 28 and 90 day after surgery Secondary endpoint: ▶ 1-year mortality	▶ Patient in no-TIPS group had higher rates of ACLF within 28 days (29% v 9%; p=0.016) and 90 days (33% vs 13%; p=0.02) after surgery ▶ 1-year mortality was also higher in the no TIPS group (38% vs 18%; p=0.023) in comparison to TIPS group. ▶ Surgery without preoperative TIPS and CLIF-C AD score were independent predictors of mortality and ACLF development at 28 and 90 days. ▶ CLIF-C AD score >45 was identified as a threshold for patients at risk of ACLF development in the postoperative period and will benefit from TIPS.

ACLF, acute-on-chronic liver failure; ASA, American Society of Anesthesiologist; CLIF-C AD, Chronic Liver Failure Consortium-Acute Decompensation score; CTP, Child-Turcotte-Pugh score; HCC, hepatocellular carcinoma; TIPS, Transjugular intrahepatic portosystemic shunt.

appendicectomy was 9%, in comparison to 0.3% in those without cirrhosis. In patients with compensated cirrhosis, laparoscopic appendicectomy is safer compared with an open approach. However, in many studies there was a lack of information on the severity of cirrhosis and other patient characteristics.[73]

Orthopaedic surgery

Adverse events are reported for cirrhosis patients undergoing total knee and hip arthroplasty but studies are mostly retrospective and limited.[74–77] In a systematic review, cirrhotic patients are more likely to experience postoperative haemorrhage, surgical site infection and need for revision surgery after total hip arthroplasty.[78] However, the severity of liver disease was not presented, and some studies report only short-term outcomes (table 2).

Interventions to mitigate the risk of surgery in patients with cirrhosis

A joint care approach is desirable to mimise the additional risk of surgery in patients with cirrhosis. The degree of portal hypertension can accurately predict postsurgical outcomes in cirrhosis. In the study by Reverter *et al*, patients with HVPG >16 mm Hg and ≥20 mm Hg were considered high and very high risk, respectively. Liver stiffness measurement of >25 kPa also correlates with CSPH and can be helpful in stratifying compensated cirrhosis.[79] Endoscopy and contrast-enhanced CT scanning of the abdomen are indicated in all patients with cirrhosis. National guidance for endoscopic and pharmacological management of varices should be followed.[80 81] Attention should also be given to optimising nutrition where possible.[6] An area of debate is the role of portal decompression prior to surgery. Prophylactic TIPSS may facilitate planned surgery by reducing complications pertaining to portal hypertension. Uncontrolled retrospective studies suggest a potential role for TIPSS prior to surgery in selected patients[82–86] (table 3). However, there is no evidence of improved surgical outcomes, and patient selection is not defined, although HVPG could be helpful as a guide. Moreover, the optimal timing of surgery after TIPSS is unclear and procedure-related complications should be considered. The present BSG guidance advises further research.[81]

Areas requiring further study

1. Role of HVPG in stratifying risk prior to surgery, in patients with compensated cirrhosis or prior decompensation. Controlled studies are recommended.
2. Further multicentre prospective study on the utility of bespoke prognostic scoring systems. For patients with decompensated cirrhosis, these might include the EF-Chronic Liver Failure Acute Decompensation Score to guide risk.
3. In compensated cirrhosis, assessment of non-invasive markers of CSPH, such as liver stiffness measurements as a means of stratifying risk and selection for interventions prior to surgery.
4. The role of facilitative TIPSS prior to surgery. Further prospective comparative multicentre studies with a focus on patient selection criteria, for example, HVPG or liver stiffness measurements and postoperative outcomes.
5. Prospective studies to address the role of portal pressure lowering agents prior to surgery to reduce risk, including carvedilol, statins and combinations including rifaximin.
6. Prospective studies to investigate any potential role for prehabilitation within these cohorts of patients, which may improve surgical outcomes and reduce postoperative complications.
7. Further study to investigate the role of dynamic function testing such as viscoelastic tests and newer assays such as platelet function assays in predicting bleeding risk.

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