



Published in final edited form as:

Hepatology. 2026 June 01; 83(6): 1609–1645. doi:10.1097/HEP.0000000000001644.

AASLD AST Practice Guideline on Adult Liver Transplantation: Candidate Evaluation

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Abstract

Background and Aims: Liver transplant is a specialized treatment for a spectrum of indications that use a scarce resource. Transplant is guided by principles of justice, equity and benefit with a constant conflict between competing interests. Organs are a national resource with a goal of equitable distribution across sites. An AASLD guideline for the evaluation and selection of appropriate transplant candidates has been available since 2005.

Methods: A multidisciplinary writing group of liver transplant experts and a librarian convened over 24 months. The writing group reviewed the literature, generated guideline recommendations and rated the level of evidence for each recommendation based on the Oxford Center for

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Disclosures of Conflicts of Interest:

Jennifer C. Lai consults for Novo Nordisk, Boehringer Ingelheim, and GenFit. Neehar Parikh consults for Eli Lilly, Genentech, BMS, Exact Sciences, and Bayer. Lanla Conteh consults for Gilead. James Trotter consults for Moderna. Gonzalo Sapisochin consults for Integra, AstraZeneca, Novartis, and Roche. The remaining authors have no conflicts to report.

Evidence-Based Medicine. The group categorized the strength of recommendations based on the level of evidence, risk–benefit ratio, and patient preferences.

Conclusions: Liver transplant is a lifesaving procedure that should be offered to selected patients with clear indications and a reasonable prospect of benefit. The evaluation is designed to identify those in need, to outline hurdles to a successful outcome, and to develop an effective transplant plan. The goal of this document is to provide a template for this process.

Keywords

Liver Transplant; Evaluation; Cirrhosis; Acute Liver Failure; Portal Hypertension; Hepatocellular Carcinoma; Contraindications; Frailty; Nutrition; Cardiopulmonary Evaluation; Psychosocial Evaluation; Living Donor Liver Transplant

Introduction:

The first human liver transplant was performed in 1963. By 2003, approximately 10,000 transplants had been performed in the US.¹ In 2023, over 10,000 liver transplants were performed in the US in a single year.² The growth of the field has been driven by developments in immunosuppression, wider patient selection, advances in pre- and post-transplant medical care, better surgical techniques, and most recently in management of donors prior to transplantation.³

Liver transplantation (LT) is life saving for many patients with acute or chronic liver dysfunction not amenable to medical management. It is also a therapeutic option for some with malignancy or metabolic illnesses that have no effective medical treatment. Thus, transplant is a therapy option that is etiology agnostic. It is a rescue treatment, and the work up and waitlist management of a patient prior to transplantation is individualized based on several factors. These factors include the severity of illness, surgical complexity, co-morbidities, familial and social circumstances, and the costs to the health care system. Challenges are further exacerbated by the scarcity of organs so that not every patient who might benefit from transplantation receives this life-saving treatment. Utility is tempered by concepts of social justice. As outlined by the ethics committee of the Organ Procurement and Transplantation Network (OPTN), “However, in public policy related to allocation of organs using the principle of utility, there is widespread consensus that certain social aspects of utility should not be considered. In particular, the social worth or value of individuals should not be considered, including social status, occupation, and so forth.”⁴

This is the third guideline published by the AASLD. Many of the topics covered in the prior documents⁵, are again raised, with updated guidance based on the most recent evidence from the literature. New topics not previously discussed, including new indications for transplantation, are also addressed based on the most recent available data. It is out of the scope of this guidance to provide a comprehensive discussion of all disease processes that can lead to transplantation or their management. Rather, we seek to provide an outline for the provider evaluating a patient for liver transplantation. The only diagnoses that are considered separately are those in which the indications for transplantation are not related to progression of liver disease (e.g., liver tumors). Irrespective of diagnosis, all

evaluation and testing must be tailored to the individual patient, the disease that led to the patient's presentation, and their risk/benefit profile. Transparency and consistency should be included in the liver transplant evaluation process. In an ideal system, all parties, including patients, families and providers should be able to understand all stages of the evaluation and selection process. Consistency refers to consistent selection practices both within and between centers. This goal of consistency forms the foundation of these guidelines. With this guideline, a provider should have a template to understand and initiate a liver transplant evaluation.

Methods

Formulation of Clinical questions

Prior to the literature search and writing, the committee developed questions to be addressed in the guidelines. The goal was to address all issues important to a multidisciplinary committee evaluating the benefits and risks of transplant for an individual candidate. These questions formed the foundation of the literature search.

Evidence Review

Literature Search and Grading of Evidence: Literature search strategies were developed in collaboration with a medical librarian for the concepts, indications and contraindications for liver transplantation in adult liver transplant patients. Databases searched included Ovid MEDLINE and [Embase.com](https://www.embase.com), and searches for gray literature were run in the Cochrane Library and relevant association websites. Initial search was completed on May 15, 2023. All searches were limited to English, humans, and from January 1, 2016, to August 31, 2023. MEDLINE and conference abstract records were excluded in the Embase search.

Studies were selected for inclusion in the systematic review of evidence if they met the following criteria: (1) peer reviewed full-text articles; (2) population of patients with consideration for liver transplantation; (3) population of patients who have received a liver transplantation; and (4) include one of the outcomes of interest. Articles were excluded from the systematic review if they were conference abstracts that were not published in peer-reviewed journals, editorials, commentaries, case reports, narrative reviews, consensus documents, and letters; full text articles that were not available in English; and studies that did not report on outcomes of interest.

A total of 1066 unique studies met the search term requirements. Based on a screening of titles and abstracts from these studies, 344 articles continued to full-text review and 183 articles to data extraction. A total of 261 studies provided data that informed the recommendations. Data was not extracted from excluded articles, but these were available as discussion or background references. A refresher literature search was conducted on January 23, 2025, and relevant articles that addressed the PICO questions published since the previous search were also included. Additional articles not identified in the search but thought to be key to the evidence needed to formulate recommendations were also rarely included.

Guideline statements were developed and graded by members of the writing group based on available evidence and level of evidence was assessed using the Oxford Grading system.⁶ Recommendations were then assigned the strength of recommendations based on the level of evidence, risk-benefit ratio and patient preferences. Recommendations were graded as strong when supporting evidence was robust and consistent to allow the adoption of the recommendations by clinicians as standard of care. Recommendations were graded as weak when the evidence was weaker, inconsistent or conditional and alternative approaches were available, to allow clinicians to be flexible in their decision-making. Agreement or disagreement on each guideline statement was voted upon by each member of the writing group using the Alchemer survey platform.

Panel Composition, Review process, Funding: The guideline was developed by a multidisciplinary writing group. The guidelines were reviewed by the Practice Guidelines Committee, made available for public comment approved by the AASLD Governing Board and the AST Board of Directors. The AASLD Governing Board approved the final version on October, 2025. Conflict of interest was managed according to AASLD's Code for the Assessment and Management of Conflict of Interest (3). This guideline was funded by the AASLD.

Section 1: Referral for Liver Transplantation

Question 1: Which patients with chronic liver disease are appropriate to be considered for liver transplant evaluation?

Guideline Statements:

1. Patients with chronic liver disease who experience a decompensating event should be referred for liver transplant evaluation. In the absence of a decompensating event, the MELD score threshold for referral is unclear, but data suggest that for patients on the waitlist, LT survival benefit may be achieved at MELD scores greater than 12. MELD score alone should not be a barrier to referral for transplantation. (Strong, Level 4)
2. Patients with acute-on chronic liver failure (ACLF) should be considered for referral to a liver transplant center. (Strong, Level 4)

Rationale and Background: Patients with cirrhosis who experience sentinel events that signify a worsening prognosis warrant referral for LT evaluation³. As shown in Figure 1, these include but are not limited to decompensating events related to portal hypertension such as ascites, hepatic encephalopathy, or variceal hemorrhage. Unfortunately, many patients who meet criteria for referral, either are never sent to a transplant center or if they are, are not placed on the transplant waiting list.⁸ Based on a national VA database, patients with certain diagnoses (e.g. alcohol-associated liver disease) or social factors (e.g. African-American race, lower annual income) have a lower likelihood of being referred or listed. We believe that it is incumbent on transplant centers to facilitate referral whenever possible.

The 2013 AASLD Practice Guideline advised that referral should be considered in patients with a “*complication such as ascites, hepatic encephalopathy, or variceal hemorrhage*” or a MELD score of 15 or greater”.⁵ A more recent analysis indicates that though the prognosis of patients with calculated MELD scores of 29 or less has improved, MELD score still accurately stratifies patients in ranks of greater 90-day mortality without transplantation.⁹

Since 2013, the MELD score has undergone several adjustments to account for the excess risk of hyponatremia, female sex, and malnutrition on mortality.¹⁰ Data utilizing MELD-Na, the precursor to the most recent version of MELD, suggested a 1-year survival of deceased donor liver transplant for patients on the wait list with MELD-NA scores as low as 12.¹¹ It is important to recognize that while MELD score is invaluable at calculating survival, these studies were not designed to evaluate timing for referral. These studies evaluated survival on the wait list as compared to survival one year after transplant. Many of the patients with lower MELD score may have had complications of portal hypertension that were not reflected in their MELD score. These are patients who are sometimes called “underrepresented by MELD.” This group could have been referred based on their clinical symptoms rather than their score. While we lack contemporary data to establish an absolute threshold of MELD 3.0 at which patients should be referred for liver transplantation (LT), the majority of the working group believes that a MELD score (in its most recent iteration) of 15 still appears to be a reasonable threshold in the absence of portal hypertensive complications.¹² Patients should be considered for LT referral at any MELD score in the presence of uncontrolled portal hypertensive complications. Furthermore, a survival benefit of live-donor liver transplantation has been reported in recipients with MELD scores as low as 11.¹³ Thus, lower MELD score should never be a barrier to referral for transplantation if the provider believes that the patient will benefit from transplantation. Additionally, this discussion does not encompass MELD exceptions which include but are not limited to hepatocellular carcinoma (HCC) and the liver-lung syndromes whose prognosis is not well characterized by MELD score.³

Acute-on-chronic liver failure (ACLF) refers to acute decompensation occurring in patients with chronic liver disease.¹⁴ It is characterized by intense systemic inflammation, organ failure, and a poor prognosis. ACLF is often precipitated by infection, such as spontaneous bacterial peritonitis (SBP), decompensating events such as variceal bleeding, or alcohol-associated hepatitis in patients with alcohol-associated liver disease. ACLF scoring systems enable the stratification of patients into subgroups with escalating risk of death based on cumulative multisystem failures of liver, kidney and brain function, coagulation, circulation, and respiration. Patients with ACLF typically have high MELD scores, and thus would merit consideration for LT.¹⁵ Unfortunately, it appears that patients with ACLF often fail to receive LT, when it could have been lifesaving.¹⁶

Question 2: Which patients with acute liver failure (ALF) should be referred to a liver transplant center?

Guideline Statements:

3. All patients with acute liver failure should be referred to a liver transplant center for urgent evaluation. (Strong, Level 2)

4. Liver transplant centers should be able to respond promptly to requests for transfer of patients with acute liver failure. (Strong, Level 5)

Rationale and Background: The definition of acute liver failure (ALF) can vary depending on geography and has been modified since first description.^{17, 18} In the United States, ALF generally refers to acute liver disease (less than 26 weeks) in a patient with no history of chronic liver disease or cirrhosis that is associated with encephalopathy and coagulopathy. Every patient with ALF should be considered for referral/transfer to a liver transplant center to provide a higher level of care with or without liver transplant.^{19,20} Since only 1/3 of patients with ALF ultimately undergo liver transplantation and 1/3 recover, timely referral to a transplant center may allow for better management to avoid transplant altogether. Referral to the transplant center should be made in the first few hours after presentation, and prior to meeting ALF diagnostic criteria, as the complications of the disease could jeopardize safe transfer.^{21, 22}

Given that expedited transfer is critical, providers should quickly assess any barriers to transfer. In many areas of the United States, insurance can be a barrier for transplant.^{23,24} Additional barriers to be quickly evaluated are concomitant substance use disorder and/or systemic infection which could either temporarily or permanently disqualify the affected patient for transplant listing. However, the presence of these barriers should not prevent referral as experienced transplant centers may be able to mitigate these barriers to transplantation. Hospitals that offer liver transplantation should make every effort to create and facilitate systems that allow easy referral and transfer. Insurance providers need to become educated on the medical acuity of these cases and expedite case review.

Question 3: Which patients with hepatocellular carcinoma (HCC) should be considered for liver transplant evaluation?

Guideline Statements

5. Patients diagnosed with HCC without extrahepatic metastases should be considered for liver transplantation. (Strong, Level 1)
6. Staging for HCC should be done with multiphasic contrast enhanced abdominal CT or MRI, with interpretation of imaging at a transplant center, and a staging CT chest to rule out thoracic metastases. (Strong, Level 2)
7. Milan criteria should be used as a guide for transplantation listing and the goal of downstaging therapies. Transplantation for patients beyond Milan should be reserved for patients demonstrating favorable tumor biology. (Strong, Level 2)
8. Patients with HCC being considered for liver transplantation should have an AFP less than 1000 ng/ml or less than 500 ng/ml if the AFP was ever above 1000 ng/ml. (Strong, Level 2)

Rationale and Background: Liver transplantation is a curative treatment for patients with hepatocellular carcinoma (HCC) as it removes the cancerous tissue and the underlying carcinogenic liver. All patients diagnosed with HCC should be evaluated to determine

whether they may be a candidate for transplantation. Patients with HCC should be managed in a multidisciplinary setting to improve receipt of appropriate therapies and improve patient outcomes.^{25,26} Patient selection for transplantation in the setting of HCC is centered on identifying those not amenable to other curative medical or surgical treatments, while minimizing the risk of post-operative HCC recurrence.

Currently, in the US, LT for HCC is restricted to patients with early-stage disease as defined by the Milan Criteria without evidence of macrovascular invasion or extrahepatic disease (OPTN link for current guidelines, https://optn.transplant.hrsa.gov/media/xpdfswdv/nlr-guidance_adult-transplant-oncology_feb-2025.pdf). Expected 5-year survival rates are more than 70% with post-LT recurrence rates of approximately 10%.^{27, 28} Patients who are being considered for transplantation with HCC should undergo multiphasic contrast enhanced imaging of the liver with a CT or MRI and a staging CT chest. Given heterogeneity in read quality at community sites, abdominal imaging conducted in community settings should be reviewed and interpreted at a UNOS Transplant center.²⁹ Serial abdominal staging is recommended every 3 months while awaiting transplantation, and CT chest staging is recommended every 6-12 months. Bridging locoregional therapies are effective in maintaining patients within transplantation criteria and assessing tumor biology.^{30,31} Current UNOS policy requires a six-month observation period while on the waitlist prior to being granted a MELD exception for HCC. Patients with complete response after surgical or locoregional therapy who recur within 6-60 months after complete response with T1 or T2 HCC may be considered for a MELD exception without the 6-month waiting period after review by the National Liver Review Board (NLRB). Patients who demonstrate favorable tumor biology can receive LT early through their natural MELD score or LDLT, even if beyond Milan criteria.³²

Alpha fetoprotein (AFP), a serum biomarker, has been integrated into the inclusion criteria for transplantation in patients with HCC. AFP levels correlate with tumor biology and thus, levels are required to be below 1000 ng/mL prior to transplantation.³³ If the AFP ever exceeds 1000 ng/mL then it must be brought down to below 500 ng/mL using HCC therapy prior to proceeding with transplantation.^{34,35}

The treatment of an extensive HCC using locoregional or systemic therapies to bring the tumor burden within Milan criteria (often referred to as ‘downstaging’) is an acceptable means by which patients with locally advanced disease can be offered liver transplantation. MELD exception points can be granted after successful downstaging to within Milan criteria in patients that are initially within UNOS downstaging criteria https://optn.transplant.hrsa.gov/media/xpdfswdv/nlr-guidance_adult-transplant-oncology_feb-2025.pdf. Over 80% of patients that meet the UNOS downstaging criteria, can be successfully down staged using locoregional therapy if administered in a protocolized fashion.^{36 37} Patients who have been successfully down staged to within Milan have similar post-LT outcomes to patients within Milan criteria without downstaging.³⁸

There are insufficient data to recommend routine downstaging or bridging with immunotherapy-based systemic therapies for HCC alone. However, there are ongoing prospective trials to address this issue.

In patients with HCCs beyond UNOS downstaging criteria, early data suggest that up to 65% of patients can be successfully down staged to within Milan criteria.³⁹ While patients beyond UNOS downstaging criteria do not qualify for an automatic MELD after the standard waiting period, they can be considered for a MELD exception on a case-by-case basis by the NLRB. For patients with portal vein tumor invasion, transplantation may be feasible after complete resolution of the thrombus with locoregional or systemic treatment with tyrosine kinase inhibitors and or immune checkpoint inhibitors; however, there is insufficient data to recommend liver transplantation in this population, and patients should be evaluated on a case-by-case basis. Patients with extrahepatic HCC are not candidates for liver transplantation.

Question 4: Which patients with cholangiocarcinoma (CCA) should be considered for liver transplantation?

Guideline Statements

9. Patients with unresectable peri-hilar cholangiocarcinoma that meet size criteria (< 3cm in radial diameter) should be considered for liver transplant evaluation. (Strong, Level 3)
10. A neoadjuvant protocol with radiation and chemotherapy and pre-operative surgical staging in patients with peri-hilar cholangiocarcinoma should be administered prior to transplantation. (Strong, Level 3)
11. Patients with biopsy proven unresectable intrahepatic cholangiocarcinoma or mixed-hepatocellular carcinoma-cholangiocarcinoma with a maximum diameter < 3 cm, without extrahepatic disease, may be considered for liver transplantation. (Weak, Level 4)

Rationale and Background: Cholangiocarcinoma (CCA) is a highly aggressive malignancy originating from the hepatobiliary system. Anatomically, CCA is classified into three categories: intrahepatic CCA (iCCA), perihilar CCA (pCCA) and distal (dCCA). Specifically, iCCAs arise above the second-order bile ducts, while the demarcation between pCCA and dCCA is defined by the insertion of the cystic duct. Currently liver transplantation for pCCA, mixed HCC-CCA, and iCCA is accepted under strict selection criteria (see optn guidelines, https://optn.transplant.hrsa.gov/media/xpdfswdv/nlr-guidance_adult-transplant-oncology_feb-2025.pdf).^{5 40} Patients with uncontrolled infection, prior radiation or chemotherapy, prior biliary resection or attempted resection, intrahepatic metastases, and/or evidence of extrahepatic disease are not candidates for liver transplantation.

In patients with pCCA, the Mayo Clinic protocol for neoadjuvant therapy and staging prior to liver transplantation includes the use of intravenous 5-fluorouracil to enhance radiosensitivity, followed by external beam radiotherapy and catheter-based brachytherapy. Notably alternate neoadjuvant protocols, with different radiation and chemotherapy regimens, have been evaluated for pCCA and appear to have similar efficacy.^{41,42} Following neoadjuvant therapy, operative staging is conducted to ensure patients with lymphatic or peritoneal disease are not considered for transplantation. Notably, around 20% of patients

have positive surgical staging. The timing for this staging is strategically set, either just before living donor liver transplantation (LDLT), or as the time for deceased donor liver transplantation (DDLT) approaches, determined by the patient's MELD score and regional access to transplantation. Patients with unresectable small (<3 cm in diameter) solitary iCCAs or mixed HCC-CCAs without extrahepatic disease in the setting of underlying cirrhosis can also be considered for transplantation and can receive a MELD exception of MMAT-3 if imaging shows 6 months of stability after locoregional or systemic therapy prior to listing. Listed patients with MELD exceptions must show stability of the lesion without development of new cancer foci on cross-sectional imaging every 3 months. The rationale for these criteria are based on small observational studies showing excellent oncologic outcomes in patients receiving transplant for iCCA, however we lack robust prospective data evaluating these criteria.^{43 44 45}

Section 2: The Transplant Evaluation

Question 5: How should patients being considered for liver transplant be evaluated?

Guideline Statements

12. Liver transplant evaluation should be conducted in a multidisciplinary fashion to identify patients likely to benefit from liver transplantation. (Strong, Level 4)

Rationale and Background: Each patient undergoing evaluation has an individualized set of tests and assessments aimed at answering three questions:

- I. What is the patient's prognosis without liver transplantation? This is in recognition of the current priority schema of liver transplantation in the US, wherein the priority for receipt of a deceased donor liver is given to patients who are most urgent risk of dying (sometimes referred to as 'the sickest first' policy).
- II. Does the patient have the physical, mental, and psychosocial circumstances that would facilitate a successful transplant? This is in response to the requirement to avoid 'futile' transplants.
- III. What are the wishes of the patient: i.e. recognition of patient autonomy

Selecting the patients that will benefit from transplantation requires evaluating medical, psychosocial, and financial factors that will impact both short term success and long-term outcomes. The issues are multifaceted and require expertise from providers with different perspective and skill sets. Early in the field's evolution the need for liver transplant evaluation to be a multidisciplinary endeavor was recognized.⁴⁶ This culminated in the development of the final rule and the OPTN in 2000. In the current model, transplant team members make individual assessments that then become a component of a larger complex treatment plan. Formal studies that demonstrate that this approach is superior to single provider evaluations are lacking, but the benefits of multidisciplinary care have been demonstrated in varying disciplines.^{47 48 49}

Figure 2 displays the assessments that are frequently included in a transplant evaluation.

Cardiac Evaluation: Question 6: What testing should be included in the cardiac evaluation for liver transplant?

Guideline Statements

13. Initial pre-liver transplant evaluation should include electrocardiography and comprehensive transthoracic echocardiography screening for cardiac functional and structural defects. (Strong, Level 2)
14. All liver transplant candidates require a risk factor-based assessment of coronary artery disease. A single risk factor for metabolic dysfunction-associated steatotic liver disease, or one of the following risk factors including chronic kidney disease, left ventricular hypertrophy, family history of premature coronary artery disease, active or past tobacco use, and coronary artery calcification score greater than zero should prompt the clinician to order advanced testing for the assessment of coronary artery disease. (Strong, Level 2)
15. Centers should develop an algorithm for the evaluation of coronary artery disease in conjunction with their cardiology services. The selection of appropriate testing including stress echocardiography, coronary computed tomography, and cardiac catheterization will depend on available resources. (Strong, Level 2)
16. Findings of clinically significant but asymptomatic coronary artery disease should be managed in a multidisciplinary fashion (including but not limited to transplant hepatology, transplant anesthesia, interventional cardiology, transplant cardiology, and cardiac surgery), with the goal to assess the risks and benefits of revascularization in the pre versus peri-transplant period. (Strong, Level 4)

Rationale and Background: The LT perioperative period places several cardiopulmonary stresses on the patient secondary to hypovolemia, vasoplegia, vascular clamping, and the impact of graft reperfusion with potential post reperfusion syndrome. Therefore, it is not surprising that the presence of cardiac disease, particularly coronary artery disease (CAD) and impaired systolic function, are associated with increased mortality after LT.⁵⁰ Patients with pre-existing cardiac comorbidity should be optimized under the care of a cardiologist prior to the initiation of a liver transplant evaluation. For patients with no underlying cardiac disease, transthoracic echocardiography, incorporating strain and tissue doppler imaging, detects both systolic and diastolic impairment as well as valvular abnormalities and is also an accepted screening tool for portopulmonary hypertension and hepatopulmonary syndrome.⁵¹ Whether and how to use newer echocardiographic criteria for cirrhotic cardiomyopathy in the evaluation of LT candidates have not been defined.⁵²

The burden of CAD is increasing in LT candidates due to the increase in metabolic dysfunction associated steatotic liver disease (MASLD). Therefore, preoperative evaluation is focused on optimizing the detection, treatment and impact on LT candidacy of clinically significant cardiac disease while limiting the potential adverse consequences and costs of invasive testing. This focus requires multidisciplinary expertise in cardiology and anesthesiology with providers who are experienced with managing patients with cirrhosis associated physiology. There is an increasing number of testing options available, and

no generally accepted algorithm is in use for the detection of CAD. Impaired functional status, blunted chronotropy, vasodilation and increased cardiac output that occur with decompensated cirrhosis limit the accuracy of stress testing for detection of ischemia. This has increased focus on computed tomography (CT)-based assessments of coronary occlusion and perfusion.^{53,54} A meta-analysis of LT studies including 15,880 participants led to a coronary risk score based on clinical risk factors, allowing targeted use of stress echocardiography and coronary catheterization.⁵⁰ In addition, an American Heart Association Scientific Statement, endorsed by the American Society of Transplantation (AST), supports the use of a combination of cardiovascular risk factor scoring like CAD-LT score⁵⁵ and CT based assessment of coronary disease to define burden of disease and target the use of stress imaging and coronary angiography.^{56 57 58} CT coronary assessment is a well-tolerated study, but providers must be cognizant of the standard contraindications for all CT contrast studies. The only relative contraindication of note for patients with liver disease is significant hypotension at baseline as beta blockers and nitroglycerin are required to be administered during the procedure.⁵⁹

In the asymptomatic patient, we suggest a stepwise approach (Figure 3) to assess for CAD that is directed by non-invasive testing results, risk factors, and age. It should be noted that the numerical age as a risk factor is variable depending on the studies evaluated.⁵⁶ There was no consensus among this expert panel on a single best approach to the evaluation of a patient with risk factors for CAD. We recommend that centers develop an approach to evaluation that is supported by the most recent data, available resources and input from their local cardiology consultants.

If the diagnosis of clinically significant CAD is made, it is important to have a multidisciplinary discussion to assess the necessity and feasibility of revascularization in the perioperative period or if the presence of CAD precludes a candidate from pursuing liver transplantation. This recommendation is a departure from previous guidance that recommended consideration of revascularization in all patients with significant coronary artery disease. Finally, it must be noted that development of screening strategies for CAD is advancing at a pace that is outside the boundaries of this article. Appropriate testing continues to evolve, and providers must consider the dynamics of the field when choosing the most appropriate testing for their patients in the future.

Pulmonary Evaluation: Question 7: What pulmonary evaluation testing should be performed in patients being evaluated for liver transplantation?

Guideline Statements

17. Chest imaging should be performed in all patients. (Strong, Level 4)
18. In the absence of concomitant lung disease and/or significant pulmonary risk factors (tobacco use, occupational or environmental pathology), routine pulmonary function tests are not indicated. (Strong, Level 2)
19. Echocardiography with agitated saline contrast is the most sensitive screening test to detect intrapulmonary vascular dilatations (IPVD) and hepatopulmonary

syndrome (HPS) and is recommended for screening when available for use in the pre-LT setting. (Weak, Level 1)

20. In centers not using echocardiography with agitated saline contrast for routine screening, the evaluation of the presence of pulmonary symptoms or oxygenation abnormalities should include this test to detect potential HPS. (Strong, Level 3)
21. In patients with positive contrast echocardiography confirming the presence of intrapulmonary vascular dilatations (IPVD), pulse oximetry and arterial blood gases can be considered to determine severity and urgency for transplantation. (Strong, Level 3)

Rationale and Background

General Pulmonary and Hepatopulmonary Syndrome: Pulmonary abnormalities are common in patients being considered for LT and may influence candidacy and outcomes. Pulmonary disorders may be divided into three categories: 1) disorders that may affect both organs (cystic fibrosis, alpha one antitrypsin deficiency syndrome, sarcoid, hereditary hemorrhagic telangiectasia)- these are uncommon and recognized prior to consideration of LT where pulmonary evaluation and/or therapy has occurred; 2) lung disorders independent of liver disease (asthma, chronic obstructive pulmonary disease (COPD), interstitial lung disease (ILD), lung nodules) where the value of specific screening protocols is not established, but testing is common; and 3) pulmonary vascular complications of liver disease, including hepatopulmonary syndrome (HPS) and portopulmonary hypertension (POPH), which are unique to liver disease and portal hypertension, relatively common and may resolve with LT.⁵¹ As a result, screening chest imaging to assess the first two categories is included in the preoperative workup for all patients. However, the specific imaging studies used have not been standardized or studied across centers. Pulmonary function tests (PFTs) have very little utility for routine use in the liver transplant evaluation itself, with most of their benefit being in optimizing or prognosticating the patients with underlying lung pathology.^{60,61}

Hepatopulmonary syndrome (HPS) must be evaluated for in all patients with chronic liver disease undergoing evaluation for LT. In patients with clinical data suspicious for HPS (dyspnea in the absence of cardiac dysfunction, platypnea, orthodeoxia), routine pulse oximetry along with arterial blood gas, and contrast-enhanced (bubble) echocardiography should be performed to increase the diagnostic yield.^{62,63} The authors of this paper could not come a consensus for the routine use of bubble echocardiography in all prospective LT candidates, therefore its usage is recommended when available and when HPS is suspected. The diagnostic criteria for HPS are the presence of microbubbles in the left heart ≥ 3 cardiac cycles after right heart microbubbles following 10 mL agitated saline injection in a peripheral arm vein on bubble echocardiography, and the presence of an alveolar arterial gradient greater than 15mmHg (20mmHg in patient age greater than 64)⁶² MELD exception points in the United States can be offered in the setting of PaO₂ less than 60mmHg in the setting of portal hypertension with no other etiology of pulmonary disease noted.¹⁹ See OPTN policies (https://optn.transplant.hrsa.gov/media/eavh5bf3/optn_policies.pdf) for a list of non-malignancy etiologies for MELD exception points. There is no PaO₂ cutoff

for patients with HPS as liver transplant is curative, with select patients with $\text{PaO}_2 < 50$ getting successfully transplanted.⁵⁸ This severity of disease can also be supported with extracorporeal membrane oxygenation for oxygenation in the perioperative period.⁶⁴

Portopulmonary Hypertension (POPH): Question 8: What testing is required if portopulmonary hypertension is suspected?

Question 9: Can we offer transplant to patients with portopulmonary hypertension?

22. The presence of an elevated right ventricular systolic pressure (greater than 45mmHg) or abnormalities in right ventricular structure or function on transthoracic echocardiogram require a right heart catheterization to evaluate for portopulmonary hypertension with subsequent subspecialty consultation if the diagnosis is confirmed. (Strong, Level 1)
23. In those with portopulmonary hypertension and a sustained response to medical therapy, LT can be considered, particularly in those with more advanced liver disease.
(Weak, Level 2)
24. In the patient undergoing treatment for portopulmonary hypertension on optimized therapies as determined by a pulmonary hypertension specialist, a mean pulmonary artery pressure of 45 mmHg with a pulmonary vascular resistance greater than 3 woods units should be considered a contraindication to transplantation. (Strong, Level 1)

Rationale and Background: POPH results from vasoconstriction and remodeling in pulmonary arterial resistance vessels occurring in the setting of cirrhosis and/or portal hypertension and is categorized in Group 1 in the WHO classification.⁶⁵ Poorly controlled POPH carries a poor five-year survival and is a contraindication to consideration of LT.⁶² Multiple new targeted medications have improved the ability to control POPH and have resulted in prolonged survival.⁶⁷ Assessment of the estimated pulmonary artery systolic pressure (threshold PASP > 45mm Hg) and right ventricular size, shape, and contractility during echocardiography is the current screening approach and right heart catheterization is required to confirm the presence of elevated mean pulmonary artery pressure and increased pulmonary vascular resistance.⁶² The recognition that long-term survival is excellent after LT and that at least 50% of patients have resolution of POPH has resulted in standard MELD exception for a subset of patients with POPH.⁶⁸ Current exception criteria include a response to medical treatment for POPH to mitigate the adverse impact of elevated pulmonary pressures on early LT outcomes (mPAP < 35mmHg and PVR < 5 WU, or mPAP 35-45mmHg and PVR < 3WU).¹⁹ Recent data supports that LT has the greatest impact on improving survival in those with POPH who respond to medical therapy in the subgroup with more advanced liver disease (MELD > 15).⁶⁶ There is increasing interest in the use of extracorporeal support intraoperatively to bridge these higher risk patients through the perioperative period, however its use in liver transplantation has not been associated with any additional long term survival benefit due the paucity of patients supported with this therapy undergoing liver transplantation.⁷⁰

Screening for Infection and Recommendations for Vaccination: Question 10: Which infection risks should be considered during liver transplant evaluation?

Guideline Statements

25. All candidates should receive screening for infections that may pose a peri or post-transplant risk. This screening may differ based on age and geography and should be directed by guidance from both the liver transplant and infectious disease communities. (Strong, Level 3)
26. Patients should receive age-appropriate vaccinations based on individual risk factors, as well as local and national public health recommendations. (Strong, Level 3)

Rationale and Background: Complications from infection continue to be a major cause of post-transplant morbidity and mortality.^{71 72} The risk of infection is determined by recipient, donor, and health care system exposures. Given that recipient derived risks can differ based on personal experiences, a complete history of habits, travel, occupations, hobbies and known lifetime infections is essential. In addition, the immunodeficiencies associated with cirrhosis as well as frequent interaction with the health care system increases the risk of hospital acquired infection and colonization with multidrug resistant organisms in patients undergoing transplant evaluation.⁷³ Pre transplant evaluation should both estimate the risk of infection after transplant and provide a pathway to mitigate that risk or determine if transplantation is a safe option. To determine prophylaxis and treatment strategies, standard testing is recommended (Table 1).^{74 75}

If an infection or an increased risk for infection post-transplant is identified during the evaluation process, consultation with an infectious disease professional experienced in transplant is recommended. A clear plan for managing infections should be developed and included in the patient's management strategy at the time of presentation and listing. This plan should include selected anti-microbial agents, timing of treatment and length of therapy if appropriate. The AST Infectious Diseases Community of Practice has published guidelines on appropriate infection screening of potential recipients and donors.⁷⁶

Another pre-transplant strategy to decrease post-transplant infection risk is age-appropriate vaccinations.⁷⁷ Vaccines administered while on immunosuppression after transplant are less effective.^{78 79} Therefore, disease immunity should be checked during evaluation, and patients should have needed vaccines administered prior to transplantation. If that is impossible, vaccines can be given 3-6 months post-transplant when the patient is no longer on maximum immunosuppression. Live vaccines are not recommended post-transplant and therefore all efforts should be made to give those before transplant if needed. Some vaccination recommendations may vary based on the level of infection in the community. Therefore, all recommendations should be personalized to individual risks, geography, local and national recommendations by public health agencies. We recognize that changes to national policies are ongoing. Providers should stay informed and follow scientific evidence. Current evidence based recommendations are provided (Table 2 and Figure 4).

Finally, donor derived infections are an acknowledged risk of transplantation. Screening donors allows us to mitigate risks. If a donor screen is positive for infection, consultation with infectious disease is recommended to determine best evaluation and treatment.^{80 81 82}

Cancer Screening in Transplant Candidate: Question 11: What cancer screening should be included in a liver transplant evaluation?

Guideline Statements

27. Screening for breast, cervical, colorectal, liver, lung, and prostate cancers should be individualized and conducted using methods and at intervals according to existing screening guidelines. (Strong, Level 1)

Rationale and Background: In LT candidates, various forms of cancer screening are recommended, including screening for liver malignancies, and other age-appropriate cancer screening. The recommendations for liver, colorectal, breast, cervical, lung, and prostate cancer screening in average risk individuals are outlined in Table 3.^{25 83 84 85 86 87 88} Candidates at higher than average risk should have individualized screening strategies prior to listing and during the waitlist period. Although there are no specific recommendations for head and neck cancer screening, targeted screening with a clinical exam could be considered in some patients with tobacco use or significant alcohol use.⁸⁹ Other cancers such as skin and upper GI cancers can be screened for in liver transplant candidates on an individualized basis.

Nutrition: Question 12: Should nutrition assessment be included in the liver transplant evaluation?

Guideline Statements

28. Consultation with a registered dietician to assess for malnutrition and risk for malnutrition should be included in the transplant evaluation of all patients. (Strong, Level 2)
29. In liver transplant candidates who are at moderate to high risk for malnutrition or have evidence of malnutrition, interventions to improve nutritional status should be initiated pre-transplant. (Weak, Level 4)

Rationale and Background: Malnutrition is a common complication of end-stage liver disease occurring in 45-95% of patients with cirrhosis depending on Child-Turcotte-Pugh class.⁹⁰ The cause of poor nutritional status is multifactorial and can be linked to imposed dietary limitations, poor appetite, ascites with secondary early satiety, hepatic encephalopathy and malabsorption. Malnutrition and sarcopenia increase pre-transplant morbidity and mortality,^{91,92} and small studies have demonstrated an impact on post-transplant survival.^{93,94 95} More research is needed on the long-term impact of pre-transplant malnutrition on the post-transplant patient. In one review of more than 45,000 patients in the UNOS database who underwent transplant, being underweight (BMI < 18.5) or morbidly obese was associated with an increased 90- day mortality, but no significant impact on five-year survival was demonstrated.⁹⁶ The accuracy and prognostic value

of BMI is unclear.⁹⁷ Therefore, patients with nutrition extremes should not be excluded from transplant, but evaluation of nutritional status may be useful in directing pre and post-transplant management.

Many screening tools exist to assess nutritional *risk* and nutritional *status*. One of the most commonly studied cirrhosis-specific nutritional *risk* screening tools is the Royal Free Hospital Nutrition Prioritizing Tool (RFH-NPT). This instrument has been shown to predict clinical decompensation and death in patients with cirrhosis.⁹⁸ To assess nutritional *status*, the subjective global assessment is one of the most commonly studied tools in patients with cirrhosis, although results from this tool may be confounded by the presence of fluid retention. While these are the 2 most commonly studied tools in cirrhosis patients, there are insufficient data to recommend one tool over another. Assessment of nutritional risk and status should be guided by a registered dietician upon initial evaluation of the liver transplant candidate, who can initiate nutritional interventions in patients with malnutrition to optimize nutritional status prior to liver transplantation.⁹⁹ In a single center study of 234 patients with cirrhosis, regular nutritional counseling by a dietician was associated with higher survival rates and quality of life compared to those who did not receive nutritional counseling.¹⁰⁰ A complete evaluation may include malnutrition screening, sarcopenia assessment, subjective global assessment, and dietary intake assessment.^{101, 102 103 104}

More specific recommendations on the management of nutrition in transplant candidates are beyond the scope of this document. However, a recent review and a guideline that address nutrition in patients with end stage liver disease and the transplant patient are available.¹⁰⁵

Hepatic Osteodystrophy: Question 13: How should liver transplant candidates be evaluated and managed for evidence of bone disease?

Guideline Statements

30. Evaluation of vitamin D levels and bone density (if the patient is medically stable to perform the test) should be performed in all adult patients undergoing evaluation for liver transplantation. (Strong, Level 2)
31. Calcium supplementation, vitamin D repletion and weight-bearing exercise are recommended for patients with low bone mineral density prior to liver transplantation unless a contraindication has been identified. (Strong, Level 2)
32. Use of bisphosphonates in liver transplant candidates at high risk for osteoporotic fractures should be considered on a case-by case basis. (Strong, Level 3)

Rationale and Background: Hepatic osteodystrophy refers to bone disease, including osteopenia, osteoporosis, and osteomalacia, that occurs in patients with chronic liver disease. While osteomalacia (which typically is only seen in severe malnutrition) is rare, osteopenia and osteoporosis are reported in up to 55% of patients with cirrhosis.¹⁰⁶ A number of factors related to chronic liver disease and cirrhosis increase risk of development of hepatic osteodystrophy including chronic cholestasis with vitamin D deficiency, physical inactivity, under-nutrition, hypogonadism, and sarcopenia. Factors specific to liver disease etiology include chronic biliary disease (leading to vitamin D deficiency), chronic alcohol use

(and subsequent under-nutrition), and immunosuppressive medications (i.e., for autoimmune hepatitis or after liver transplantation). Patients with chronic liver disease have 2 times the odds of osteoporotic fracture compared to those without chronic liver disease,¹⁰⁷ with a prevalence of fractures ranging from 6% to 35%.¹⁰⁸ After LT, bone density decreases within the first three to six months following surgery, likely related to the combination of relative physical inactivity and use of high-dose corticosteroids. Bone density only starts to increase after the first year¹⁰⁹, and incident fractures occur in up to 20% of liver transplant recipients.¹¹⁰

Given the high prevalence of hepatic osteodystrophy in patients being considered for LT and risk for worsening immediately following LT, assessment of vitamin D levels and bone density is advised in patients undergoing evaluation for LT. Regular weight-bearing exercise should be recommended for all LT candidates, and calcium and vitamin D supplementation for those found to have hepatic osteodystrophy. Use of bisphosphonates, while commonly recommended for patients (without chronic liver disease) at high risk for osteoporotic fracture, has not been consistently shown to improve bone mineral density or osteoporotic fractures in multiple studies of patients with primary biliary cholangitis,^{111 112} and their effect on bone-related outcomes in patients with other liver disease etiologies has not been well-studied. However, studies have demonstrated no increased risk of adverse events associated with bisphosphonate use in those with and without cirrhosis (including esophageal varices).¹¹³ Therefore, use of bisphosphonates in select patients with cirrhosis who are at higher risk for osteoporotic fracture may be considered, such as those with additional risk factors such as low BMI, cholestatic or alcohol-related liver disease, or long-term glucocorticoid use.

Physical Function: Question 14: How should physical function be assessed in liver transplant candidates?

Guideline Statements

33. In ambulatory patients undergoing evaluation for liver transplantation, we recommend the use of a standardized tool to assess physical function, such as the Liver Frailty Index or Karnofsky Performance Status. (Strong, Level 2)

Rationale and Background: In the context of liver transplantation, the term —physical functionll has encompassed a broad range of concepts including physical frailty, performance status, aerobic exercise capacity, and disability. Many standardized tools to capture physical function have been studied in patients with cirrhosis including those awaiting liver transplantation.^{114 115 116 117} These have included the Liver Frailty Index (LFI), Fried Frailty Phenotype (FFP), Short Physical Performance Battery (SPPB), Karnofsky Performance Status (KPS), 6-minute walk test, cardiopulmonary exercise test (CPET), and activities of daily living. (See Table 4)^{118 119 120,121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142} Among these tools, the only metric that is specific to patients with cirrhosis is the LFI; the other tools were developed in the general population, often older adults. While these tools have demonstrated that poor physical function is associated with increased risk of mortality (including wait-list mortality) in patients with

cirrhosis, only the LFI, KPS, and CPET have been associated with outcomes *after* liver transplantation.^{118 119 120,121 122 123 125} Lastly, the only metrics that have been studied in patients in the inpatient setting are KPS and the LFI; all the other metrics have only been studied in patients with cirrhosis in the ambulatory setting.

At the current time, there is insufficient evidence to support a recommendation for a single metric of physical function based on prognostic value alone, as there are no studies that have directly compared the test performance characteristics of these metrics against one another. Rather, we recommend that selection of a tool to measure physical function during the *ambulatory* evaluation of a patient for liver transplantation consider not only the data supporting its prognostic value for both pre- and post-transplant outcomes but its feasibility to measure (ideally, longitudinally) in clinical transplant practice. Among the three measures that have been associated with both pre- and post-transplant outcomes—LFI, KPS, and CPET—only LFI and KPS meet the feasibility criterion. While CPET requires specialized equipment, technician, and at least one hour, the LFI takes on average 90 seconds to complete, and the KPS can be assessed within a few seconds.¹⁴³

For patients who are hospitalized, the association between physical function and post-transplant outcomes has not been fully established. Among hospitalized liver transplant candidates, only the LFI and KPS have been studied. While the LFI can feasibly be administered in hospitalized patients with cirrhosis and is associated with waitlist mortality¹³⁹, no study has yet evaluated its association with post-transplant outcomes. Conceptually, physical function may be a less reliable marker of underlying physiologic reserve in a patient who is acutely ill than in the ambulatory setting when the patient is in their —steady state. Further study is needed before a formal recommendation can be made regarding use of tests of physical function for transplant decisionmaking among hospitalized patients.

Dental Evaluation: Question 15: Should an assessment of dental health be included in the liver transplant evaluation?

Guideline Statements

34. Dental evaluation should be included in the liver transplant evaluation providing the patient is stable for examination. A life-saving transplant should not be delayed for non-urgent dental treatment. (Strong, Level 3)

Rationale and Background: Dental disease has been demonstrated to increase the risk of bacterial infections both before and after liver transplant.¹⁴⁴ Potential sources of infection include caries, damaged teeth, periodontitis, and dental calculus.¹⁴⁵ The prevalence of dental caries in pre-transplant patients has been reported to be over 70% and dental care and extractions are safe in the majority of patients with no significant bleeding, which is the primary risk, occurring in less than 10%.^{146 147} Patients with bleeding tend to have higher INR and lower platelet counts, but these are not reliable predictors and correction with transfusion has not been demonstrated to decrease risk.¹⁴⁸ If possible, management of dental issues that predispose to infection should be handled prior to transplantation. However, in

patients with high MELD and or high risk of bleeding, procedures should be deferred until after LT.

The Psychosocial Evaluation: Question 16: What should be included in the psychosocial assessment of liver transplant evaluation, and how should the liver transplant team manage identified challenges?

Guideline Statements

35. Patients should be evaluated for and meet reasonable expectations for adherence to medical directives and mental health stability as determined by the psychosocial evaluation. (Strong, Level 2)
36. Patients should have adequate social/caregiver support to provide the necessary assistance both while waitlisted and until independently functioning in the postoperative period. If problems are identified, transplant teams should help identify strategies to mitigate social and financial barriers to transplant listing. (Strong, Level 3)
37. Patients with alcohol associated liver disease and indications for LT should be referred for liver transplant evaluation early, to allow for psychosocial assessment and establishing addiction treatment goals prior to the patient decompensating. (Strong, Level 3)
38. Length of alcohol abstinence should not be a criterion for listing exclusion, especially when the severity of the patient's liver disease prevents achieving a longer length of sobriety. (Strong, Level 3)
39. Ongoing monitoring for alcohol cessation should be performed for listed patients with alcohol associated liver disease. (Strong, Level 3)
40. Discontinuing tobacco, smoked/inhaled marijuana, and drug misuse should be an expectation for liver transplant candidates. Monitoring for cessation of these substances should be performed. (Strong, Level 2)
41. Patients on medication assisted therapy (e.g., methadone, buprenorphine) for an opioid use disorder should not be denied transplantation based on their medication use alone, and expectations of reduction or discontinuation of medication assisted therapy should not be a requirement for transplant listing. (Strong, Level 3)
42. The transplant team should assist in identifying access to appropriate mental health evaluation and, if required, adequate longitudinal mental health treatment. (Strong, Level 3)

Rationale and Background: The goal of the psychosocial assessment is to identify any psychosocial area requiring intervention before transplant and to assist with strategies or treatments to address areas requiring intervention. **(Figure 5)** Domains of the psychosocial evaluation that are especially relevant to transplant outcomes include evidence of adherence with medical directives, adequate support from able caregivers especially in

the perioperative period, cognitive capacity to understand information and participate in decision making, and an absence of active psychiatric disorders with the potential to impact compliance, health outcomes, or include behaviors harmful to health such as substance use disorder.^{5 149} Additional areas covered in the psychosocial assessment include the patient's understanding of their illness, coping behaviors in relation to their illness and knowledge and understanding of treatment options including transplantation.¹⁴⁷ As the care of a transplant patient involves frequent clinic visits and tests, a primary caregiver needs to be identified to undertake transportation and other logistical tasks, especially in patients with a history of encephalopathy who should not be left alone to drive or care for themselves. The psychosocial assessor should interview and establish the support person(s) is free of any barriers to providing care and has understanding, willingness, and ability to assist with the patient's care needs and medical regimen before and after transplantation.¹⁴⁹ Given the complexities of insurance for medical care, it is also necessary to ensure that a potential recipient will have adequate posttransplant medication coverage. However, recognizing that social support and financial requirements may lend to socioeconomic and racial/ethnic transplant listing disparities,^{150 151} transplant teams have an obligation to identify all possible strategies to mitigate social and financial barriers to transplant listing. Patients should be re-evaluated at regular intervals while awaiting transplantation to update psychosocial information and address any psychosocial issues that may have arisen in the interval period.

The psychosocial evaluation must be conducted by an evaluator with training, credentialing, and competency in a health-care discipline directly relevant to the content of the evaluation.¹⁴⁹ For most transplant programs social workers and/or mental health professionals typically perform the psychosocial evaluation with input from other specialists, psychiatrists or other specialty physicians (e.g., addiction medicine), as required based on the patient's history or symptoms. Although the psychosocial assessment is primarily based on direct patient interview, other sources of collateral information should be considered including family/caregivers, medical and pharmacy records and medical/mental health providers. Toxicology testing may be needed to corroborate the absence of alcohol, tobacco, or unprescribed medication use, and to be equitable, toxicology testing is recommended for all candidates during the initial evaluation.¹⁵² Screening tools or measures completed by the assessor to gather and synthesize information can aid in the standardization and organization of the interview data but there is no evidence that these measures can predict outcomes. Examples of instruments that have been used to evaluate transplant candidates include transplant-specific instruments (e.g., Stanford Integrated Psychosocial Assessment for Transplant [SIPAT]); ; disorder specific instruments (e.g., Patient Health Questionnaire [PHQ; for depression; and substance use screeners (e.g., the Alcohol Use Disorders Identification Test—Consumption for alcohol consumption).^{153,154,155} These measures are not meant to determine eligibility for transplant, rather as tools to ensure all areas of the psychosocial assessment are covered and accurately summarized.^{149,156 157}

The negative impact of substance use, particularly alcohol and tobacco use, on post-LT outcomes, is well established.^{158 159 160 161} While the effects of nonsubstance use-related psychiatric disorders on transplant outcomes have not been fully determined, significant evidence exists demonstrating depressive symptoms pre- or post-transplant are associated

with poorer outcomes after transplant.¹⁶² However, existing evidence does not show patients with serious mental health disorders will have worse adherence or poorer survival.¹⁶³ ¹⁶⁴ . Therefore, there is no psychiatric disorder that is an absolute contraindication to transplantation. Even the most psychiatrically complex patients, for example those with a psychotic disorder or serious substance use disorder, can have successful long-term outcomes provided that they have proper evaluation, provision of appropriate mental health treatment, and adequate social support. Consensus opinion is that psychiatric disorders must be well controlled before transplantation and that psychosocial supports must be optimized to help patients cope with the stresses of transplantation, remain adherent to follow-up care, and avoid complications related to mental health disorders.

Specific Substance Use Considerations

Alcohol Use Disorders: Patients transplanted for alcohol associated liver disease (ALD) have long term post-LT survival and disease-free outcomes similar to other types of liver diseases. However, controversy still surrounds ALD as an LT indication and patients with decompensated ALD are under referred for LT evaluation.¹⁶⁵ Virtually all patients with ALD have the co-existing psychiatric diagnosis of an alcohol use disorder.¹⁶⁶ ¹⁶⁷ Patients with ALD require evaluation by clinicians skilled in mental health, optimally with addiction experience, in order to establish the correct psychiatric diagnoses and adequate treatment plan. Even patients not referred for ALD, especially those with HCV, may have alcohol use disorders that are missed on referral but should be identified by structured psychiatric and substance abuse interviews, and alcohol biomarkers. Up to recently, a 6-month minimum period of abstinence was commonly required prior to LT, on the basis that this period allows addiction issues to be addressed, and in patients with recent alcohol consumption or acute alcohol associated hepatitis, may allow for recovery and obviate the need for LT as well as reduce the risk of alcohol relapse if LT remains necessary. The most recent AASLD guidance on alcohol-associated liver disease advocated abandoning a required fixed interval of abstinence as a sole criterion for selection for LT.¹⁶⁸ Furthermore, it is critical not to neglect the need for addiction rehabilitation during the interval from referral to the transplant center and LT. To merely achieve a pre-determined interval of abstinence without assessment or treatment does not therapeutically address the addiction and does not provide the patient with psychotherapeutic support and skills to remain abstinent. Therefore, abstinence alone may not meet the listing criteria for LT. Post-LT contracting for alcohol treatment and counseling may be considered for those patients who are too sick to attend appropriate rehabilitation prior to transplant (e.g., AAH non-responsive to treatment).¹⁶⁹ Optimally, a patient with ALD should be referred in ample time to permit the transplant mental health clinicians to complete initial LT evaluation for the patient to begin/complete any addiction treatment requirements, and for any necessary reassessment to be performed. While some programs may not consider evaluating a patient with less than 6 months sobriety, waiting until they achieve 6 months before the referral or evaluation for LT is arranged may result in deterioration of the patient's medical condition so that psychosocial or addiction requirements determined from the initial evaluation may not be achievable. Ongoing monitoring by interview and toxicology screening may be considered for waitlisted candidates to document sobriety and continued participation in rehabilitation. Discovery

of alcohol use on the waitlist typically results in delisting and the requirement for further psychiatric and alcohol treatment intervention.¹⁷⁰

Opioid Use Disorders and Medication Assisted Treatment: Patients on methadone or buprenorphine as opioid replacement therapy should not be tapered off as a requirement for transplant listing.¹⁷¹ Requiring a dose reduction or discontinuation as a condition for LT could destabilize the patient and precipitate a relapse. Dosing of these medications should be done by the prescriber in discussion with the patient about the longitudinal treatment plan. Post-LT dosing may need to be increased to accommodate improved liver function.

Tobacco Consumption: Cigarette smoking is implicated in adverse outcomes in LT recipients including cardiovascular mortality, increased incidence of hepatic artery thrombosis, oropharyngeal and other neoplasms following LT resulting in significant potentially avoidable long-term mortality.¹⁷² While tobacco use is common in patients with a history of liver disease, the use of chewing tobacco, which is associated with oropharyngeal malignancies, is not well studied. There are compelling reasons to prohibit all tobacco use in LT candidates, and indeed some programs make cigarette and or tobacco cessation a condition for listing for LT, especially in those with COPD or CAD and require negative serial nicotine or anabasine screens for documenting tobacco cessation. However, recent US data Centers for Disease Control and Prevention (CDC), Office on Smoking and Health. Tobacco Disparities Dashboard. U.S. Department of Health and Human Services show that cigarette smoking is disproportionately prevalent in persons from disadvantaged backgrounds, as assessed by household income or level of educational achievement, such that smoking cessation requirements could promote inequity.¹⁷³ Transplant teams should assist candidates in tobacco cessation efforts.

Marijuana Use: The effects of inhaled marijuana on post-transplant outcomes have not been rigorously studied. However, the National Academy of Medicine has cautioned about the negative health effects of inhaled marijuana and case reports have identified possible association between smoked marijuana and lung infections in immunosuppressed transplant patients.^{174 175} While some programs exclude patients with active marijuana use from LT, this remains controversial despite well founded fears on adverse health effects.¹⁷⁶ Many programs will accept conversion to medicinal marijuana with edible, not inhaled or vaped, routes of delivery.

Section 3: Contraindications to Liver Transplant (When referral may not be appropriate, Figure 6)

Question 17: What factors should be considered when evaluating contraindications to liver transplantation?

Guideline Statements

43. Neither high MELD score (>40) nor ACLF are contraindications to transplant. Providers should assess trajectory of clinical course, probability of an acceptable outcome, and risk of futility when deciding to move forward with transplantation. (Strong, Level 3)

44. Physical frailty/function, while a risk factor for worse outcomes after liver transplantation, should not be considered a *sole* contraindication to liver transplantation. (Strong, Level 2)
45. When physical frailty/function are being considered as a criterion for evaluating a patient's transplant candidacy, we recommend use of a standardized metric to reduce subjectivity and error in this assessment. (Strong, Level 2)
46. Mental health disorders, even if serious, are not an absolute contraindication to liver transplantation. Efforts should be made to treat and stabilize mental health disorders with an opportunity for reassessment of transplant eligibility. (Strong, Level 3)
47. Yerdel grade IV PVT (complete splanchnic vein thrombosis) without sufficient collateral veins (left gastric vein, pericholedochal collaterals) is a relative contraindication to isolated liver transplantation. (Weak, Level 2)
48. Patients with BMI greater than 40 or BMI less than 18.5 should undergo muscle mass and nutritional status screening to identify treatable factors. (Strong, Level 3)
49. Patients should not be excluded from liver transplant evaluation based on BMI alone. (Strong, Level 3)

Rationale and Background

Medical:

ACLF/Infection/MELD: Acute on chronic liver failure (ACLF) is a term to describe patients with or without cirrhosis who have both hepatic and extrahepatic organ failure. The care of these patients utilizes significant hospital resources, and the outcomes are often poor.^{177, 178} While ACLF and multiorgan dysfunction is associated with high pre-LT mortality, post-LT survival is as high as 80%, independent of grade of ACLF.^{15 16} Certain comorbid conditions with a diagnosis of ACLF may make transplantation prohibitive due to the risk of peri-operative mortality. Factors that have been recognized to worsen post-transplant outcomes include high lactate levels, severe respiratory failure and increasing vasopressor requirements.^{179 180 181} Despite the recognition of the impact of these factors on morbidity and mortality, absolute cutoffs have not been established and decisions are still at the discretion of the providers taking care of the patients. One factor that appears to be most predictive of outcome and futility is the trajectory of the patient's clinical course.^{182 183 184} Treatment and stabilization of these conditions, however, can lead to acceptable LT outcomes. A MELD greater than 40 in patients with ACLF in isolation is not a contraindication to transplantation; additive factors such as advanced age, need for mechanical ventilation, need for retransplant, extremes of BMI, and need for dialysis may make the risks of transplantation so high to not be safe or feasible.^{185 186 187 188}

Frailty: While frailty is a multidimensional state of vulnerability encompassing a broad spectrum of domains including physical, cognitive, psychological, nutritional, and social, studies of liver transplant candidates have largely focused on the *physical* aspects of the

frail phenotype that include not only physical frailty itself but also performance status, aerobic capacity, and disability.¹¹⁷ Pre-transplant frailty has been strongly associated with hepatic decompensation and waitlist mortality, independent of disease severity including MELD, ascites, and hepatic encephalopathy.^{189 190 191 192} Importantly, it is also associated with adverse outcomes *after* liver transplant. For example, in a study of over 1,100 liver transplant recipients at 8 U.S. liver transplant centers, frailty [as measured by the LFI] was associated with over two-fold increased risk of death after liver transplant (HR 2.13, 95% CI 1.39–3.26), as well as increased healthcare utilization (e.g., longer length of stay, ICU days, etc.).¹¹⁸ Low KPS score, defined as between 10–40%, was associated with an 43% increased risk of post-transplant mortality (95% CI 35–52%) and 38% increased risk of graft failure (95% CI 31–46%).¹²⁶ That being said, acceptable survival rates among frail patients who were selected for liver transplantation have been reported. U.S. multi-center data have demonstrated that net survival benefit of liver transplantation can be achieved at all stages of frailty (by the LFI).¹⁹³ Furthermore, frailty and self-reported physical functioning improves in most patients after liver transplantation, although only 40% achieve —robustness at 1-year post-transplant, suggesting an unmet need for interventions beyond liver transplant alone to optimize and accelerate recovery of physical fitness after liver transplantation.^{120 193}

Given these data, frailty should not be considered an absolute contraindication to liver transplantation; however, transplantation of a patient who meets criterion for frailty should be considered with caution. Frailty should be considered one among many factors that are considered in the global clinician assessment of a liver transplant candidate.^{194 195} Use of a standardized metric to assess frailty can improve mortality risk prediction above and beyond clinician assessment (“the eyeball test”) alone in patients with cirrhosis awaiting liver transplantation.¹⁹⁶

Psychosocial: While significant untreatable mental health or cognitive disorders could negate potential gains from transplant, active mental health disorders that could respond to treatment should not be considered absolute contraindications. It may be assumed that serious mental health disorders (e.g., psychotic disorders, bipolar disorder, post-traumatic stress disorder, serious alcohol or substance use disorders or serious character pathology) would lead to worse medical and surgical outcomes following transplant. However, patients who have good social support and receive expert mental health care in collaboration with their transplant care do not have worse outcomes or poorer adherence to medical directives.^{149 197 198 199 200} Adequate attempts at treatment and symptom resolution should be made with an opportunity for reassessment for transplant. Significant mental health disorders that are unresponsive to treatment, repeated suicide attempts or those that have a deteriorating course could be considered relative if not absolute contraindications. Examples include cognitive disorders (e.g., mild dementia) with deteriorating cognitive course or a serious ongoing alcohol or substance use disorder with poor insight or motivation for abstinence. Individuals who are unable to care for themselves (e.g., intellectually disabled or cognitively impaired) can have successful outcomes if the deficits are stable and adequate long-term care provision has been made. Serious psychopathology that prevents adherence to medical directives or formation of a cooperative relationship with the transplant team is a

potential contraindication if mental health treatments or therapies targeting these behaviors are unsuccessful. Thus, a history of potentially injurious health behaviors that have been addressed or effectively treated, should not disqualify patients from transplantation. Transplant programs should work with patients to help them overcome barriers to obtaining adequate treatment and remain in remission before transplant to ensure a successful outcome after transplant.²⁰¹

Surgical

PVT: Yerdel grade IV PVT (complete splanchnic vein thrombosis) without sufficient collateral veins (left gastric vein, pericholedochal collaterals etc.) is a relative contraindication for isolated liver transplantation. There are case reports/case series of experienced centers successfully revascularizing these patients with interventional radiology techniques.^{202 203 204}

BMI: There remains controversy surrounding the impact of BMI, both low and high on post-transplant outcome.^{5 205} However, it should be noted that various studies have shown both lower or no change in transplant survival despite severe obesity.^{206 207 208 209 210} Therefore, there is no consensus on lower or upper BMI thresholds to be considered for liver transplant.

BMI likely does not capture the complete physical condition of the patients as outlined in earlier sections. Muscle mass (including in those with sarcopenic obesity) and nutritional status should be considered as concomitant, but potentially modifiable factors when risk stratifying patients at extremes of BMI.^{210 211} However, the impact of modifying these risk factors either before or at the time of transplantation remains unclear. Small studies have evaluated combined liver transplantation with bariatric procedures for obese patients and reported acceptable short- and long-term outcomes with a non-significant difference in mortality and no increase in surgical complications as compared to liver transplant alone.^{212 213 214}

Section 4: Special Situations

Living Donor Liver Transplant: Question 18: Are there unique issues that should be addressed in patients considering a living donor liver transplant?

Guideline Statements

50. Potential LT recipients should be educated regarding all donor types including living donors to give them the option to pursue LDLT. (Strong, Level 2)
51. Older recipient age should not be the sole criterion to deny LDLT to potential transplant recipients. (Strong, Level 2)
52. Assurance of an adequate graft-to-recipient weight ratio (generally $\geq 0.8\%$) is an important consideration in the feasibility of LDLT. (Strong, Level 1)
53. LDLT should be considered in all patients, including those with higher MELD, with attention to recipient clinical predictors of outcome, assurance of a high-quality donor graft with adequate graft-to-recipient weight and venous outflow,

in the context of surgical and center experience and expertise. Caution is warranted in candidates with MELD >30. (Strong, Level 2)

Rationale and Background: Living donor liver transplantation (LDLT) offers an opportunity to expand transplant access for persons with end stage liver disease (ESLD) and is associated with improved survival, shorter waiting time, and lower Model for End Stage Liver Disease (MELD) score at transplant.²¹⁵ Donor safety is prioritized with comprehensive evaluation protocols, data driven informed consent processes, and perioperative care pathways utilized to mitigate risk and provide optimized donor outcomes.^{216 217} There is significant variation across transplant centers in the United States in LDLT and resulting disparity in access.²¹⁸ While some differences in patient access to LDLT reflect clinical factors, disparity in LDLT is also noted based on center practice and socioeconomic determinants of health.²¹⁹ All potential recipients should be educated regarding all donor types including living donors and the option to pursue LDLT.

Given the technically complex nature of LDLT, and the reduced size of the liver graft in the perioperative period presenting risk for small-for-size syndrome, special consideration is warranted regarding the evaluation of the adult patient's clinical factors in determining LDLT candidacy. Thresholds of acceptance across clinical domains may vary dependent on surgical team expertise and transplant center experience, volume, and resources.²²⁰ Recipient age, obesity, and MELD are discussed below. Ethical considerations involve assessing and optimizing donor safety, evaluating expected recipient outcomes, and considering individual and societal needs towards tripartite ethical equipoise, a framework that aims to balance these three considerations.²²¹ (Figure 7)

Upper Age Threshold: In an analysis of the Adult-to-Adult Living Donor Liver Transplantation Cohort (A2ALL) outcomes compared to the national US experience, recipient age per 10 years was associated with increased mortality risk (HR 1.20).²²² Though recipient age greater than 60 has been associated with reduced early graft failure (within 30 days).²²³ In more recent scarce and primarily international literature, "older" age has been variably defined and data on outcomes specific to "older" recipients of LDLT conflicting.^{224 225 226 227 228 229 230 231} A recent OPTN/UNOS liver transplant registry study analyzed patients ≥70 years old receiving a LDLT vs a DDLT and additionally analyzed recipients ≥70 years old undergoing LDLT vs patients 18-69 undergoing LDLT. Graft and patient survival rates at 1-, 3-, and 5-years were comparable for LDLT and DDLT among recipients ≥ 70 yr. When compared to younger recipients of a graft from a living donor, patients in the LDLT ≥70yr group had similar post-transplant functional status, re-transplant rates and similar causes contributing to graft failure. However, significantly lower graft and patient survival rates were observed.²³² Considering transplant-related survival benefit rather than expected posttransplant survival alone may allow for a more complete assessment of the utility of transplantation in older recipients.^{233 234} Consideration of physiologic age rather than chronologic age with attention to cardiovascular disease, functional status, and assessment of malignancy risk is prudent.²³⁵

Obesity in Potential LDLT Recipients: Unique considerations to LDLT for patients with obesity include the ability to achieve an adequate graft-to-recipient weight ratio (GRWR)^{236 237}, the impact of recipient obesity on liver regeneration, and operative complications. Adequate GRWR is generally considered $\geq 0.8\%$ though it has been shown in patients receiving a graft with a GRWR less than 0.8 that an absolute graft weight of 650 grams predicted a good outcome with a positive predictive value of 94%).^{236 237 238 239}

It should be noted that data focused on graft and patient survival among obese recipients of LDLT has been focused on LDLT in the overweight (BMI 25-30) and those with class 1 obesity (BMI of 30-35). Body mass index in the overweight or obese range alone has not been associated with a significant detriment in graft survival, recipient survival, or post-LDLT outcomes in international studies. Extrapolation of this data to a US population and US transplant centers should be done with caution.^{240 241 242 243} Sarcopenic obesity, acknowledging its variable definitions across studies, impairs liver volume increase post LDLT, and leads to reduction in 1 and 5-year overall survival.^{244 245}

Upper MELD Threshold: There are numerous international studies supporting LDLT utilization in high MELD candidates that are summarized in Table 5.^{246 247 248 249} US data also shows some similar benefits of LDLT with increasing MELD, however there is a tendency for worsened graft survival with MELD >30 .²⁵⁰ It should be noted that there was significant variability in center volume as well as a defined impact of LDLT center volume on graft survival. In addition, the nature of study of national registry data limits our ability to examine granular data which may impact outcome including GRWR, surgical outflow construction, and use of inflow modulation and relevant outcomes including occurrence of small-for-size syndrome.^{250 251}

Non-hepatic Malignancies with Liver Involvement: Question 19: Should patients with non-hepatic malignancy with liver involvement be considered for liver transplantation?

54. Patients with neuroendocrine tumors and neuroendocrine metastases not amenable to surgical resection should be considered for liver transplant evaluation with strict selection criteria. (Strong, Level 1)
55. In patients with biopsy confirmed hereditary hepatic epithelioid hemangioendotheliomas (HEHE), liver transplant evaluation should be considered. (Strong, Level 4)
56. In patients with nonresectable hepatic colorectal metastases within strict eligibility, liver transplant may be considered. (Strong, Level 2)

Rationale and Background

Neuroendocrine tumors: Neuroendocrine tumors (NET) are uncommon tumors, typically arising from the gastrointestinal tract, pancreas, or lung with a high rate of liver metastasis.²⁵² The optimal management of NET liver metastases remains controversial with many centers utilizing LT in this population. Patients with NET liver metastasis (NELM) have acceptable 5-year survival rates ranging from less than 60% up to 97% in well-selected patients.^{252 253} Unfortunately, the recurrence rate after LT is 31-57%, speaking to the

need for appropriate patient selection. Patients with primary pancreatic NET (PNET) have the worst 5-year survival of the group with a 44% survival rate compared to Gastrointestinal NET (GI NET) of 62%.²⁰⁵ Some of the centers with the best survival for NELM recommend the use of the Milan Criteria based on low grade histology, metastatic diffusion less than 50%, primary tumor drained by portal system and stable disease for 6-months.²⁵³ Specific recommendations for identifying patients for LT with NET are proposed based on the Organ Procurement and Transplantation Network (OPTN) data from July 27, 2023 https://optn.transplant.hrsa.gov/media/xpdfswdv/nlrp-guidance_adult-transplant-oncology_feb-2025.pdf

Hereditary hepatic epithelioid hemangioendothelioma: Hereditary hepatic epithelioid hemangioendothelioma (HEHE) is a very rare vascular tumor with an erratic clinical course and often not amenable for surgical resection due to multifocal liver involvement at presentation.²⁵⁴ The most effective treatment is LT, which has survival rates up to 90%-100% and 70%-70% at 1 and 5 years, respectively.²⁴⁷ MELD exception points for prioritization for LT can be given to patients with HEHE after hepatic sarcoma has been ruled out. HEHE is rare, and a limited number of providers have experience treating this population. Therefore, experienced centers are best positioned to consider LT and associated neoadjuvant therapy for this diagnosis.

Colorrectal Cancer Liver Metastases (CRLM): Patients with unresectable oligometastatic liver metastases from colorectal cancer can be eligible for transplantation and MELD exception points (MMAT-20 or 15 points, whichever is higher) provided stringent selection criteria are met. The evidence for the benefits of transplant in patients with CLRM comes from prospective observation studies and trials. In the prospective (SECA-II) study, patients with unresectable CLRM were selected for LT if they met prespecified inclusion criteria, including resection of primary colon cancer, no evidence of extrahepatic disease, and response to first line chemotherapy. Overall survival of the 15 patients who underwent transplant at 1, 3, and 5 years were 100%, 83%, and 83%, respectively with a median follow-up of 36 months. Disease-free survival at 1, 2, and 3 years were 53%, 44%, and 35%, respectively. Overall survival from time of relapse at 1, 2, and 4 years were 100%, 73%, and 73%, respectively. Recurrence was mainly slow growing pulmonary metastases amenable to curative therapies.²⁵⁵ Most recently the TransMet trial, 94 patients with unresectable CLRM were randomized 1:1 to LT + chemotherapy vs chemotherapy alone. In the intention-to-treat population, 5-year overall survival was 56·6% (95% CI 43·2–74·1) for liver transplantation plus chemotherapy and 12·6% (5·2–30·1) for chemotherapy alone (HR 0·37 [95% CI 0·21–0·65]; p=0·0003).²⁵⁶ Current OPTN selection criteria include patients with colorectal metastases are outlined in optn guidance: https://optn.transplant.hrsa.gov/media/xpdfswdv/nlrp-guidance_adult-transplant-oncology_feb-2025.pdf.

Multiple-Organ Transplantation: Question 20: What additional factors should be considered when evaluating a patient for multi-organ transplant?

57. All multi-organ transplants should be evaluated and listed as a consensus between organ specific multi-disciplinary teams. (Strong, Level 5)

58. Multi-organ transplant for patients with congenital heart disease and patients requiring multi-visceral transplantation may be best conducted at centers with established protocols and providers with prior experience. (Weak, Level 5)
59. Preparation for multi-organ transplants should include detailed pre, peri, and postoperative planning with clear communication and delineation of responsibilities. (Strong, Level 4)

Rationale and Background: Patients in need of LT may have coexisting diseases in other organs that can both impair their ability to tolerate liver transplantation and/or curtail their overall survival. In addition, other patients with end-organ disease of the kidney, heart or lung, may have liver disease that impairs their ability to tolerate transplantation of that organ. In these candidates, multi-organ transplantation is a consideration (Table 6). Therefore, we currently have populations being considered for simultaneous liver-kidney transplant (SLKT), combined liver-heart transplant (CHLT) and simultaneous lung-liver transplant (LLT). Multi-organ transplantation represents a small proportion of all transplants, but numbers are growing.^{257 258 259} The number of heart -liver transplants over the past 20 years has increased steadily with forty to fifty CHLT surgeries now performed each year in the United States.²⁶⁰ A full discussion of the complexities of multi-organ transplant is out of the scope of this document. The topic is included to highlight the need for multidiscipline directed guidance and research. In addition, multi-visceral transplantation and multi-organ transplant in the patient with congenital heart disease require an additional level of expertise and attention beyond the co-existence of individual transplant teams in a center.

Simultaneous transplantation of two organs can be controversial as providers try to balance equity and utility for a single patient requiring two organs as compared to two patients that can benefit from a single organ.²⁶¹ The foundation of transplantation principles states that utility should maximize the benefit that is realized by the population of potential organ recipients. Equity in transplantation implies that the access of two candidates to an available organ should be equivalent if they are both expected to derive similar benefit.²⁶² Depending on the organ combination, post-transplant outcomes vary.

The outcome data on combined heart liver transplant is complicated by the different etiologies of both heart and liver disease in the population. A patient with alcohol associated liver and heart disease does not have the same risk profile as a patient with congenital heart disease and associated liver disease. Recent evidence suggests that post-transplant outcomes are at least equivalent and may be better in patients with Fontan-associated liver disease (FALD) who received a combined heart-liver transplant when compared to patients who received heart transplant alone. Combined heart liver transplant recipients demonstrated a trend toward improved survival at 1 year (93% vs 74%; $P = 0.097$) and improved survival at 5 years (86% vs 52%; $P = 0.041$) compared with those who received heart transplant alone.²⁶³

Data are mixed in patients being evaluated for liver-lung transplant. In one study, patients who received LLT had comparable survival to patients who received an isolated lung transplant²⁶⁴, but a different study demonstrated that LLT recipients had significantly worse

survival when compared to patients who received liver transplant alone. Unadjusted 1, 3, and 5-year patient survival in the matched cohort was 92.2%, 82.8%, and 80.9% for the liver-alone recipients and 82.5%, 72.2%, and 62.2% for the LLT recipients ($p = 0.005$).²⁶⁵ This highlights the challenge of quantifying benefit which may vary depending on the population and the outcomes that are being analyzed.

The liver and kidney transplant communities have worked together to create medical criteria that optimize outcomes, https://optn.transplant.hrsa.gov/media/ulvk1dug/mot_slk_policy-notice_062023.pdf. These criteria establish medical eligibility for adult SLK candidates and have created a safety net kidney allocation priority for liver-alone recipients with new or continued renal impairment. Early analysis of data after implementation of the policy has demonstrated a decrease in SLK transplant, decreased waitlist mortality rates in kidney-after-liver (KAL) listings within one year of liver transplant, and an increase in transplant rates with no significant difference in 1-year patient /graft survival when comparing KAL patients to patients who received kidneys alone.²⁶⁶

Similar types of medical eligibility criteria are needed when choosing patients to be considered for CHLT and LLT. Recently, a consensus conference of cardiothoracic and liver transplant providers met to develop criteria for those who may need dual heart-liver transplant, to discuss the ethical issues related to multiorgan transplant and to optimize pre, peri and post-transplant management.²⁶⁷ The current criteria for CHLT and LLT have no medical basis and are largely based on geography and not equity or utility https://optn.transplant.hrsa.gov/media/b13dlep2/policy-notice_lung_continuous-distribution.pdf. Though criteria for listing are still in development, once a patient is deemed to be a multi-organ candidate, clear ongoing communication is needed before, during, and after transplantation. The patient selection must be a multidisciplinary process with detailed perioperative, intraoperative and postoperative planning.²⁶⁸

Conclusions and Unanswered Questions:

Liver transplantation has become part of the standard of care for patients with life-threatening acute and chronic liver disease. Over the last 40 years, as some diagnoses have declined as indication for LT because of better medical and surgical care (e.g., the significant decline of HCV as an indication for LT is the most notable example in the Western world), other causes of liver disease have risen in prominence to take their place. As a result, despite a steady year to year increase in the number of utilizable livers in the US, the number of potential recipients has always exceeded the available donor organs. Despite evolution in management of potential donor organs both in- and ex-vivo, and further advances in the treatment of an array of liver diseases (steatotic-fibrotic liver disease, infections, cancer) we anticipate that the imbalance between patient demand and donor supply will persist for at least the next decade.³ On this basis, the need for a careful, fair, and equitable selection process for liver transplantation will continue. Each component should be based on available data with the goal of achieving the best outcomes. This requires ongoing review and modification of our systems and criteria. Future research should help us reach that goal. A list of potential and pertinent topics has been identified (Table 7). This list is not exhaustive and is meant to inspire not limit.

References

1. STARZL TE, MARCHIORO TL, VONKAULLA KN, HERMANN G, BRITTAIN RS, WADDELL WR. HOMOTRANSPLANTATION OF THE LIVER IN HUMANS. *Surg Gynecol Obstet*. 1963;117:659–676. [PubMed: 14100514]
2. matthewroop. “A Decade of Record Increases in Liver Transplant - UNOS.” UNOS, 13 Feb. 2024, unos.org/news/in-focus/a-decade-of-record-increases-in-liver-transplant. Accessed 8 Sept. 2024.
3. Lucey Michael R, et al. “Liver Transplantation.” *The New England Journal of Medicine*, vol. 389, no. 20, 16 Nov. 2023, pp. 1888–1900, 10.1056/nejmra2200923. [PubMed: 37966287]
4. OPTN. “Ethics - Ethical Principles in the Allocation of Human Organs - OPTN.” *Optn.transplant.hrsa.gov*, June 2019, optn.transplant.hrsa.gov/professionals/by-topic/ethical-considerations/ethical-principles-in-the-allocation-of-human-organs/.
5. Martin Paul, et al. “Evaluation for Liver Transplantation in Adults: 2013 Practice Guideline by the American Association for the Study of Liver Diseases and the American Society of Transplantation.” *Hepatology*, vol. 59, no. 3, 25 Feb. 2014, pp. 1144–1165, 10.1002/hep.26972. [PubMed: 24716201]
6. OCEBM Levels of Evidence Working Group*. “The Oxford Levels of Evidence 2”. Oxford Centre for Evidence-Based Medicine. <https://www.cebm.ox.ac.uk/resources/levels-of-evidence/ocebml-levels-of-evidence>. OCEBM Levels of Evidence Working Group = Jeremy Howick, Iain Chalmers (James Lind Library), Paul Glasziou, Trish Greenhalgh, Carl Heneghan, Alessandro Liberati, Ivan Moschetti, Bob Phillips, Hazel Thornton, Olive Goddard and Mary Hodgkinson
7. Code for the Assessment and Management of Conflict of Interest | AASLD. *Aasld.org*. Published 2024. Accessed April 20, 2025. <https://www.aasld.org/code-assessment-and-management-conflict-interest>
8. Kanwal F, Hernaez R, Liu Y, et al. Factors Associated With Access to and Receipt of Liver Transplantation in Veterans With End-stage Liver Disease. *JAMA Intern Med*. 2021;181(7):949–959. doi:10.1001/jamainternmed.2021.2051 [PubMed: 34028505]
9. VanDerwerken DN, Wood NL, Segev DL, Gentry SE. The Precise Relationship Between Model for End-Stage Liver Disease and Survival Without a Liver Transplant. *Hepatology*. 2021;74(2):950–960. doi:10.1002/hep.31781 [PubMed: 33655565]
10. Kim WR, Mannalithara A, Heimbach JK, et al. MELD 3.0: The Model for End-Stage Liver Disease Updated for the Modern Era. *Gastroenterology*. 2021;161(6):1887–1895.e4. doi:10.1053/j.gastro.2021.08.050. [PubMed: 34481845]
11. Malamon JS, Kaplan B, Jackson WE, et al. Reassessing the survival benefit of deceased donor liver transplantation – retrospective cohort study. *International Journal of Surgery*. Published online May 23, 2023. doi:10.1097/j.s9.0000000000000498
12. Merion RM, Schaubel DE, Dykstra DM, Freeman RB, Port FK, Wolfe RA. The survival benefit of liver transplantation. *Am J Transplant*. 2005;5(2):307–313. doi:10.1111/j.1600-6143.2004.00703.x [PubMed: 15643990]
13. Jackson WE, Malamon JS, Kaplan B, et al. Survival Benefit of Living-Donor Liver Transplant. *JAMA Surg*. 2022;157(10):926–932. doi:10.1001/jamasurg.2022.3327 [PubMed: 35921119]
14. Arroyo V, Moreau R, Jalan R. Acute-on-Chronic Liver Failure. *N Engl J Med*. 2020;382(22):2137–2145. doi:10.1056/NEJMra1914900 [PubMed: 32459924]
15. Sundaram V, Shah P, Wong RJ, et al. Patients With Acute on Chronic Liver Failure Grade 3 Have Greater 14-Day Waitlist Mortality Than Status-1a Patients. *Hepatology*. 2019;70(1):334–345. doi:10.1002/hep.30624 [PubMed: 30908660]
16. Belli LS, Duvoux C, Artzner T, et al. Liver transplantation for patients with acute-on-chronic liver failure (ACLF) in Europe: Results of the ELITA/EF-CLIF collaborative study (ECLIS). *J Hepatol*. 2021;75(3):610–622. doi:10.1016/j.jhep.2021.03.030 [PubMed: 33951535]
17. Mochida S, Takikawa Y, Nakayama N, et al. Diagnostic criteria of acute liver failure: A report by the Intractable Hepato-Biliary Diseases Study Group of Japan. *Hepatology Research*. 2011;41(9):805–812. doi:10.1111/j.1872-034x.2011.00860.x [PubMed: 21884340]
18. Williams R, Schalm SW, O’Grady JG. Acute liver failure: redefining the syndromes. *The Lancet*. 1993;342(8866):273–275. doi:10.1016/0140-6736(93)91818-7

19. OPTN: Organ Procurement and Transplantation Network - OPTN. Hrsa.gov. Published 2019. <http://optn.transplant.hrsa.gov>
20. Stravitz RT, Lee WM. Acute liver failure. *Lancet*. 2019;394(10201):869–881. doi:10.1016/S0140-6736(19)31894-X [PubMed: 31498101]
21. Stravitz RT, Fontana RJ, Karvellas C, et al. Future directions in acute liver failure. *Hepatology*. 2023;78(4):1266–1289. doi:10.1097/HEP.0000000000000458 [PubMed: 37183883]
22. Shingina A, Mukhtar N, Wakim-Fleming J, et al. Acute Liver Failure Guidelines. *Am J Gastroenterol*. 2023;118(7):1128–1153. doi:10.14309/ajg.0000000000002340 [PubMed: 37377263]
23. Wahid N, Lee J, Rosenblatt R, et al. Affordable Care Act Medicaid expansion associated with increased liver transplant waitlist access without worsening mortality. *Liver Transpl*. 2024;30(1):20–29. doi:10.1097/LVT.0000000000000221 [PubMed: 37486623]
24. Yilma M, Cogan R, Shui AM, et al. Community-level social vulnerability and individual socioeconomic status on liver transplant referral outcome. *Hepatol Commun*. 2023;7(7):e00196. Published 2023 Jun 28. doi:10.1097/HC9.0000000000000196 [PubMed: 37378636]
25. Seif El Dahan K, Reczek A, Daher D, et al. Multidisciplinary care for patients with HCC: a systematic review and meta-analysis. *Hepatol Commun*. 2023;7(5):e0143. Published 2023 Apr 26. doi:10.1097/HC9.0000000000000143 [PubMed: 37102768]
26. Singal AG, Llovet JM, Yarchoan M, et al. AASLD Practice Guidance on prevention, diagnosis, and treatment of hepatocellular carcinoma [published correction appears in *Hepatology*. 2023 Dec 1;78(6):E105. doi: <https://doi.org/10.1097/HEP.0000000000000621>]. *Hepatology*. 2023;78(6):1922–1965. doi:10.1097/HEP.0000000000000466 [PubMed: 37199193]
27. Mazzaferro V, Regalia E, Doci R, et al. Liver transplantation for the treatment of small hepatocellular carcinomas in patients with cirrhosis. *N Engl J Med*. 1996;334(11):693–699. doi:10.1056/NEJM199603143341104 [PubMed: 8594428]
28. Mazzaferro V, Bhoori S, Sposito C, et al. Milan criteria in liver transplantation for hepatocellular carcinoma: an evidence-based analysis of 15 years of experience. *Liver Transpl*. 2011;17 Suppl 2:S44–S57. doi:10.1002/lt.22365 [PubMed: 21695773]
29. Rahman WT, Hussain HK, Parikh ND, Davenport MS. Reinterpretation of Outside Hospital MRI Abdomen Examinations in Patients With Cirrhosis: Is the OPTN Mandate Necessary?. *AJR Am J Roentgenol*. 2016;207(4):782–788. doi:10.2214/AJR.16.16209 [PubMed: 27440522]
30. DiNoria J, Florman SS, Haydel B, et al. Pathologic Response to Pretransplant Locoregional Therapy is Predictive of Patient Outcome After Liver Transplantation for Hepatocellular Carcinoma: Analysis From the US Multicenter HCC Transplant Consortium. *Ann Surg*. 2020;271(4):616–624. doi:10.1097/SLA.0000000000003253 [PubMed: 30870180]
31. Agopian VG, Harlander-Locke MP, Ruiz RM, et al. Impact of Pretransplant Bridging Locoregional Therapy for Patients With Hepatocellular Carcinoma Within Milan Criteria Undergoing Liver Transplantation: Analysis of 3601 Patients From the US Multicenter HCC Transplant Consortium. *Ann Surg*. 2017;266(3):525–535. doi:10.1097/SLA.0000000000002381 [PubMed: 28654545]
32. Halazun KJ, Sapisochin G, von Ahrens D, Agopian VG, Tabrizian P. Predictors of outcome after liver transplantation for hepatocellular carcinoma (HCC) beyond Milan criteria. *Int J Surg*. 2020;82S:61–69. doi:10.1016/j.ijsu.2020.07.029 [PubMed: 32707331]
33. Hameed B, Mehta N, Sapisochin G, Roberts JP, Yao FY. Alpha-fetoprotein level > 1000 ng/mL as an exclusion criterion for liver transplantation in patients with hepatocellular carcinoma meeting the Milan criteria. *Liver Transpl*. 2014;20(8):945–951. doi:10.1002/lt.23904 [PubMed: 24797281]
34. Merani S, Majno P, Kneteman NM, et al. The impact of waiting list alpha-fetoprotein changes on the outcome of liver transplant for hepatocellular carcinoma. *J Hepatol*. 2011;55(4):814–819. doi:10.1016/j.jhep.2010.12.040 [PubMed: 21334400]
35. Mehta N, Dodge JL, Roberts JP, Hirose R, Yao FY. Alpha-Fetoprotein Decrease from > 1,000 to < 500 ng/mL in Patients with Hepatocellular Carcinoma Leads to Improved Posttransplant Outcomes. *Hepatology*. 2019;69(3):1193–1205. doi:10.1002/hep.30413 [PubMed: 30548884]
36. Parikh ND, Waljee AK, Singal AG. Downstaging hepatocellular carcinoma: A systematic review and pooled analysis [published correction appears in *Liver Transpl*. 2016 Jan;22(1):138.

- doi: <https://doi.org/10.1002/lt.24384>. Liver Transpl. 2015;21(9):1142–1152. doi:10.1002/lt.24169 [PubMed: 25981135]
37. Sinha J, Mehta N, Dodge JL, Poltavskiy E, Roberts J, Yao F. Are There Upper Limits in Tumor Burden for Down-Staging of Hepatocellular Carcinoma to Liver Transplant? Analysis of the All-Comers Protocol. Hepatology. 2019;70(4):1185–1196. doi:10.1002/hep.30570 [PubMed: 30779440]
 38. Tabrizian P, Holzner ML, Mehta N, et al. Ten-Year Outcomes of Liver Transplant and Downstaging for Hepatocellular Carcinoma. JAMA Surg. 2022;157(9):779–788. doi:10.1001/jamasurg.2022.2800 [PubMed: 35857294]
 39. Sinha J, Mehta N, Dodge JL, Poltavskiy E, Roberts J, Yao F. Are There Upper Limits in Tumor Burden for Down-Staging of Hepatocellular Carcinoma to Liver Transplant? Analysis of the All-Comers Protocol. Hepatology. 2019;70(4):1185–1196. doi:10.1002/hep.30570 [PubMed: 30779440]
 40. Heimbach JK, Gores GJ, Haddock MG, et al. Liver transplantation for unresectable perihilar cholangiocarcinoma. Semin Liver Dis. 2004;24(2):201–207. doi:10.1055/s-2004-828896 [PubMed: 15192792]
 41. Loveday BPT, Knox JJ, Dawson LA, et al. Neoadjuvant hyperfractionated chemoradiation and liver transplantation for unresectable perihilar cholangiocarcinoma in Canada. J Surg Oncol. 2018;117(2):213–219. doi:10.1002/jso.24833 [PubMed: 29480952]
 42. Welling TH, Feng M, Wan S, et al. Neoadjuvant stereotactic body radiation therapy, capecitabine, and liver transplantation for unresectable hilar cholangiocarcinoma. Liver Transpl. 2014;20(1):81–88. doi:10.1002/lt.23757 [PubMed: 24115315]
 43. Sapisochin G, de Lope CR, Gastaca M, et al. Intrahepatic cholangiocarcinoma or mixed hepatocellular-cholangiocarcinoma in patients undergoing liver transplantation: a Spanish matched cohort multicenter study. Ann Surg. 2014;259(5):944–952. doi:10.1097/SLA.0000000000000494 [PubMed: 24441817]
 44. De Martin E, Rayar M, Golse N, et al. Analysis of Liver Resection Versus Liver Transplantation on Outcome of Small Intrahepatic Cholangiocarcinoma and Combined Hepatocellular-Cholangiocarcinoma in the Setting of Cirrhosis. Liver Transpl. 2020;26(6):785–798. doi:10.1002/lt.25737 [PubMed: 32090444]
 45. Sapisochin G, Facciuto M, Rubbia-Brandt L, et al. Liver transplantation for “very early” intrahepatic cholangiocarcinoma: International retrospective study supporting a prospective assessment. Hepatology. 2016;64(4):1178–1188. doi:10.1002/hep.28744 [PubMed: 27481548]
 46. Schilsky ML, Emre SH. An abbreviated history of liver transplantation. Clin Liver Dis (Hoboken). 2024;23(1):e0244. Published 2024 Jun 28. doi:10.1097/CLD.0000000000000244 [PubMed: 38952697]
 47. Tareen K Advancing Models of Care in Transplant Psychiatry: A Review and Considerations for Enhancing the Multidisciplinary Approach. Curr Psychiatry Rep. 2024;26(11):626–634. doi:10.1007/s11920-024-01535-y [PubMed: 39305360]
 48. Derman BA, Kordas K, Ridgeway J, et al. Results from a multidisciplinary clinic guided by geriatric assessment before stem cell transplantation in older adults. Blood Adv. 2019;3(22):3488–3498. doi:10.1182/bloodadvances.2019000790 [PubMed: 31725894]
 49. Magistri P, Marzi L, Guerzoni S, et al. Impact of a Multidisciplinary Team on Alcohol Recidivism and Survival After Liver Transplant for Alcoholic Disease. Transplant Proc. 2019;51(1):187–189. doi:10.1016/j.transproceed.2018.02.212 [PubMed: 30736972]
 50. Xiao J, Yong JN, Ng CH, et al. A Meta-Analysis and Systematic Review on the Global Prevalence, Risk Factors, and Outcomes of Coronary Artery Disease in Liver Transplantation Recipients. Liver Transpl. 2022;28(4):689–699. doi:10.1002/lt.26331 [PubMed: 34626045]
 51. Raevens S, Boret M, De Pauw M, Fallon MB, Van Vlierberghe H. Pulmonary Abnormalities in Liver Disease: Relevance to Transplantation and Outcome. Hepatology. 2021;74(3):1674–1686. doi:10.1002/hep.31770 [PubMed: 33636019]
 52. Izzy M, VanWagner LB, Lin G, et al. Redefining Cirrhotic Cardiomyopathy for the Modern Era [published correction appears in Hepatology. 2020 Sep;72(3):1161. doi: <https://doi.org/10.1002/hep.31463>]. Hepatology. 2020;71(1):334–345. doi:10.1002/hep.30875 [PubMed: 31342529]

53. Patel SS, Nabi E, Guzman L, et al. Coronary artery disease in decompensated patients undergoing liver transplantation evaluation. *Liver Transpl.* 2018;24(3):333–342. doi:10.1002/lt.25012 [PubMed: 29328556]
54. Harrington CR, Levy P, Cabrera E, et al. Evolution of pretransplant cardiac risk factor burden and major adverse cardiovascular events in liver transplant recipients over time. *Liver Transpl.* 2023;29(6):581–590. doi:10.1097/LVT.000000000000013 [PubMed: 36724875]
55. Rachwan RJ, Kutkut I, Timsina LR, et al. CAD-LT score effectively predicts risk of significant coronary artery disease in liver transplant candidates. *J Hepatol.* 2021;75(1):142–149. doi:10.1016/j.jhep.2021.01.008 [PubMed: 33476745]
56. Cheng XS, VanWagner LB, Costa SP, et al. Emerging Evidence on Coronary Heart Disease Screening in Kidney and Liver Transplantation Candidates: A Scientific Statement From the American Heart Association: Endorsed by the American Society of Transplantation. *Circulation.* 2022;146(21):e299–e324. doi:10.1161/CIR.0000000000001104 [PubMed: 36252095]
57. Patel KK, Young L, Carey W, et al. Preoperative dobutamine stress echocardiography in patients undergoing orthotopic liver transplantation. *Clin Cardiol.* 2018;41(7):931–935. doi:10.1002/clc.22980 [PubMed: 29781184]
58. Löffler AI, Gonzalez JA, Sundararaman SK, et al. Coronary Computed Tomography Angiography Demonstrates a High Burden of Coronary Artery Disease Despite Low-Risk Nuclear Studies in Pre-Liver Transplant Evaluation. *Liver Transpl.* 2020;26(11):1398–1408. doi:10.1002/lt.25869 [PubMed: 32772465]
59. Abbara S, Blanke P, Maroules CD, et al. SCCT guidelines for the performance and acquisition of coronary computed tomographic angiography: A report of the society of Cardiovascular Computed Tomography Guidelines Committee: Endorsed by the North American Society for Cardiovascular Imaging (NASCI). *J Cardiovasc Comput Tomogr.* 2016;10(6):435–449. doi:10.1016/j.jcct.2016.10.002 [PubMed: 27780758]
60. Buggs J, LaGoy M, Ermekbaeva A, et al. Cost Utilization and the Use of Pulmonary Function Tests in Preoperative Liver Transplant Patients. *Am Surg.* 2020;86(8):996–1000. doi:10.1177/0003134820942159 [PubMed: 32762467]
61. Kia L, Cuttica MJ, Yang A, et al. The utility of pulmonary function testing in predicting outcomes following liver transplantation. *Liver Transpl.* 2016;22(6):805–811. doi:10.1002/lt.24426 [PubMed: 26929108]
62. Krowka MJ, Fallon MB, Kawut SM, et al. International Liver Transplant Society Practice Guidelines: Diagnosis and Management of Hepatopulmonary Syndrome and Portopulmonary Hypertension. *Transplantation.* 2016;100(7):1440–1452. doi:10.1097/TP.0000000000001229 [PubMed: 27326810]
63. Forde KA, Fallon MB, Krowka MJ, et al. Pulse Oximetry Is Insensitive for Detection of Hepatopulmonary Syndrome in Patients Evaluated for Liver Transplantation. *Hepatology.* 2019;69(1):270–281. doi:10.1002/hep.30139 [PubMed: 30070715]
64. Wu WK, Grogan WM, Ziogas IA, Patel YJ, Bacchetta M, Alexopoulos SP. Extracorporeal membrane oxygenation in patients with hepatopulmonary syndrome undergoing liver transplantation: A systematic review of the literature. *Transplant Rev (Orlando).* 2022;36(2):100693. doi:10.1016/j.ttre.2022.100693 [PubMed: 35413506]
65. Fritz JS, Fallon MB, Kawut SM. Pulmonary vascular complications of liver disease. *Am J Respir Crit Care Med.* 2013;187(2):133–143. doi:10.1164/rccm.201209-1583CI [PubMed: 23155142]
66. DuBrock HM, Savale L, Sitbon O, et al. International liver transplantation society practice guideline update on portopulmonary hypertension. *Liver Transpl.* Published online March 18, 2025. doi:10.1097/LVT.0000000000000600
67. DuBrock Hilary M, et al. “The Clinical Course of Portopulmonary Hypertension and Outcomes with Endothelin Receptor Antagonist Treatment: Observational Study of Data from the US Organ Procurement and Transplantation Network.” *Transplantation Direct*, vol. 10, no. 3, 21 Feb. 2024, pp. e1586–e1586, 10.1097/txd.0000000000001586. Accessed 12 Sept. 2024. [PubMed: 39877650]
68. Cartin-Ceba R, Burger C, Swanson K, et al. Clinical Outcomes After Liver Transplantation in Patients With Portopulmonary Hypertension. *Transplantation.* 2021;105(10):2283–2290. doi:10.1097/TP.0000000000003490 [PubMed: 33065725]

69. Aggarwal M, Li M, Bhardwaj A, et al. Predictors of survival in portopulmonary hypertension: a 20-year experience. *Eur J Gastroenterol Hepatol*. 2022;34(4):449–456. doi:10.1097/MEG.0000000000002322 [PubMed: 34907982]
70. Barbas AS, Schroder JN, Borle DP, et al. Planned Initiation of Venoarterial Extracorporeal Membrane Oxygenation Prior to Liver Transplantation in a Patient With Severe Portopulmonary Hypertension. *Liver Transpl*. 2021;27(5):760–762. doi:10.1002/lt.25871 [PubMed: 32799425]
71. Incicco S, Tonon M, Zeni N, et al. Impact of bacterial infections prior to liver transplantation on post-transplant outcomes in patients with cirrhosis [published correction appears in *JHEP Rep*. 2024 May 18;6(6):101096. doi: <https://doi.org/10.1016/j.jhepr.2024.101096>]. *JHEP Rep*. 2023;5(9):100808. Published 2023 Jun 7. doi:10.1016/j.jhepr.2023.100808 [PubMed: 37534231]
72. van Delden C, Stampf S, Hirsch HH, et al. Burden and Timeline of Infectious Diseases in the First Year After Solid Organ Transplantation in the Swiss Transplant Cohort Study. *Clin Infect Dis*. 2020;71(7):e159–e169. doi:10.1093/cid/ciz1113 [PubMed: 31915816]
73. Ziakas PD, Pliakos EE, Zervou FN, Knoll BM, Rice LB, Mylonakis E. MRSA and VRE colonization in solid organ transplantation: a meta-analysis of published studies. *Am J Transplant*. 2014;14(8):1887–1894. doi:10.1111/ajt.12784 [PubMed: 25040438]
74. Hand J, Sigel K, Huprikar S, Hamula C, Rana M. Tuberculosis after liver transplantation in a large center in New York City: QuantiFERON® -TB Gold-based pre-transplant screening performance and active tuberculosis post-transplant. *Transpl Infect Dis*. 2018;20(2):e12845. doi:10.1111/tid.12845 [PubMed: 29359834]
75. Campos-Varela I, Blumberg EA, Giorgio P, et al. What is the optimal antimicrobial prophylaxis to prevent postoperative infectious complications after liver transplantation? A systematic review of the literature and expert panel recommendations. *Clin Transplant*. 2022;36(10):e14631. doi:10.1111/ctr.14631 [PubMed: 35257411]
76. Malinis M, Boucher HW; AST Infectious Diseases Community of Practice. Screening of donor and candidate prior to solid organ transplantation-Guidelines from the American Society of Transplantation Infectious Diseases Community of Practice. *Clin Transplant*. 2019;33(9):e13548. doi:10.1111/ctr.13548 [PubMed: 30900327]
77. Danziger-Isakov L, Kumar D; AST ID Community of Practice. Vaccination of solid organ transplant candidates and recipients: Guidelines from the American society of transplantation infectious diseases community of practice [published correction appears in *Clin Transplant*. 2020 Mar;34(3):e13806. doi: <https://doi.org/10.1111/ctr.13806>]. *Clin Transplant*. 2019;33(9):e13563. doi:10.1111/ctr.13563 [PubMed: 31002409]
78. McCashland TM, Preheim LC, Gentry MJ. Pneumococcal vaccine response in cirrhosis and liver transplantation. *J Infect Dis*. 2000;181(2):757–760. doi:10.1086/315245 [PubMed: 10669371]
79. Ballester MP, Jalan R, Mehta G. Vaccination in liver diseases and liver Transplantation: Recommendations, implications and opportunities in the post-covid era. *JHEP Rep*. Published online April 26, 2023. doi:10.1016/j.jhepr.2023.100776
80. Echenique IA, Ison MG. Update on donor-derived infections in liver transplantation. *Liver Transpl*. 2013;19(6):575–585. doi:10.1002/lt.23640 [PubMed: 23526639]
81. Wolfe CR, Ison MG; AST Infectious Diseases Community of Practice. Donor-derived infections: Guidelines from the American Society of Transplantation Infectious Diseases Community of Practice. *Clin Transplant*. 2019;33(9):e13547. doi:10.1111/ctr.13547 [PubMed: 30903670]
82. Ison MG, Hager J, Blumberg E, et al. Donor-derived disease transmission events in the United States: data reviewed by the OPTN/UNOS Disease Transmission Advisory Committee. *Am J Transplant*. 2009;9(8):1929–1935. doi:10.1111/j.1600-6143.2009.02700.x [PubMed: 19538493]
83. Chong N, Schoenberger H, Yekkaluri S, et al. Association between ultrasound quality and test performance for HCC surveillance in patients with cirrhosis: a retrospective cohort study. *Aliment Pharmacol Ther*. 2022;55(6):683–690. doi:10.1111/apt.16779 [PubMed: 35170052]
84. US Preventive Services Task Force, Davidson KW, Barry MJ, et al. Screening for Colorectal Cancer: US Preventive Services Task Force Recommendation Statement [published correction appears in *JAMA*. 2021 Aug 24;326(8):773. doi: <https://doi.org/10.1001/jama.2021.12404>]. *JAMA*. 2021;325(19):1965–1977. doi:10.1001/jama.2021.6238 [PubMed: 34003218]

85. Siu AL; U.S. Preventive Services Task Force. Screening for Breast Cancer: U.S. Preventive Services Task Force Recommendation Statement [published correction appears in Ann Intern Med. 2016 Mar 15;164(6):448. doi: <https://doi.org/10.7326/L16-0404>]. Ann Intern Med. 2016;164(4):279–296. doi:10.7326/M15-2886 [PubMed: 26757170]
86. US Preventive Services Task Force, Curry SJ, Krist AH, et al. Screening for Cervical Cancer: US Preventive Services Task Force Recommendation Statement. JAMA. 2018;320(7):674–686. doi:10.1001/jama.2018.10897 [PubMed: 30140884]
87. US Preventive Services Task Force, Krist AH, Davidson KW, et al. Screening for Lung Cancer: US Preventive Services Task Force Recommendation Statement. JAMA. 2021;325(10):962–970. doi:10.1001/jama.2021.1117 [PubMed: 33687470]
88. US Preventive Services Task Force, Grossman DC, Curry SJ, et al. Screening for Prostate Cancer: US Preventive Services Task Force Recommendation Statement [published correction appears in JAMA. 2018 Jun 19;319(23):2443. doi: <https://doi.org/10.1001/jama.2018.7453>]. JAMA. 2018;319(18):1901–1913. doi:10.1001/jama.2018.3710 [PubMed: 29801017]
89. Hashibe M, Brennan P, Benhamou S, et al. Alcohol drinking in never users of tobacco, cigarette smoking in never drinkers, and the risk of head and neck cancer: pooled analysis in the International Head and Neck Cancer Epidemiology Consortium [published correction appears in J Natl Cancer Inst. 2008 Feb 6;100(3):225. Fernandez, Leticia [added]]. J Natl Cancer Inst. 2007;99(10):777–789. doi:10.1093/jnci/djk179 [PubMed: 17505073]
90. Carvalho L, Parise ER. Evaluation of nutritional status of nonhospitalized patients with liver cirrhosis. Arq Gastroenterol. 2006;43(4):269–274. doi:10.1590/s0004-28032006000400005 [PubMed: 17406753]
91. Kalafateli M, Mantzoukis K, Choi Yau Y, et al. Malnutrition and sarcopenia predict post-liver transplantation outcomes independently of the Model for End-stage Liver Disease score. J Cachexia Sarcopenia Muscle. 2017;8(1):113–121. doi:10.1002/jcsm.12095 [PubMed: 27239424]
92. Gunsar F, Raimondo ML, Jones S, et al. Nutritional status and prognosis in cirrhotic patients. Aliment Pharmacol Ther. 2006;24(4):563–572. doi:10.1111/j.1365-2036.2006.03003.x [PubMed: 16827812]
93. Durand F, Buyse S, Francoz C, et al. Prognostic value of muscle atrophy in cirrhosis using psoas muscle thickness on computed tomography. J Hepatol. 2014;60(6):1151–1157. doi:10.1016/j.jhep.2014.02.026 [PubMed: 24607622]
94. Englesbe MJ, Patel SP, He K, et al. Sarcopenia and mortality after liver transplantation. J Am Coll Surg. 2010;211(2):271–278. doi:10.1016/j.jamcollsurg.2010.03.039 [PubMed: 20670867]
95. Wang M, Shui AM, Rubin JB, Pyrsopoulos N, Lai JC. Association between protein-energy malnutrition and healthcare use among adult patients after liver transplantation: A retrospective cohort study. JPEN J Parenter Enteral Nutr. 2024;48(6):756–763. doi:10.1002/jpen.2667 [PubMed: 38944761]
96. Kalafateli M, Mantzoukis K, Choi Yau Y, et al. Malnutrition and sarcopenia predict post-liver transplantation outcomes independently of the Model for End-stage Liver Disease score. J Cachexia Sarcopenia Muscle. 2017;8(1):113–121. doi:10.1002/jcsm.12095 [PubMed: 27239424]
97. Ayloo S, Hurton S, Cwinn M, Molinari M. Impact of body mass index on outcomes of 48281 patients undergoing first time cadaveric liver transplantation. World J Transplant. 2016;6(2):356–369. doi:10.5500/wjt.v6.i2.356 [PubMed: 27358781]
98. Borhofen SM, Gerner C, Lehmann J, et al. The Royal Free Hospital-Nutritional Prioritizing Tool Is an Independent Predictor of Deterioration of Liver Function and Survival in Cirrhosis. Dig Dis Sci. 2016;61(6):1735–1743. doi:10.1007/s10620-015-4015-z [PubMed: 26725059]
99. Tandon P, Raman M, Mourtzakis M, Merli M. A practical approach to nutritional screening and assessment in cirrhosis. Hepatology. 2017;65(3):1044–1057. doi:10.1002/hep.29003 [PubMed: 28027577]
100. Iwasa M, Iwata K, Hara N, et al. Nutrition therapy using a multidisciplinary team improves survival rates in patients with liver cirrhosis. Nutrition. 2013;29(11-12):1418–1421. doi:10.1016/j.nut.2013.05.016 [PubMed: 24103520]
101. van Vugt JL, Levolger S, de Bruin RW, van Rosmalen J, Metselaar HJ, IJzermans JN. Systematic Review and Meta-Analysis of the Impact of Computed Tomography-Assessed Skeletal Muscle

- Mass on Outcome in Patients Awaiting or Undergoing Liver Transplantation. *Am J Transplant*. 2016;16(8):2277–2292. doi:10.1111/ajt.13732 [PubMed: 26813115]
102. Morgan MY, Madden AM, Soulsby CT, Morris RW. Derivation and validation of a new global method for assessing nutritional status in patients with cirrhosis. *Hepatology*. 2006;44(4):823–835. doi:10.1002/hep.21358 [PubMed: 17006918]
 103. Burra P, Giannini EG, Caraceni P, et al. Specific issues concerning the management of patients on the waiting list and after liver transplantation. *Liver Int*. 2018;38(8):1338–1362. doi:10.1111/liv.13755 [PubMed: 29637743]
 104. Ruiz-Margáin A, Macías-Rodríguez RU, Flores-García NC, Román Calleja BM, Fierro-Angulo OM, González-Regueiro JA. Assessing nutrition status, sarcopenia, and frailty in adult transplant recipients. *Nutr Clin Pract*. 2024;39(1):14–26. doi:10.1002/ncp.11107 [PubMed: 38097210]
 105. European Association for the Study of the Liver. Electronic address: easloffice@easloffice.eu; European Association for the Study of the Liver. EASL Clinical Practice Guidelines on nutrition in chronic liver disease. *J Hepatol*. 2019;70(1):172–193. doi:10.1016/j.jhep.2018.06.024 [PubMed: 30144956]
 106. Patel N, Muñoz SJ. Bone disease in cirrhosis. *Clin Liver Dis (Hoboken)*. 2015;6(4):96–99. Published 2015 Oct 28. doi:10.1002/cld.498 [PubMed: 31040999]
 107. Hidalgo DF, Boonpheng B, Sikandar S, Nasr L, Hidalgo J. Chronic Liver Disease and the Risk of Osteoporotic Fractures: A Meta-Analysis. *Cureus*. 2020;12(9):e10483. Published 2020 Sep 16. doi:10.7759/cureus.10483 [PubMed: 33083184]
 108. Guañabens N, Parés A. Osteoporosis in chronic liver disease. *Liver Int*. 2018;38(5):776–785. doi:10.1111/liv.13730 [PubMed: 29479832]
 109. George J, Ganesh HK, Acharya S, et al. Bone mineral density and disorders of mineral metabolism in chronic liver disease. *World J Gastroenterol*. 2009;15(28):3516–3522. doi:10.3748/wjg.15.3516 [PubMed: 19630107]
 110. Lim WH, Ng CH, Ow ZGW, et al. A systematic review and meta-analysis on the incidence of osteoporosis and fractures after liver transplant. *Transpl Int*. 2021;34(6):1032–1043. doi:10.1111/tri.13863 [PubMed: 33835638]
 111. Danford CJ, Ezaz G, Trivedi HD, Tapper EB, Bonder A. The Pharmacologic Management of Osteoporosis in Primary Biliary Cholangitis: A Systematic Review and Meta-Analysis. *J Clin Densitom*. 2020;23(2):223–236. doi:10.1016/j.jocd.2019.05.003 [PubMed: 31146965]
 112. Rudic JS, Giljaca V, Krstic MN, Bjelakovic G, Gluud C. Bisphosphonates for osteoporosis in primary biliary cirrhosis. *Cochrane Database Syst Rev*. 2011;(12):CD009144. Published 2011 Dec 7. doi:10.1002/14651858.CD009144.pub2 [PubMed: 22161446]
 113. Lima TB, Santos LAA, Nunes HRC, et al. Safety and efficacy of risedronate for patients with esophageal varices and liver cirrhosis: a non-randomized clinical trial. *Sci Rep*. 2019;9(1):18958. Published 2019 Dec 12. doi:10.1038/s41598-019-55603-y [PubMed: 31831865]
 114. Williams FR, Milliken D, Lai JC, Armstrong MJ. Assessment of the Frail Patient With End-Stage Liver Disease: A Practical Overview of Sarcopenia, Physical Function, and Disability. *Hepatol Commun*. 2021;5(6):923–937. Published 2021 Feb 26. doi:10.1002/hep4.1688 [PubMed: 34141980]
 115. Lai JC, Sonnenday CJ, Tapper EB, et al. Frailty in liver transplantation: An expert opinion statement from the American Society of Transplantation Liver and Intestinal Community of Practice. *Am J Transplant*. 2019;19(7):1896–1906. doi:10.1111/ajt.15392 [PubMed: 30980701]
 116. Lai JC, Tandon P, Bernal W, et al. Malnutrition, Frailty, and Sarcopenia in Patients With Cirrhosis: 2021 Practice Guidance by the American Association for the Study of Liver Diseases [published correction appears in *Hepatology*. 2021 Dec;74(6):3563. doi: <https://doi.org/10.1002/hep.32224>]. *Hepatology*. 2021;74(3):1611–1644. doi:10.1002/hep.32049 [PubMed: 34233031]
 117. Tandon P, Zanetto A, Piano S, Heimbach JK, Dasarathy S. Liver transplantation in the patient with physical frailty. *J Hepatol*. 2023;78(6):1105–1117. doi:10.1016/j.jhep.2023.03.025 [PubMed: 37208097]
 118. Lai JC, Shui AM, Duarte-Rojo A, et al. Frailty, mortality, and health care utilization after liver transplantation: From the Multicenter Functional Assessment in Liver Transplantation (FrAILT) Study. *Hepatology*. 2022;75(6):1471–1479. doi:10.1002/hep.32268 [PubMed: 34862808]

119. Thuluvath PJ, Thuluvath AJ, Savva Y. Karnofsky performance status before and after liver transplantation predicts graft and patient survival. *J Hepatol.* 2018;69(4):818–825. doi:10.1016/j.jhep.2018.05.025 [PubMed: 29883596]
120. Lai JC, Shui AM, Duarte-Rojo A, et al. Association of Frailty With Health-Related Quality of Life in Liver Transplant Recipients. *JAMA Surg.* 2023;158(2):130–138. doi:10.1001/jamasurg.2022.6387 [PubMed: 36515937]
121. Prentis JM, Manas DM, Trenell MI, Hudson M, Jones DJ, Snowden CP. Submaximal cardiopulmonary exercise testing predicts 90-day survival after liver transplantation. *Liver Transpl.* 2012;18(2):152–159. doi:10.1002/lt.22426 [PubMed: 21898768]
122. Wang M, Shui AM, Ruck J, et al. The liver frailty index is a predictor of healthcare utilization after liver transplantation in older adults. *Clin Transplant.* 2024;38(1):e15219. doi:10.1111/ctr.15219 [PubMed: 38064281]
123. Shamseddeen H, Pike F, Ghabril M, et al. Karnofsky performance status predicts outcomes in candidates for simultaneous liver-kidney transplant. *Clin Transplant.* 2021;35(2):e14190. doi:10.1111/ctr.14190 [PubMed: 33320383]
124. Thuluvath PJ, Thuluvath AJ, Savva Y, Zhang T. Karnofsky Performance Status Following Liver Transplantation in Patients With Multiple Organ Failures and Probable Acute-on-Chronic Liver Failure. *Clin Gastroenterol Hepatol.* 2020;18(1):234–241. doi:10.1016/j.cgh.2019.03.016 [PubMed: 30885883]
125. Tandon P, Reddy KR, O’Leary JG, et al. A Karnofsky performance status-based score predicts death after hospital discharge in patients with cirrhosis. *Hepatology.* 2017;65(1):217–224. doi:10.1002/hep.28900 [PubMed: 27775842]
126. Orman ES, Ghabril M, Chalasani N. Poor Performance Status Is Associated With Increased Mortality in Patients With Cirrhosis. *Clin Gastroenterol Hepatol.* 2016;14(8):1189–1195.e1. doi:10.1016/j.cgh.2016.03.036 [PubMed: 27046483]
127. Choudhary NS, Sonavane A, Saraf N, et al. Poor Performance Status Predicts Mortality After Living Donor Liver Transplantation. *J Clin Exp Hepatol.* 2020;10(1):37–42. doi:10.1016/j.jceh.2019.06.006 [PubMed: 32025165]
128. Bajaj JS, Lai JC, Tandon P, et al. Role of Oral Health, Frailty, and Minimal Hepatic Encephalopathy in the Risk of Hospitalization: A Prospective Multi-Center Cohort of Outpatients With Cirrhosis. *Clin Gastroenterol Hepatol.* 2023;21(7):1864–1872.e2. doi:10.1016/j.cgh.2022.10.023 [PubMed: 36328307]
129. Tandon P, Tangri N, Thomas L, et al. A Rapid Bedside Screen to Predict Unplanned Hospitalization and Death in Outpatients With Cirrhosis: A Prospective Evaluation of the Clinical Frailty Scale. *Am J Gastroenterol.* 2016;111(12):1759–1767. doi:10.1038/ajg.2016.303 [PubMed: 27481305]
130. Tapper EB, Finkelstein D, Mittleman MA, Piatkowski G, Lai M. Standard assessments of frailty are validated predictors of mortality in hospitalized patients with cirrhosis. *Hepatology.* 2015;62(2):584–590. doi:10.1002/hep.27830 [PubMed: 25846824]
131. Lai JC, Feng S, Terrault NA, Lizaola B, Hayssen H, Covinsky K. Frailty predicts waitlist mortality in liver transplant candidates. *Am J Transplant.* 2014;14(8):1870–1879. doi:10.1111/ajt.12762 [PubMed: 24935609]
132. Sinclair M, Poltavskiy E, Dodge JL, Lai JC. Frailty is independently associated with increased hospitalisation days in patients on the liver transplant waitlist. *World J Gastroenterol.* 2017;23(5):899–905. doi:10.3748/wjg.v23.i5.899 [PubMed: 28223735]
133. Carey EJ, Steidley DE, Aqel BA, et al. Six-minute walk distance predicts mortality in liver transplant candidates. *Liver Transpl.* 2010;16(12):1373–1378. doi:10.1002/lt.22167 [PubMed: 21117246]
134. Dang TT, Ebadi M, Abalde JG, et al. The 6-Minute Walk Test Distance Predicts Mortality in Cirrhosis: A Cohort of 694 Patients Awaiting Liver Transplantation. *Liver Transpl.* 2021;27(10):1490–1492. doi:10.1002/lt.26087 [PubMed: 33905166]
135. Alameri HF, Sanai FM, Al Dukhayil M, et al. Six Minute Walk Test to assess functional capacity in chronic liver disease patients. *World J Gastroenterol.* 2007;13(29):3996–4001. doi:10.3748/wjg.v13.i29.3996 [PubMed: 17663517]

136. Lai JC, Dodge JL, Kappus MR, et al. Changes in frailty are associated with waitlist mortality in patients with cirrhosis. *J Hepatol.* 2020;73(3):575–581. doi:10.1016/j.jhep.2020.03.029 [PubMed: 32240717]
137. Kardashian A, Ge J, McCulloch CE, et al. Identifying an Optimal Liver Frailty Index Cutoff to Predict Waitlist Mortality in Liver Transplant Candidates. *Hepatology.* 2021;73(3):1132–1139. doi:10.1002/hep.31406 [PubMed: 32491208]
138. Lai JC, Ganger DR, Volk ML, et al. Association of Frailty and Sex With Wait List Mortality in Liver Transplant Candidates in the Multicenter Functional Assessment in Liver Transplantation (FrAILT) Study. *JAMA Surg.* 2021;156(3):256–262. doi:10.1001/jamasurg.2020.5674 [PubMed: 33377947]
139. Serper M, Tao SY, Kent DS, et al. Inpatient Frailty Assessment Is Feasible and Predicts Nonhome Discharge and Mortality in Decompensated Cirrhosis. *Liver Transpl.* 2021;27(12):1711–1722. doi:10.1002/lt.26100 [PubMed: 34018303]
140. Fozouni L, Mohamad Y, Lebsack A, Freise C, Stock P, Lai JC. Frailty Is Associated With Increased Rates of Acute Cellular Rejection Within 3 Months After Liver Transplantation. *Liver Transpl.* 2020;26(3):390–396. doi:10.1002/lt.25669 [PubMed: 31655014]
141. Bernal W, Martin-Mateos R, Lipcsey M, et al. Aerobic capacity during cardiopulmonary exercise testing and survival with and without liver transplantation for patients with chronic liver disease. *Liver Transpl.* 2014;20(1):54–62. doi:10.1002/lt.23766 [PubMed: 24136710]
142. Ney M, Haykowsky MJ, Vandermeer B, Shah A, Ow M, Tandon P. Systematic review: pre- and post-operative prognostic value of cardiopulmonary exercise testing in liver transplant candidates. *Aliment Pharmacol Ther.* 2016;44(8):796–806. doi:10.1111/apt.13771 [PubMed: 27539029]
143. Wang CW, Lebsack A, Chau S, Lai JC. The Range and Reproducibility of the Liver Frailty Index. *Liver Transpl.* 2019;25(6):841–847. doi:10.1002/lt.25449 [PubMed: 30884128]
144. Göbel P, Forsting C, Klüners A, et al. Persisting dental foci increase the risk for bacterial infections before and after liver transplant. *Clin Transplant.* 2023;37(2):e14857. doi:10.1111/ctr.14857 [PubMed: 36372930]
145. Wu JH, Lee CY, Chang WT, et al. The association between oral health status and the clinical outcome of cirrhotic patients on the waiting list for liver transplantation. *Kaohsiung J Med Sci.* 2021;37(10):910–917. doi:10.1002/kjm2.12406 [PubMed: 34288387]
146. Di Profio B, Inoue G, Marui VC, et al. Periodontal status of liver transplant candidates and healthy controls. *J Periodontol.* 2018;89(12):1383–1389. doi:10.1002/JPER.17-0710 [PubMed: 30005127]
147. Oliveira CS, Galdino TM, Limeira FIR, Moreira AN, de Magalhães CS, Abreu LG. Is dental caries associated with liver transplantation? A systematic review and metaanalysis. *Oral Dis.* 2021;27(6):1346–1355. doi:10.1111/odi.13439. [PubMed: 32469441]
148. Helenius-Hietala J, Åberg F, Meurman JH, Nordin A, Isoniemi H. Oral surgery in liver transplant candidates: a retrospective study on delayed bleeding and other complications. *Oral Surg Oral Med Oral Pathol Oral Radiol.* 2016;121(5):490–495. doi:10.1016/j.oooo.2016.01.025 [PubMed: 27068309]
149. Dew MA, DiMartini AF, Dobbels F, et al. The 2018 ISHLT/APM/AST/ICCAC/STSW recommendations for the psychosocial evaluation of adult cardiothoracic transplant candidates and candidates for long-term mechanical circulatory support. *J Heart Lung Transplant.* 2018;37(7):803–823. doi:10.1016/j.healun.2018.03.005 [PubMed: 29709440]
150. Wadhvani SI, Lai JC, Gottlieb LM. Medical Need, Financial Resources, and Transplant Accessibility. *JAMA.* 2022;327(15):1445–1446. doi:10.1001/jama.2022.5283 [PubMed: 35357415]
151. Ladin K, Daniels A, Osani M, Bannuru RR. Is social support associated with post-transplant medication adherence and outcomes? A systematic review and meta-analysis. *Transplant Rev (Orlando).* 2018;32(1):16–28. doi:10.1016/j.trre.2017.04.001 [PubMed: 28495070]
152. Jowsey-Gregoire S, Jannetto PJ, Jesse MT, et al. Substance use screening in transplant populations: Recommendations from a consensus workgroup. *Transplantation Reviews.* 2022;36(2):100694. doi:10.1016/j.trre.2022.100694 [PubMed: 35537285]

153. Maldonado JR, Dubois HC, David EE, et al. The Stanford Integrated Psychosocial Assessment for Transplantation (SIPAT): A New Tool for the Psychosocial Evaluation of Pre-Transplant Candidates. *Psychosomatics*. 2012;53(2):123–132. doi:10.1016/j.psych.2011.12.012 [PubMed: 22424160]
154. Kroenke K, Spitzer RL, Williams JBW. The PHQ-9: Validity of a Brief Depression Severity Measure. *Journal of General Internal Medicine*. 2001;16(9):606–613. doi:10.1046/j.1525-1497.2001.016009606.x [PubMed: 11556941]
155. Bush K The AUDIT Alcohol Consumption Questions (AUDIT-C): an effective brief screening test for problem drinking. *Archives of Internal Medicine*. 1998;158(16):1789. doi:10.1001/archinte.158.16.1789 [PubMed: 9738608]
156. Weinrieb RM, DiMartini AF. The Role of Psychosocial Screening Tools in the Evaluation of Transplantation Patients With Alcohol-Related Liver Disease. *Liver Transpl*. 2022;28(6):915–917. doi:10.1002/lt.26449 [PubMed: 35253350]
157. Dew MA, DiMartini AF. Psychosocial Evaluation Matters. *Liver Transpl*. 2021;27(5):619–621. doi:10.1002/lt.25992 [PubMed: 33484611]
158. Castedal M, Schult A, Kotopoulis MI, et al. Alcohol as a risk factor for mortality in liver transplant patients in Sweden. *Scand J Gastroenterol*. 2023;58(3):269–275. doi:10.1080/00365521.2022.2121938 [PubMed: 36093679]
159. Faure S, Herrero A, Jung B, et al. Excessive alcohol consumption after liver transplantation impacts on long-term survival, whatever the primary indication. *J Hepatol*. 2012;57(2):306–312. doi:10.1016/j.jhep.2012.03.014 [PubMed: 22521352]
160. Carencio C, Faure S, Herrero A, et al. Incidence of solid organ cancers after liver transplantation: comparison with regional cancer incidence rates and risk factors. *Liver Int*. 2015;35(6):1748–1755. doi:10.1111/liv.12758 [PubMed: 25488375]
161. Watt KD, Pedersen RA, Kremers WK, Heimbach JK, Sanchez W, Gores GJ. Long-term probability of and mortality from de novo malignancy after liver transplantation. *Gastroenterology*. 2009;137(6):2010–2017. doi:10.1053/j.gastro.2009.08.070 [PubMed: 19766646]
162. Dew MA, Rosenberger EM, Myaskovsky L, et al. Depression and Anxiety as Risk Factors for Morbidity and Mortality After Organ Transplantation: A Systematic Review and Meta-Analysis. *Transplantation*. 2015;100(5):988–1003. doi:10.1097/TP.0000000000000901 [PubMed: 26492128]
163. Price A, Whitwell S, Henderson M. Impact of psychotic disorder on transplant eligibility and outcomes. *Curr Opin Organ Transplant*. 2014;19(2):196–200. doi:10.1097/MOT.0000000000000057 [PubMed: 24553499]
164. Evans LD, Stock EM, Zeber JE, et al. Posttransplantation Outcomes in Veterans With Serious Mental Illness. *Transplantation*. 2015;99(8):e57–e65. doi:10.1097/TP.0000000000000616 [PubMed: 25706275]
165. Kotlyar DS, Burke A, Campbell MS, Weinrieb RM. A critical review of candidacy for orthotopic liver transplantation in alcoholic liver disease. *Am J Gastroenterol*. 2008;103(3):734–744. doi:10.1111/j.1572-0241.2007.01691.x [PubMed: 18081918]
166. DiMartini A, Weinrieb R, Lane T, Day N, Fung J. Defining the alcoholic liver transplant population: implications for future research. *Liver Transpl*. 2001;7(5):428–431. doi:10.1053/jlts.2001.23915 [PubMed: 11349263]
167. Mellinger JL, Winder GS, Fernandez AC, et al. Feasibility and early experience of a novel multidisciplinary alcohol-associated liver disease clinic. *J Subst Abuse Treat*. 2021;130:108396. doi:10.1016/j.jsat.2021.108396 [PubMed: 34118717]
168. Crabb DW, Im GY, Szabo G, Mellinger JL, Lucey MR. Diagnosis and Treatment of Alcohol-Associated Liver Diseases: 2019 Practice Guidance From the American Association for the Study of Liver Diseases. *Hepatology*. 2020;71(1):306–333. doi:10.1002/hep.30866 [PubMed: 31314133]
169. Asrani SK, Trotter J, Lake J, et al. Meeting Report: The Dallas Consensus Conference on Liver Transplantation for Alcohol Associated Hepatitis. *Liver Transpl*. 2020;26(1):127–140. doi:10.1002/lt.25681 [PubMed: 31743578]

170. Lim N, Leventhal TM, Thomson MJ, et al. Protocolized screening and detection of occult alcohol use before and after liver transplant: Lessons learned from a quality improvement initiative. *Clin Transplant*. 2023;37(9):e15036. doi:10.1111/ctr.15036 [PubMed: 37218656]
171. Joyal K, Peckham AM, Wakeman SE, et al. Management of Opioid Agonist Treatment for Opioid Use Disorder in the Setting of Solid Organ Transplant. *Transplantation*. 2022;106(5):900–903. doi:10.1097/TP.0000000000003926 [PubMed: 34406186]
172. Corbett C, Armstrong MJ, Neuberger J. Tobacco smoking and solid organ transplantation. *Transplantation*. 2012;94(10):979–987. doi:10.1097/TP.0b013e318263ad5b [PubMed: 23169222]
173. CDC. State Tobacco-Related Disparities. Tobacco - Health Equity. Published 2024. <https://www.cdc.gov/tobacco-health-equity/data-research/index.html>
174. Serrano Rodriguez P, Strassle PD, Barritt AS 4th, et al. Marijuana Consumption in Liver Transplant Recipients. *Liver Transpl*. 2019;25(5):734–740. doi:10.1002/lt.25417 [PubMed: 30693668]
175. Likhitsup A, Saeed N, Winder GS, Hassan A, Sonnenday CJ, Fontana RJ. Marijuana use among adult liver transplant candidates and recipients. *Clin Transplant*. 2021;35(7):e14312. doi:10.1111/ctr.14312 [PubMed: 33829569]
176. Winder GS, Andrews SR, Banerjee AG, et al. Cannabinoids and solid organ transplantation: Psychiatric perspectives and recommendations. *Transplant Rev (Orlando)*. 2022;36(4):100715. doi:10.1016/j.trre.2022.100715 [PubMed: 35853383]
177. Belli LS, Duvoux C, Artzner T, et al. Liver transplantation for patients with acute-on-chronic liver failure (ACLF) in Europe: Results of the ELITA/EF-CLIF collaborative study (ECLIS). *J Hepatol*. 2021;75(3):610–622. doi:10.1016/j.jhep.2021.03.030 [PubMed: 33951535]
178. Allen AM, Kim WR, Moriarty JP, Shah ND, Larson JJ, Kamath PS. Time trends in the health care burden and mortality of acute on chronic liver failure in the United States. *Hepatology*. 2016;64(6):2165–2172. doi:10.1002/hep.28812 [PubMed: 27696493]
179. Bhakta D, Patel M, Ma TW, Boutté J, Sarmast N, Asrani SK. Model for End-Stage Liver Disease Lactate Score and Prediction of Inpatient Mortality in Critically Ill Patients With Cirrhosis. *Liver Transpl*. 2021;27(12):1861–1864. doi:10.1002/lt.26076 [PubMed: 33880857]
180. Abdallah MA, Waleed M, Bell MG, et al. Systematic review with meta-analysis: liver transplant provides survival benefit in patients with acute on chronic liver failure. *Aliment Pharmacol Ther*. 2020;52(2):222–232. doi:10.1111/apt.15793 [PubMed: 32490550]
181. Weiss E, Saner F, Asrani SK, et al. When Is a Critically Ill Cirrhotic Patient Too Sick to Transplant? Development of Consensus Criteria by a Multidisciplinary Panel of 35 International Experts. *Transplantation*. 2021;105(3):561–568. doi:10.1097/TP.0000000000003364 [PubMed: 32568955]
182. Fernández J, Saliba F. Liver transplantation in patients with ACLF and multiple organ failure: Time for priority after initial stabilization. *J Hepatol*. 2018;69(5):1004–1006. doi:10.1016/j.jhep.2018.09.002 [PubMed: 30241881]
183. Huebener P, Sterneck MR, Bangert K, et al. Stabilisation of acute-on-chronic liver failure patients before liver transplantation predicts post-transplant survival. *Aliment Pharmacol Ther*. 2018;47(11):1502–1510. doi:10.1111/apt.14627 [PubMed: 29611203]
184. Sundaram V, Kogachi S, Wong RJ, et al. Effect of the clinical course of acute-on-chronic liver failure prior to liver transplantation on post-transplant survival. *J Hepatol*. 2020;72(3):481–488. doi:10.1016/j.jhep.2019.10.013 [PubMed: 31669304]
185. Lindenmeyer CC, Kim A, Sanghi V, et al. The EMALT Score: An Improved Model for Prediction of Early Mortality in Liver Transplant Recipients. *J Intensive Care Med*. 2020;35(8):781–788. doi:10.1177/0885066618784869 [PubMed: 29996705]
186. Evans MD, Diaz J, Adamusiak AM, et al. Predictors of Survival After Liver Transplantation in Patients With the Highest Acuity (MELD $\geq$ 40). *Ann Surg*. 2020;272(3):458–466. doi:10.1097/SLA.0000000000004211 [PubMed: 32740239]
187. Molinari M, Jorgensen D, Ayloo S, et al. Preoperative Stratification of Liver Transplant Recipients: Validation of the LTRS. *Transplantation*. 2020;104(12):e332–e341. doi:10.1097/TP.0000000000003353 [PubMed: 32675743]

188. Karvellas CJ, Bajaj JS, Kamath PS, et al. AASLD Practice Guidance on Acute-on-chronic liver failure and the management of critically ill patients with cirrhosis. *Hepatology*. 2024;79(6):1463–1502. doi:10.1097/HEP.0000000000000671 [PubMed: 37939273]
189. Wang S, Whitlock R, Xu C, et al. Frailty is associated with increased risk of cirrhosis disease progression and death. *Hepatology*. 2022;75(3):600–609. doi:10.1002/hep.32157 [PubMed: 34528267]
190. Lai JC, Rahimi RS, Verna EC, et al. Frailty Associated With Waitlist Mortality Independent of Ascites and Hepatic Encephalopathy in a Multicenter Study. *Gastroenterology*. 2019;156(6):1675–1682. doi:10.1053/j.gastro.2019.01.028 [PubMed: 30668935]
191. Wang M, Shui AM, Huang CY, et al. The liver frailty index enhances mortality risk prediction above and beyond MELD 3.0 alone. *Liver Transpl*. Published online July 24, 2024. doi:10.1097/LVT.0000000000000436
192. Wang M, Shui AM, Huang CY, et al. The Liver Frailty Index enhances mortality risk prediction above and beyond MELD 3.0 alone. *Liver Transpl*. 2024;30(12):1326–1329. doi:10.1097/LVT.0000000000000436 [PubMed: 39041899]
193. Wang M, Chiou SH, Ganger D, et al. Liver transplantation provides survival benefit at all levels of frailty: From the Multicenter Functional Assessment in Liver Transplantation Study. *Hepatology*. Published online July 24, 2024. doi:10.1097/HEP.0000000000001030
194. Lai JC, Segev DL, McCulloch CE, Covinsky KE, Dodge JL, Feng S. Physical frailty after liver transplantation. *Am J Transplant*. 2018;18(8):1986–1994. doi:10.1111/ajt.14675 [PubMed: 29380529]
195. Lai JC. A framework to determine when liver transplantation is futile. *Clin Liver Dis (Hoboken)*. 2016;8(6):137–139. doi:10.1002/cld.589 [PubMed: 30294424]
196. Lai JC, Covinsky KE, McCulloch CE, Feng S. The Liver Frailty Index Improves Mortality Prediction of the Subjective Clinician Assessment in Patients With Cirrhosis. *Am J Gastroenterol*. 2018;113(2):235–242. doi:10.1038/ajg.2017.443 [PubMed: 29231189]
197. Price A, Whitwell S, Henderson M. Impact of psychotic disorder on transplant eligibility and outcomes. *Curr Opin Organ Transplant*. 2014;19(2):196–200. doi:10.1097/MOT.0000000000000057 [PubMed: 24553499]
198. Evans LD, Stock EM, Zeber JE, et al. Posttransplantation Outcomes in Veterans With Serious Mental Illness. *Transplantation*. 2015;99(8):e57–e65. doi:10.1097/TP.0000000000000616 [PubMed: 25706275]
199. Corbett C, Armstrong MJ, Parker R, Webb K, Neuberger JM. Mental health disorders and solid-organ transplant recipients. *Transplantation*. 2013;96(7):593–600. doi:10.1097/TP.0b013e31829584e0 [PubMed: 23743726]
200. Faeder S, Moschenross D, Rosenberger E, Dew MA, DiMartini A. Psychiatric aspects of organ transplantation and donation. *Curr Opin Psychiatry*. 2015;28(5):357–364. doi:10.1097/YCO.0000000000000185 [PubMed: 26186069]
201. “Ethics - General Considerations in Assessment for Transplant Candidacy - OPTN.” Hrsa.gov, 2024, optn.transplant.hrsa.gov/professionals/by-topic/ethical-considerations/general-considerations-in-assessment-for-transplant-candidacy/#_ednref51. Accessed 12 Sept. 2024.
202. Yerdel MA, Gunson B, Mirza D, et al. Portal vein thrombosis in adults undergoing liver transplantation: risk factors, screening, management, and outcome. *Transplantation*. 2000;69(9):1873–1881. doi:10.1097/00007890-200005150-00023 [PubMed: 10830225]
203. Sharshar M, Yagi S, Iida T, et al. Liver transplantation in patients with portal vein thrombosis: A strategic road map throughout management. *Surgery*. 2020;168(6):1160–1168. doi:10.1016/j.surg.2020.07.023 [PubMed: 32861438]
204. Fundora Y, Hessheimer AJ, Del Prete L, et al. Alternative forms of portal vein revascularization in liver transplant recipients with complex portal vein thrombosis. *Journal of Hepatology*. 2023;78(4):794–804. doi:10.1016/j.jhep.2023.01.007 [PubMed: 36690281]
205. European Association for the Study of the Liver. EASL Clinical Practice Guidelines: Liver transplantation. *J Hepatol*. 2016;64(2):433–485. doi:10.1016/j.jhep.2015.10.006 [PubMed: 26597456]

206. Kaur N, Emamaullee J, Lian T, et al. Impact of Morbid Obesity on Liver Transplant Candidacy and Outcomes: National and Regional Trends. *Transplantation*. 2021;105(5):1052–1060. doi:10.1097/TP.0000000000003404 [PubMed: 33741845]
207. Kardashian AA, Dodge JL, Roberts J, Brandman D. Weighing the risks: Morbid obesity and diabetes are associated with increased risk of death on the liver transplant waiting list. *Liver Int*. 2018;38(3):553–563. doi:10.1111/liv.13523 [PubMed: 28727287]
208. Schlansky B, Naugler WE, Orloff SL, Enestvedt CK. Higher Mortality and Survival Benefit in Obese Patients Awaiting Liver Transplantation. *Transplantation*. 2016;100(12):2648–2655. doi:10.1097/TP.0000000000001461 [PubMed: 27575690]
209. Ayloo S, Hurton S, Cwinn M, Molinari M. Impact of body mass index on outcomes of 48281 patients undergoing first time cadaveric liver transplantation. *World J Transplant*. 2016;6(2):356–369. doi:10.5500/wjt.v6.i2.356 [PubMed: 27358781]
210. Haldar D, Kern B, Hodson J, et al. Outcomes of liver transplantation for non-alcoholic steatohepatitis: A European Liver Transplant Registry study. *J Hepatol*. 2019;71(2):313–322. doi:10.1016/j.jhep.2019.04.011 [PubMed: 31071367]
211. Haugen CE, McAdams-DeMarco M, Verna EC, et al. Association Between Liver Transplant Wait-list Mortality and Frailty Based on Body Mass Index [published correction appears in *JAMA Surg*. 2019 Dec 1;154(12):1171. doi: <https://doi.org/10.1001/jamasurg.2019.4583>]. *JAMA Surg*. 2019;154(12):1103–1109. doi:10.1001/jamasurg.2019.2845 [PubMed: 31509169]
212. Idriss R, Hasse J, Wu T, et al. Impact of Prior Bariatric Surgery on Perioperative Liver Transplant Outcomes. *Liver Transpl*. 2019;25(2):217–227. doi:10.1002/lt.25368 [PubMed: 30369002]
213. Tariq N, Saharia A, Nwokedi U, et al. Combined liver transplantation and sleeve gastrectomy: Report of a brief-interval staged approach. *Liver Transpl*. 2023;29(4):422–430. doi:10.1002/lt.26560 [PubMed: 35976078]
214. Zamora-Valdes D, Watt KD, Kellogg TA, et al. Long-term outcomes of patients undergoing simultaneous liver transplantation and sleeve gastrectomy. *Hepatology*. 2018;68(2):485–495. doi:10.1002/hep.29848 [PubMed: 29457842]
215. Barbetta A, Aljehani M, Kim M, et al. Meta-analysis and meta-regression of outcomes for adult living donor liver transplantation versus deceased donor liver transplantation. *Am J Transplant*. 2021;21(7):2399–2412. doi:10.1111/ajt.16440 [PubMed: 33300241]
216. Abecassis MM, Fisher RA, Olthoff KM, et al. Complications of living donor hepatic lobectomy--a comprehensive report. *Am J Transplant*. 2012;12(5):1208–1217. doi:10.1111/j.1600-6143.2011.03972.x [PubMed: 22335782]
217. Cotter TG, Minhem M, Wang J, et al. Living Donor Liver Transplantation in the United States: Evolution of Frequency, Outcomes, Center Volumes, and Factors Associated With Outcomes. *Liver Transpl*. 2021;27(7):1019–1031. doi:10.1002/lt.26029 [PubMed: 33619854]
218. Liapakis A, Agbim U, Bittermann T, et al. A survey of transplant providers regarding attitudes, barriers, and facilitators to living donor liver transplantation in the United States. *Clin Transplant*. 2023;37(7):e14967. doi:10.1111/ctr.14967 [PubMed: 36938716]
219. Lentine KL, Tanaka T, Xiao H, et al. Variation in adult living donor liver transplantation in the United States: Identifying opportunities for increased utilization. *Clin Transplant*. 2023;37(7):e14924. doi:10.1111/ctr.14924 [PubMed: 36733213]
220. Sturdevant M, Ganesh S, Samstein B, et al. Advances and innovations in living donor liver transplant techniques, matching and surgical training: Meeting report from the living donor liver transplant consensus conference. *Clin Transplant*. 2023;37(7):e14968. doi:10.1111/ctr.14968 [PubMed: 37039541]
221. Miller CM, Smith ML, Diago Uso T. Living donor liver transplantation: ethical considerations. *Mt Sinai J Med*. 2012;79(2):214–222. doi:10.1002/msj.21299 [PubMed: 22499492]
222. Olthoff KM, Abecassis MM, Emond JC, et al. Outcomes of adult living donor liver transplantation: comparison of the Adult-to-adult Living Donor Liver Transplantation Cohort Study and the national experience. *Liver Transpl*. 2011;17(7):789–797. doi:10.1002/lt.22288 [PubMed: 21360649]

223. Anouti A, Al Hariri M, VanWagner LB, et al. Early Graft Failure After Living-Donor Liver Transplant. *Dig Dis Sci*. 2024;69(4):1488–1495. doi:10.1007/s10620-024-08280-5 [PubMed: 38381224]
224. Avanz A, Doğru V, Kisaoglu A, et al. Impact of older age on the long-term survival in living-donor liver transplantation: A propensity score matching analysis. *Asian J Surg*. 2022;45(11):2239–2245. doi:10.1016/j.asjsur.2021.11.061 [PubMed: 34955343]
225. Gil E, Kim JM, Jeon K, et al. Recipient Age and Mortality After Liver Transplantation: A Population-based Cohort Study. *Transplantation*. 2018;102(12):2025–2032. doi:10.1097/TP.0000000000002246 [PubMed: 30153223]
226. Hakeem AR, Fathima R, Padmanaban H, et al. Propensity Score-Matched Analysis of Posttransplant Outcomes in Living Donor Liver Transplantation for Older Adult Recipients. *Liver Transpl*. 2021;27(9):1273–1282. doi:10.1002/lt.26061 [PubMed: 33787013]
227. Ikegami T, Bekki Y, Imai D, et al. Clinical outcomes of living donor liver transplantation for patients 65 years old or older with preserved performance status. *Liver Transpl*. 2014;20(4):408–415. doi:10.1002/lt.23825 [PubMed: 24424619]
228. Nakamura T, Nobori S, Harada S, et al. Impact of Donor and Recipient Age on Outcomes After Living Donor Liver Transplant. *Transplant Proc*. 2022;54(2):438–442. doi:10.1016/j.transproceed.2021.08.068 [PubMed: 35033371]
229. Nidoni R, Kandagaddala R, Agarwal S, Dey R, Chikkala BR, Gupta S. Living Donor Liver Transplant in Patients Aged 60 Years or Older: Experience from a Large Volume Centre in India. *J Clin Exp Hepatol*. 2021;11(1):3–8. doi:10.1016/j.jceh.2020.07.007 [PubMed: 33679042]
230. Oezcelik A, Dayangac M, Guler N, et al. Living Donor Liver Transplantation in Patients 70 Years or Older. *Transplantation*. 2015;99(7):1436–1440. doi:10.1097/TP.0000000000000524 [PubMed: 25606791]
231. Ushigome H, Nakao T, Harada S, et al. Elderly Living Donor Liver Transplant Recipients Over 60 Years Old at a Japanese Single Center. *Transplant Proc*. 2016;48(4):1115–1118. doi:10.1016/j.transproceed.2015.12.103 [PubMed: 27320569]
232. Robinson T, Vargas PA, Oberholzer J, Pelletier S, Goldaracena N. Survival after LDLT in recipients ≥ 70 years old in the United States. An OPTN/UNOS liver transplant registry analysis. *Clin Transplant*. 2023;37(11):e15099. doi:10.1111/ctr.15099 [PubMed: 37589889]
233. Su F, Yu L, Berry K, et al. Aging of Liver Transplant Registrants and Recipients: Trends and Impact on Waitlist Outcomes, Post-Transplantation Outcomes, and Transplant-Related Survival Benefit. *Gastroenterology*. 2016;150(2):441–e16. doi:10.1053/j.gastro.2015.10.043 [PubMed: 26522262]
234. Goldberg DS, Charlton M. Usefulness of Liver Transplantation in the Elderly: The Converging Impact of Risk and Benefit. *Gastroenterology*. 2016;150(2):306–309. doi:10.1053/j.gastro.2015.12.020 [PubMed: 26710989]
235. Durand F, Levitsky J, Cauchy F, Gilgenkrantz H, Soubrane O, Francoz C. Age and liver transplantation. *J Hepatol*. 2019;70(4):745–758. doi:10.1016/j.jhep.2018.12.009 [PubMed: 30576701]
236. Reddy MS, Rammohan A, Gupta S, et al. International multicenter study of ultralow graft-to-recipient weight ratio grafts in adult living donor liver transplantation. *Am J Transplant*. 2024;24(12):2246–2257. doi:10.1016/j.ajt.2024.06.013 [PubMed: 38914281]
237. Yoshiya S, Itoh S, Toshima T, et al. Is preoperative weight reduction of living-donor liver transplant recipients and donors harmful to postoperative outcomes?. *J Gastrointest Surg*. 2024;28(7):1033–1038. doi:10.1016/j.gassur.2024.04.010 [PubMed: 38631611]
238. Feng Y, Han Z, Wang X, Chen H, Li Y. Association of Graft-to-Recipient Weight Ratio with the Prognosis Following Liver Transplantation: a Meta-analysis. *J Gastrointest Surg*. 2020;24(8):1869–1879. doi:10.1007/s11605-020-04598-3 [PubMed: 32306226]
239. Agarwal S, Selvakumar N, Rajasekhar K, Dey R, Verma S, Gupta S. Minimum absolute graft weight of 650 g predicts a good outcome in living donor liver transplant despite a graft recipient body weight ratio of less than 0.8. *Clin Transplant*. 2019;33(10):e13705. doi:10.1111/ctr.13705 [PubMed: 31498506]

240. Gunay Y, Guler N, Dayangac M, et al. Living donor liver transplantation for obese patients: challenges and outcomes. *Liver Transpl.* 2014;20(3):311–322. doi:10.1002/lt.23794 [PubMed: 24243642]
241. Cho CW, Choi GS, Kim JM, Kwon CHD, Joh J. Comparison of Posttransplant Outcomes in Living Donor Liver Transplantation for Obese and Nonobese Recipients. *Transplant Proc.* 2018;50(9):2679–2683. doi:10.1016/j.transproceed.2018.02.199 [PubMed: 30401376]
242. Hammad A, Kaido T, Hamaguchi Y, et al. Impact of sarcopenic overweight on the outcomes after living donor liver transplantation. *Hepatobiliary Surg Nutr.* 2017;6(6):367–378. doi:10.21037/hbsn.2017.02.02 [PubMed: 29312971]
243. Agarwal S, Goyal N, Nayeem M, Pareek S, Gupta S. Living donor liver transplantation in patients weighing ≥ 100 kg: Low graft weight and obesity do not impact outcomes. *Liver Transpl.* 2017;23(1):35–42. doi:10.1002/lt.24653 [PubMed: 27731927]
244. Ali Deeb A, Settmacher U, Fritsch J, Dondorf F, Rohland O, Rauchfuß F. Sarcopenic obesity may predict worse liver regeneration after right graft living donor liver transplantation. *Liver Transpl.* 2024;30(4):412–420. doi:10.1097/LVT.000000000000238 [PubMed: 37548548]
245. Macshut M, Kaido T, Yao S, et al. Visceral adiposity is an independent risk factor for high intra-operative blood loss during living-donor liver transplantation; could preoperative rehabilitation and nutritional therapy mitigate that risk?. *Clin Nutr.* 2021;40(3):956–965. doi:10.1016/j.clnu.2020.06.023 [PubMed: 32665100]
246. Roll GR, Spiro M, Raptis DA, et al. Which recipient pretransplant factors, such as MELD, renal function, sarcopenia, and recent sepsis influence suitability for and outcome after living donor liver transplantation? A systematic review of the literature and expert panel recommendations. *Clin Transplant.* 2022;36(10):e14656. doi:10.1111/ctr.14656 [PubMed: 35340054]
247. Jayant K, Cotter TG, Reccia I, et al. Comparing High- and Low-Model for End-Stage Liver Disease Living-Donor Liver Transplantation to Determine Clinical Efficacy: A Systematic Review and Meta-Analysis (CHALICE Study). *J Clin Med.* 2023;12(18):5795. Published 2023 Sep 6. doi:10.3390/jcm12185795 [PubMed: 37762738]
248. Yun SO, Kim J, Rhu J, Choi GS, Joh JW. Benefit of living donor liver transplantation in graft survival for extremely high model for end-stage liver disease score ≥ 35 . *J Hepatobiliary Pancreat Sci.* 2023;30(12):1293–1303. doi:10.1002/jhbp.1376 [PubMed: 37799067]
249. Matoba D, Noda T, Kobayashi S, et al. Analysis of Short-Term and Long-Term Outcomes of Living Donor Liver Transplantation for Patients with a High Model for End-Stage Liver Disease Score. *Transplant Proc.* 2023;55(4):893–897. doi:10.1016/j.transproceed.2023.03.011 [PubMed: 37120341]
250. Anouti A, Patel MS, VanWagner LB, et al. Increasing practice and acceptable outcomes of high-MELD living donor liver transplantation in the USA. *Liver Transpl.* 2024;30(1):72–82. doi:10.1097/LVT.000000000000228 [PubMed: 37490432]
251. Rosenthal BE, Abt PL, Schaubel DE, Reddy KR, Bittermann T. Living Donor Liver Transplantation for Adults With High Model for End-stage Liver Disease Score: The US Experience. *Transplantation.* 2024;108(3):713–723. doi:10.1097/TP.0000000000004767 [PubMed: 37635282]
252. Nobel YR, Goldberg DS. Variable Use of Model for End-Stage Liver Disease Exception Points in Patients With Neuroendocrine Tumors Metastatic to the Liver and Its Impact on Patient Outcomes. *Transplantation.* 2015;99(11):2341–2346. doi:10.1097/TP.0000000000000723 [PubMed: 25989503]
253. Ruzzenente A, Bagante F, Bertuzzo F, et al. Liver Resection for Neuroendocrine Tumor Liver Metastases Within Milan Criteria for Liver Transplantation. *J Gastrointest Surg.* 2019;23(1):93–100. doi:10.1007/s11605-018-3973-9 [PubMed: 30242647]
254. Brahmabhatt M, Prenner S, Bittermann T. Liver Transplantation for Hepatic Epithelioid Hemangioendothelioma Is Facilitated by Exception Points With Acceptable Long-term Outcomes. *Transplantation.* 2020;104(6):1187–1192. doi:10.1097/TP.0000000000002982 [PubMed: 31577674]
255. Dueland S, Syversveen T, Solheim JM, et al. Survival Following Liver Transplantation for Patients With Nonresectable Liver-only Colorectal Metastases. *Ann Surg.* 2020;271(2):212–218. doi:10.1097/SLA.0000000000003404 [PubMed: 31188200]

256. Adam R, Piedvache C, Chiche L, et al. Liver transplantation plus chemotherapy versus chemotherapy alone in patients with permanently unresectable colorectal liver metastases (TransMet): results from a multicentre, open-label, prospective, randomised controlled trial. *Lancet*. 2024;404(10458):1107–1118. doi:10.1016/S0140-6736(24)01595-2 [PubMed: 39306468]
257. Shingina A, Chadha R, Lim N, et al. Combined heart-liver transplantation practices survey in North America: Evaluation and organ listing practices. *Liver Transpl*. 2023;29(6):591–597. doi:10.1097/LVT.000000000000079 [PubMed: 36745932]
258. Purvis J, McLeod C, Smith B, et al. Survival following simultaneous liver-lung versus liver alone transplantation: Results of the US national experience. *Am J Surg*. 2021;222(4):813–818. doi:10.1016/j.amjsurg.2021.01.043 [PubMed: 33589242]
259. Wilk AR, Booker SE, Stewart DE, et al. Developing simultaneous liver-kidney transplant medical eligibility criteria while providing a safety net: A 2-year review of the OPTN's allocation policy. *Am J Transplant*. 2021;21(11):3593–3607. doi:10.1111/ajt.16761 [PubMed: 34254434]
260. Alexopoulos SP, Wu WK, Ziogas IA, et al. Adult Combined Heart-Liver Transplantation: The United States Experience. *Transpl Int*. 2022;35:10036. Published 2022 Jan 4. doi:10.3389/ti.2021.10036 [PubMed: 35185360]
261. Cheng XS, Wall A, Teuteberg J. Ethical decision-making in simultaneous heart-liver transplantation. *Curr Opin Organ Transplant*. 2020;25(5):519–525. doi:10.1097/MOT.0000000000000806 [PubMed: 32881719]
262. "Ethical Implications of Multi Organ Transplants - OPTN." [Optn.transplant.hrsa.gov, optn.transplant.hrsa.gov/policies-bylaws/public-comment/ethical-implications-of-multi-organ-transplants/](https://optn.transplant.hrsa.gov/optn.transplant.hrsa.gov/policies-bylaws/public-comment/ethical-implications-of-multi-organ-transplants/).
263. Lewis MJ, Reardon LC, Aboulhosn J, et al. Clinical Outcomes of Adult Fontan-Associated Liver Disease and Combined Heart-Liver Transplantation. *J Am Coll Cardiol*. 2023;81(22):2149–2160. doi:10.1016/j.jacc.2023.03.421 [PubMed: 37257950]
264. Freischlag K, Ezekian B, Schroder PM, et al. A Propensity-matched Survival Analysis: Do Simultaneous Liver-lung Transplant Recipients Need a Liver?. *Transplantation*. 2019;103(8):1675–1682. doi:10.1097/TP.0000000000002529 [PubMed: 30444805]
265. Purvis J, McLeod C, Smith B, et al. Survival following simultaneous liver-lung versus liver alone transplantation: Results of the US national experience. *Am J Surg*. 2021;222(4):813–818. doi:10.1016/j.amjsurg.2021.01.043 [PubMed: 33589242]
266. Wilk AR, Booker SE, Stewart DE, et al. Developing simultaneous liver-kidney transplant medical eligibility criteria while providing a safety net: A 2-year review of the OPTN's allocation policy. *Am J Transplant*. 2021;21(11):3593–3607. doi:10.1111/ajt.16761 [PubMed: 34254434]
267. Kobashigawa J, VanWagner LB, Hall S, et al. Summary of a consensus conference on heart-liver transplantation. *Am J Transplant*. 2024;24(3):380–390. doi:10.1016/j.ajt.2023.12.002 [PubMed: 38072122]
268. Perez-Gutierrez A, Siddiqi U, Kim G, et al. Combined heart-liver-kidney transplant: The university of Chicago medicine experience. *Clin Transplant*. 2022;36(4):e14586. doi:10.1111/ctr.14586 [PubMed: 35041226]

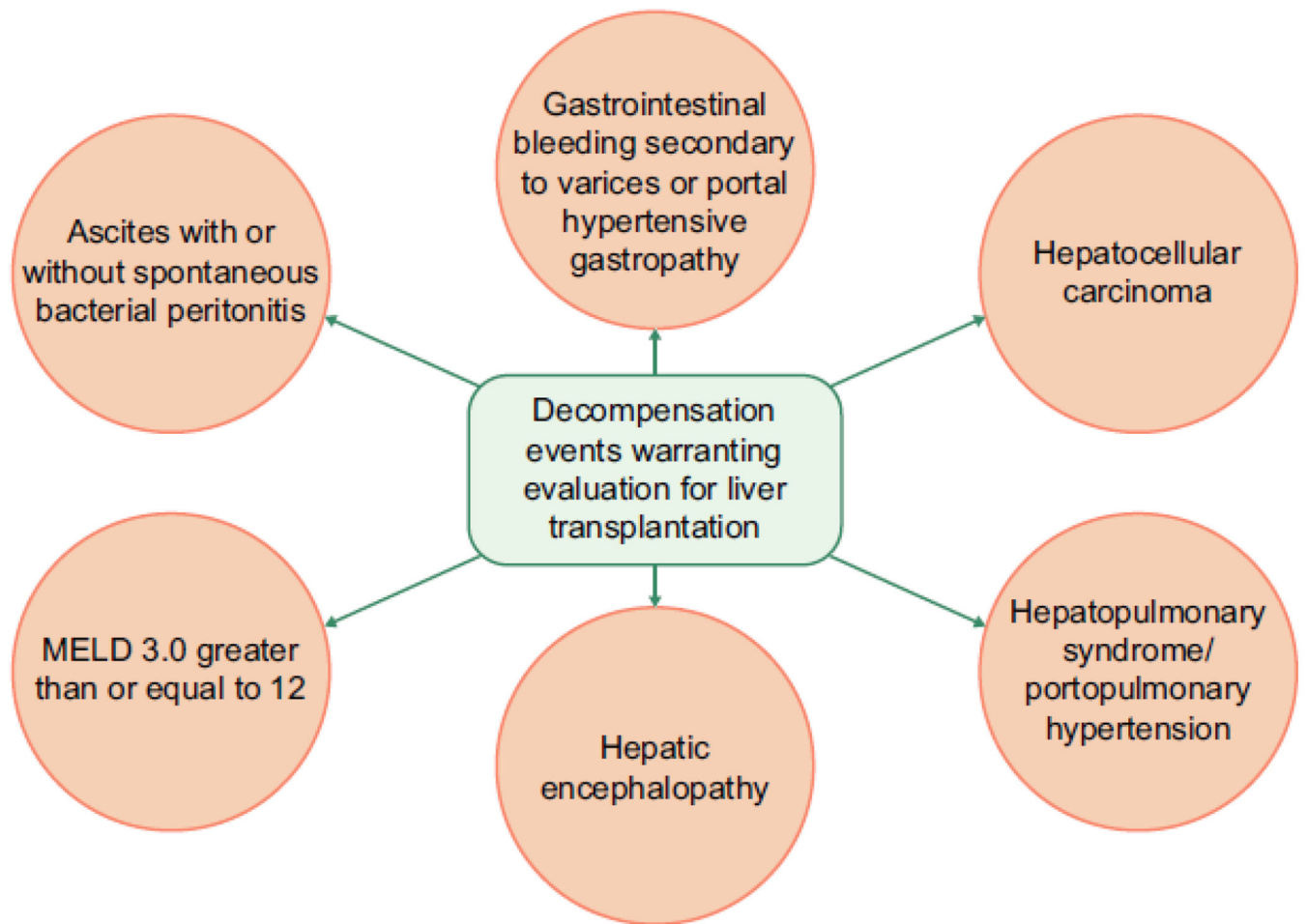


Figure 1:
Decompensation events that warrant liver transplant evaluation: This figure summarizes the most common (but not limited to) events that may demonstrate hepatic failure.

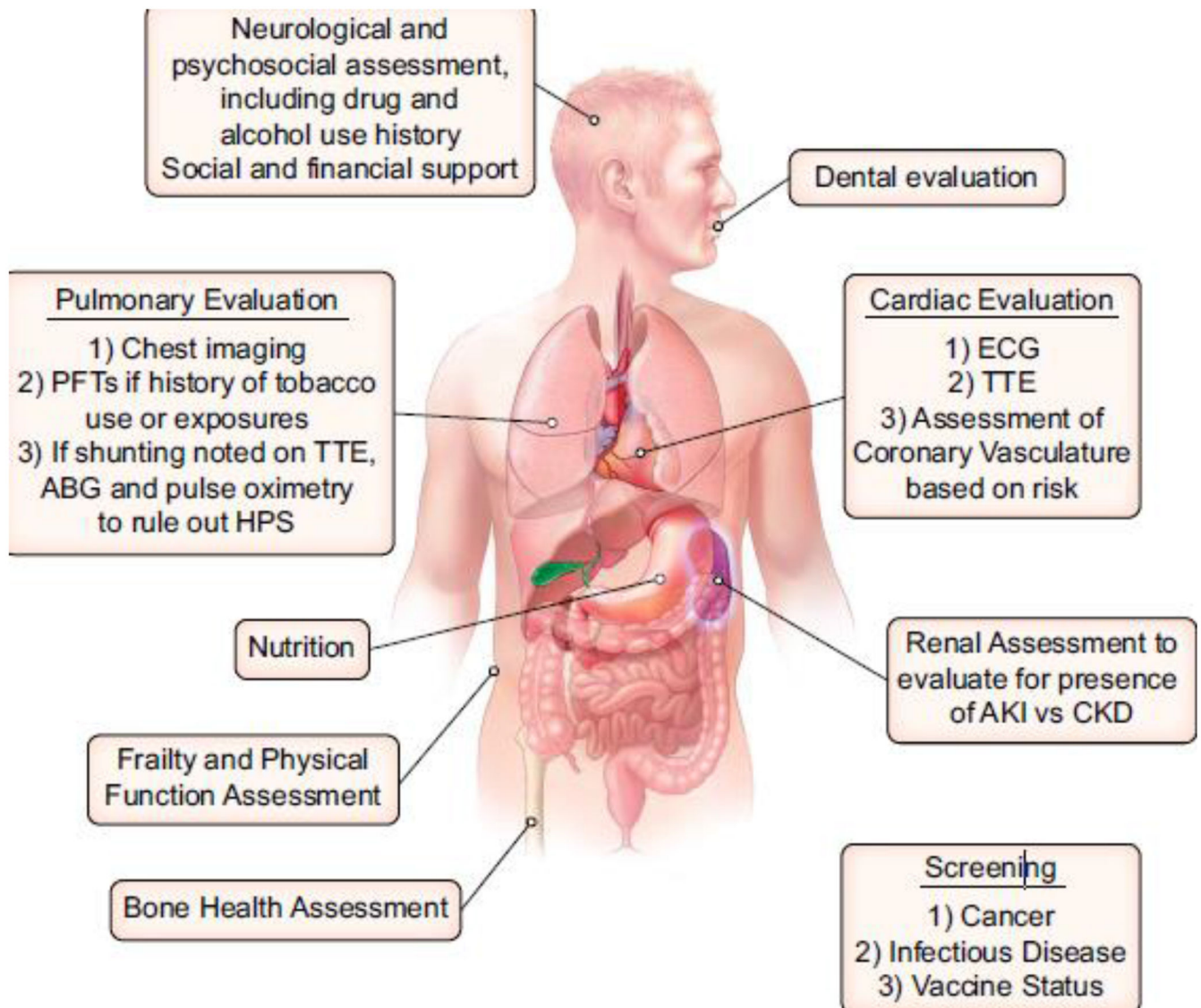


Figure 2:
The multiorgan evaluation of the pre-liver transplant patient (Used with permission of Mayo Foundation for Medical Education and Research, all rights reserved)

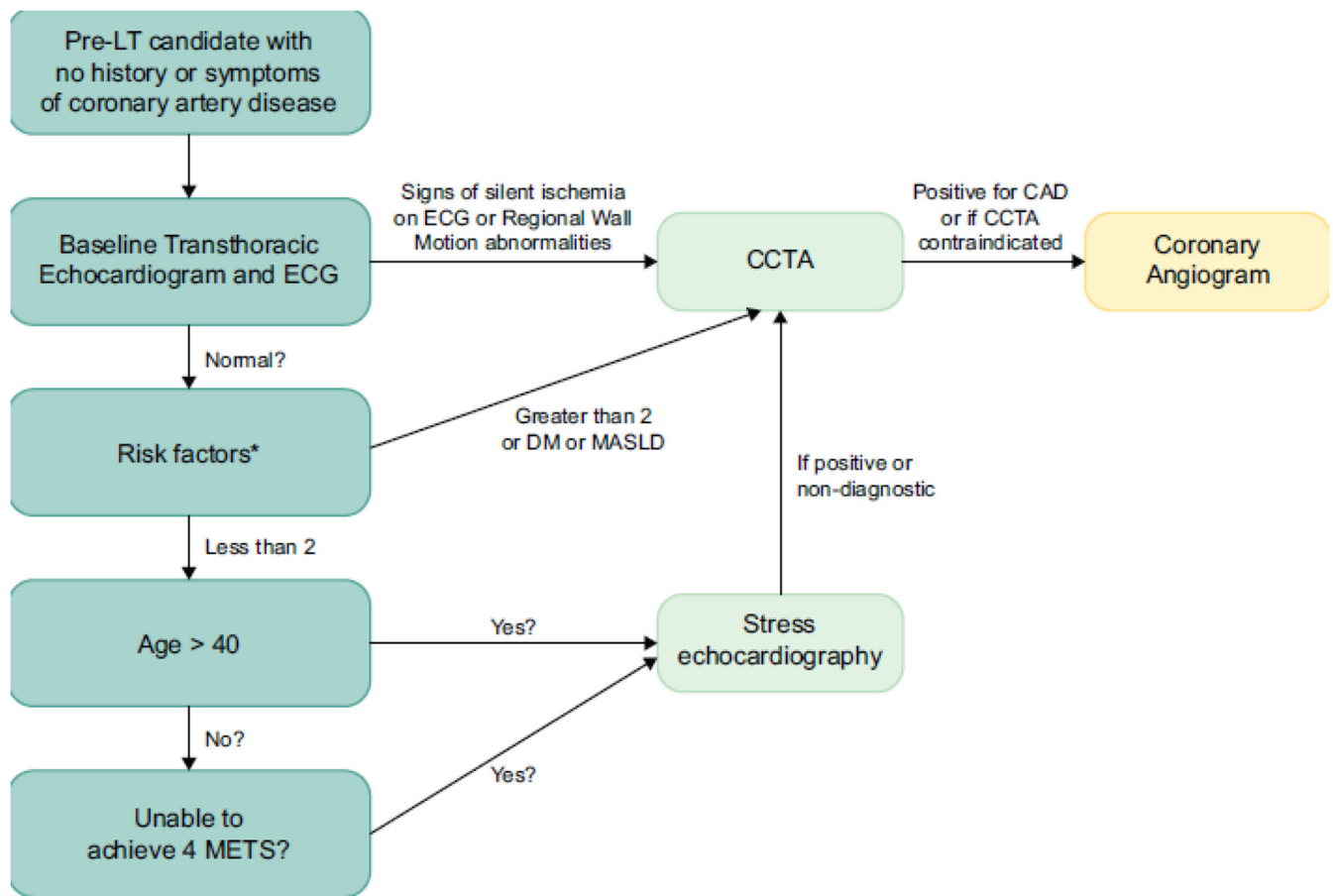


Figure 3: Potential cardiac assessment screening pathway for patient with no history of cardiac disease. (adapted from Cheng et al)

*Dyslipidemia, history of hypertension, chronic kidney disease, left ventricular hypertrophy, family history of premature CHD, active or past tobacco use, and coronary artery calcification score >0

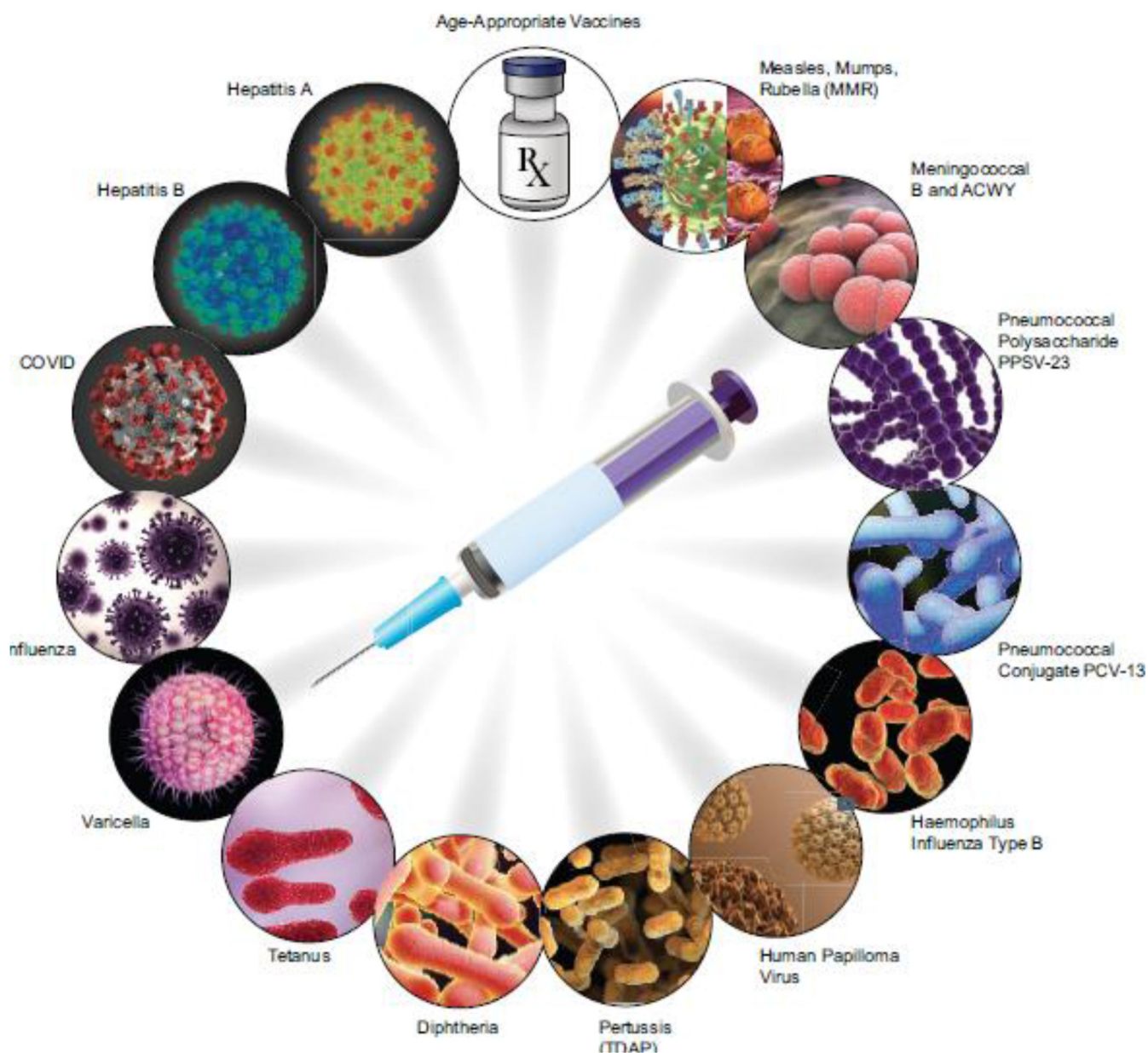


Figure 4:
A summary of the vaccines needed in the pre-liver transplant period as prophylaxis

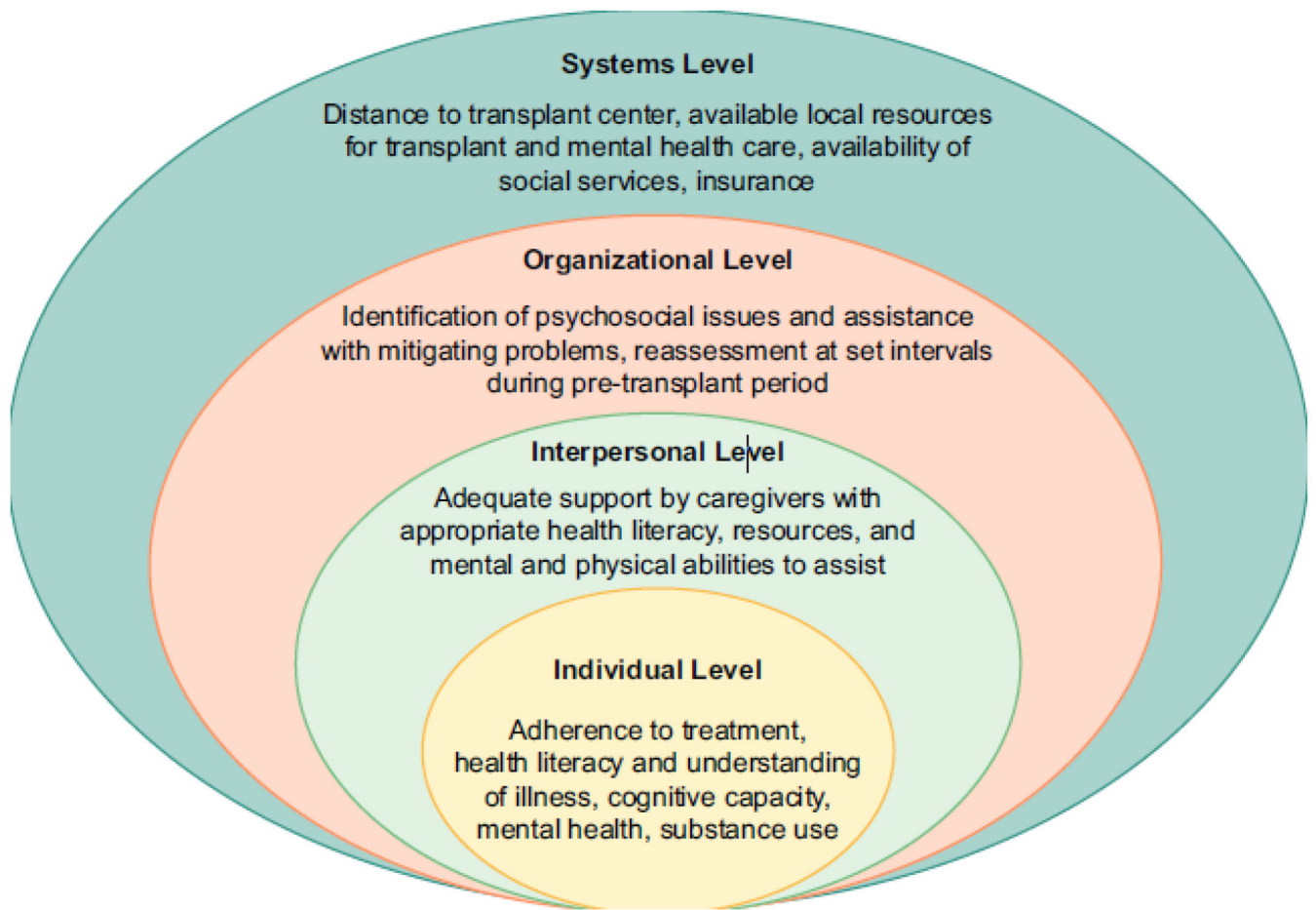


Figure 5:
Levels of Consideration and Components of the Psychosocial Evaluation

<table><tr><th>Absolute</th></tr><tr><td> • Anatomical variations that preclude transplantation </td></tr><tr><td> • Advanced cardiopulmonary disease (severely depressed left ventricular ejection fraction, severe valvular disease, end stage lung diseases) <u>and not</u> candidate for combined heart-liver or lung-liver </td></tr><tr><td></td></tr></table>	Absolute	• Anatomical variations that preclude transplantation	• Advanced cardiopulmonary disease (severely depressed left ventricular ejection fraction, severe valvular disease, end stage lung diseases) <u>and not</u> candidate for combined heart-liver or lung-liver		<table><tr><th>Case by Case Assessment</th></tr><tr><td> • Sustained hemodynamic instability requiring high vasopressor administration </td></tr><tr><td> • Fulminant hepatic failure with likely brain injury </td></tr><tr><td> • Large hepatocellular carcinomas or those with vascular invasion </td></tr><tr><td> • Metastasis to the liver, from a treated extrahepatic primary tumor </td></tr><tr><td> • Intrahepatic cholangiocarcinoma </td></tr><tr><td> • Marked frailty </td></tr><tr><td> • Alcohol use disorder with concurrent consumption </td></tr><tr><td> • Ongoing misuse of drugs as evaluated by the psychosocial team </td></tr><tr><td> • Current tobacco use </td></tr><tr><td> • History of nonadherence </td></tr><tr><td> • Inadequate social support </td></tr><tr><td> • Obesity </td></tr><tr><td> • Sepsis confined to liver (e.g. hepatic abscess, cholangitis) </td></tr><tr><td> • Mental health disease </td></tr><tr><td></td></tr></table>	Case by Case Assessment	• Sustained hemodynamic instability requiring high vasopressor administration	• Fulminant hepatic failure with likely brain injury	• Large hepatocellular carcinomas or those with vascular invasion	• Metastasis to the liver, from a treated extrahepatic primary tumor	• Intrahepatic cholangiocarcinoma	• Marked frailty	• Alcohol use disorder with concurrent consumption	• Ongoing misuse of drugs as evaluated by the psychosocial team	• Current tobacco use	• History of nonadherence	• Inadequate social support	• Obesity	• Sepsis confined to liver (e.g. hepatic abscess, cholangitis)	• Mental health disease	
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Figure 6:
Approach to Contraindications for Liver Transplantation

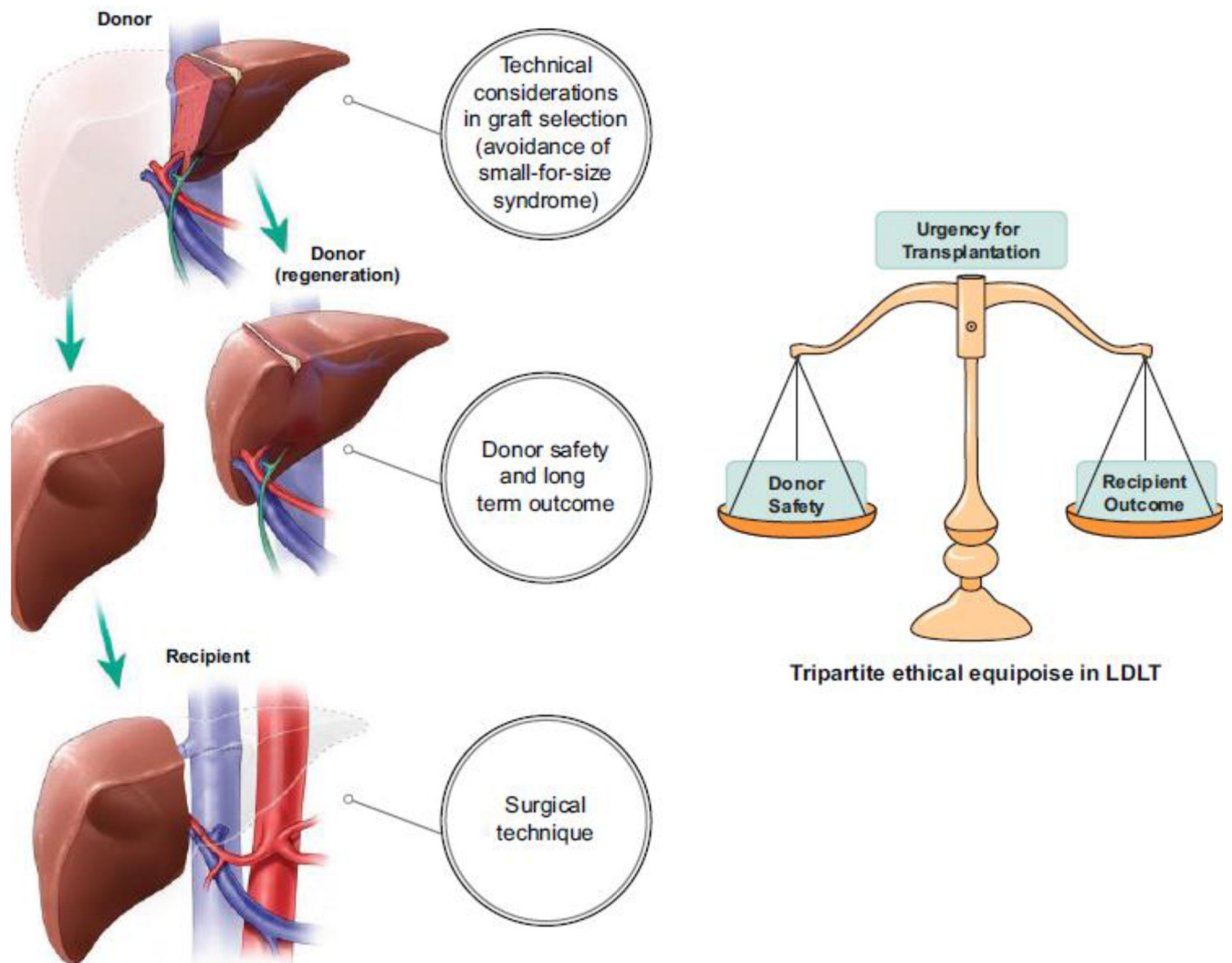


Figure 7:
 What makes living donor liver transplantation unique. From: Mayo ClinicPress. Mayo Clinic Health Letter Special Report: Liver Donor Transplant May 2020 (MC2020-0520). Rochester, MN: Mayo Clinic, May 2020; used with permission of Mayo Foundationfor Medical Education and Research, all rights reserved.

Table 1:

Screening for Infection

Recommended Screening Labs for all patients	Diagnosis
CMV IgG	CMV
EBV IgG	EBV
HBsAG, HBcAB, HBsAb	Hepatitis B
Anti HCV IgG- if positive, RNA	Hepatitis C
<i>HEV (conditional)</i>	Hepatitis E
HIV Antibody, if positive, HIV RNA	Human Immunodeficiency Virus
Rectal and nasal swab	MDRO Rectal: CPE, VRE Nasal: MRSA
PPD or IGRA (Quanti-Feron-TB Bold Plus and T-Spot	Mycobacterium Tuberculosis
RPR, if positive follow with specific treponemal test	Syphilis
Toxo IgG	Toxoplasmosis
VZV	Varicella
Conditional Screening if exposure risk	
Coccidioides serology or skin testing	Coccidioidomycosis
Serum Antibody tests	Histoplasmosis
Strongyloides IgG	Strongyloides
Trypanosoma C serology	Trypanosoma cruzi

Table 2:
Recommended Vaccine Schedules in the Pre-Liver Transplant Candidate

Vaccines	Strength of Recommendation
COVID	Adult patients should receive: 2 doses of Pfizer-BioNTech mRNA, or 2 doses of Moderna mRNA, or 2 doses of Novavax Adjuvanted, or 1 dose of Janssen Adenoviral vector; All followed by booster dose of mRNA vaccines > 2 months after primary series
HAV	2 doses of Havrix 6 to 12 months apart, or Vaqta 6 to 18 months apart, or 3 doses of Twinrix at 0, 1 and 6 months
HBV	All patients should receive: 2-dose Heplisav-B 4 weeks apart, or 3-dose Engerix-B, Recombivax-HB or Twinrix at 0, 1 and 6 months
HIB	Recommended for adults with an additional risk factor/indication, e.g. anatomical or functional asplenia, haematopoietic stem cell transplant or other additional factors
HPV	Adult patients should receive 2 or 3 doses through age 26 depending on age at initial vaccination
Influenza	One dose yearly
Pneumococcal	Patients between 19-64 years should receive 1 dose of PPSV23. Patients > 64 years should receive 1 dose of PPSV23 at least 1 or 5 years after PCV13 or PPSV23, respectively
Meningococcal ACWY/B	Recommended for adults with an additional risk factor/indication, e.g. anatomical or functional asplenia, haematopoietic stem cell transplant or other additional factors
MMR (live)	Patients with no evidence of immunity and born in 1957 or later should receive 1 or 2 dose(s) depending on indication. Should be completed 4 weeks prior to transplant
Tdap or DT	All patients should receive 1 dose of Tdap, then Td or Tdap booster every 10 years
Varicella (recombinant non-live and live)	Zoster recombinant (Shingrix): Patients > 50 years should receive 2 doses 2-6 months apart, regardless of previous herpes zoster or history of zoster live vaccine. Zoster live attenuated (Zostavax): Vaccination might be indicated if benefit of protection outweighs risk of adverse reaction in specific patient. Should be completed 4 weeks prior to transplant.

Table 3:
Recommended Cancer Screening in Liver Transplant Candidates

	Screening Test	Screening interval
Hepatocellular carcinoma	Liver ultrasound and alpha fetoprotein If poor liver visualization is noted on ultrasound a liver MRI or CT should be conducted for surveillance If cross-sectional imaging is planned for other purposes, then it should be protocolled to screen for HCC	Every 6 months
Colorectal Cancer	Average risk patients ≥ 45 years old should undergo screening using colonoscopy or Stool DNA-FIT testing Higher than average risk patients should be screened using colonoscopy	High quality colonoscopy should be conducted with the last 10 years. More frequent intervals per guidelines based on polyp history, family history, or with the presence of any hereditary syndromes Stool based DNA-FIT testing should be completed every 1-3 years
Breast Cancer	Female candidates ≥ 40 years old should undergo mammography In candidates unable to undergo mammography, alternate tests such as breast ultrasound or MRI could be considered	Screening should be conducted on a biennial basis
Cervical Cancer	Female candidates ≥ 21 years old should undergo screening with cytology and high-risk human papillomavirus testing	Screening should be conducted every 3 years in average risk individuals up to 49 years of age Screening should be conducted every 5 years in average risk individuals ≥ 50 years of age
Lung Cancer	Candidates aged ≥ 50 years old with a history of 20 pack year smoking history should undergo low dose CT chest. Screening should be discontinued in patients who have not smoked in 15 years.	Screening should be conducted annually
Prostate Cancer	Prostate cancer screening should be conducted in male candidates ≥ 50 years of age	Annual prostate specific antigen testing

Abbreviations: MRI: Magnetic Resonance Imaging, CT: Computed Tomography, DNA-FIT: Fecal Immunochemical Test

Table 4:

Metrics of Physical Function

Metric	Objective	Studied in inpatients	Associated with outcomes <i>after</i> liver transplantation	Additional comments
Karnofsky Performance Status	--	✓	✓	- Rapid, easy to administer - Strong evidence base to support its prognostic value both before and after transplant - Established cut-offs: - High=80-100 - Medium=50-70 - Low=0-40
Clinical Frail Scale	--	--	--	- Rapid, easy to administer - Low granularity - Established cut-off for frail: CFS>4
Activities of Daily Living	--	✓	--	- Low ceiling effect
Fried Frailty Instrument	--	--	--	- Captures the multi-dimensional construct of frailty
6-minute walk test	✓	--	--	- Captures aerobic exercise capacity
Liver Frailty Index	✓	✓	✓	- Cirrhosis-specific metric - Strong evidence base to support its prognostic value both before and after transplant
Short Physical Performance Battery	✓	--	--	-
Cardiopulmonary Exercise Test	✓	--	✓	- Captures aerobic exercise capacity - Requires specialized equipment and personnel
				-

Table 5:**LDLT Studies on High MELD Patients**

Author/Year	Study Design	Study Population	Outcomes
Anouti et al 2024	Retrospective Cohort Registry Study	3558 LDLT recipients	An association of high MELD (≥ 25) with lower graft survival was noted for recipients of LDLT and deceased brain-dead donor liver transplant (DBDLT), with no significant difference in 1- and 5-year graft survival between high-MELD LDLT compared with high-MELD DBDLT recipients.
Rosenthal et al 2024	Retrospective Cohort Registry Study	4495 LDLT recipients	LDLT led to superior patient survival at MELD < 20 (adjusted HR 0.92; $p = 0.024$) and 20–24 (adjusted HR 0.70; $p < 0.001$), equivalent patient survival at MELD 25–29 (adjusted HR 0.97; $p = 0.843$), but worse graft survival at MELD ≥ 30 . Sensitivity analysis exploring outcomes using a MELD score threshold of 30 or above noted LDLT had increased hazard of graft loss compared to DBDLT recipients. The effect of MELD ≥ 30 on graft survival was more pronounced in the MELD-Na era and among patients transplanted with NASH.
Roll et al 2022 (ERAS4OLT)	Systematic Review	35 studies included in final synthesis	MELD scores > 25 alone is not a contraindication to LDLT though candidacy of these patients should be determined by a multidisciplinary team that takes into consideration the presence of comorbidities as well as donor factors that influence immediate graft function (e.g., donor age, graft size, steatosis, severity of portal hypertension, and venous drainage of the graft). They specifically noted that patients with MELD scores > 35 should have an optimal graft (i.e., GRWR $> .8$, donor age < 50 -years, no steatosis, excellent venous drainage).
Jayant et al 2023 (CHALICE)	Systematic Review and Meta-analysis	10 studies with 2180 LDLT recipients	LDLT recipients and Low MELD-LDLT recipients had comparable mortality at 1, 3 and 5- years post-transplant with no differences observed in the rates of major morbidity, hepatic artery thrombosis, biliary complications, intraabdominal bleeding, wound infection and rejection; however, the High MELD -LDLT group had higher risk for pulmonary infection, abdominal fluid collection and prolonged ICU stay.
Yun et al 2023	Retrospective Single Center	223 DDLT and 126 LDLT recipients	No statistical difference in graft survival between MELD ≥ 35 LDLT and DDLT groups. Old age, acute on chronic liver failure, re-transplantation, preoperative intensive care unit stay and red blood cell (RBC) transfusion during the operation were risk factors for graft failure.
Matoba et al 2023	Retrospective Single Center	102 LDLT recipients	Comparable survival post LDLT among low MELD group: ≤ 20 , moderate MELD group: 21–30, and high MELD group: ≥ 31 .

Abbreviations: LDLT: Living Donor Liver Transplant, DDLT: Deceased Donor Liver Transplant, GRWR: Graft to Recipient Weight Ratio

Table 6:
Indications for Dual Organ Transplant Consideration

Heart	• Congenital Heart Disease ◦ Fontan Associated Liver Disease (FALD) • Non-congenital heart disease with non-cardiac cirrhosis (e.g. alcohol, hepatitis C) • Transthyretin cardiac amyloidosis • Separate liver and heart pathologies
Kidney	• Chronic Kidney Disease from alternative diagnosis • Acute Renal Failure not expected to resolve post liver transplant • Metabolic Disorders
Lung	• Cystic Fibrosis • Alpha-1-antitrypsin • Separate liver and lung etiologies
Multivisceral	• Anatomical preclusions (Grade IV Portal Vein Thrombosis)

Table 7:
Future Directions in the Liver Transplant Evaluation

Transplant Selection	Can evaluation for LT be made a community-health-based process?
	Should a quality-of-life assessment be included in candidate selection?
Malignancy	Should routine downstaging be performed in HCC looking at the impact of immunotherapy?
	When should transplant be done for non-hepatic malignancy?
	Is there a role for transplant in treating primary or secondary cancers with a goal of life-extension rather than cure? How much lifeextension justifies the transplantation?
Cardiopulmonary Testing	Are there advanced echocardiographic parameters to better define cirrhotic cardiomyopathy and its impact on transplant candidate selection?
Physical Function	Can we better understand the impact of interventions on optimizing physical function in decompensated patients in the pre-transplant period?
Psychosocial Assessment	Can prospective studies better determine what constitutes psychosocial unsuitability?
Contraindications	Does high BMI continue to have an outcome impact in the era of advanced bariatric management?
Bone Health	Do bisphosphonates have an impact on bone health outside of the pathology of primary biliary cholangitis?
Multiple Organ Transplant	What are the appropriate medical eligibility criteria for choosing patients and determining allocation for heart-liver and lung-liver transplants?