



Pre-Transplant Nutrition as a Catalyst for Post-Transplant Recovery



Benjamin Sizemore, RD, CNSC, CCTD

Clinical Nutrition Supervisor
VCU Health
Richmond, Virginia

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Disclosure

No commercial relationships to disclose



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Objectives

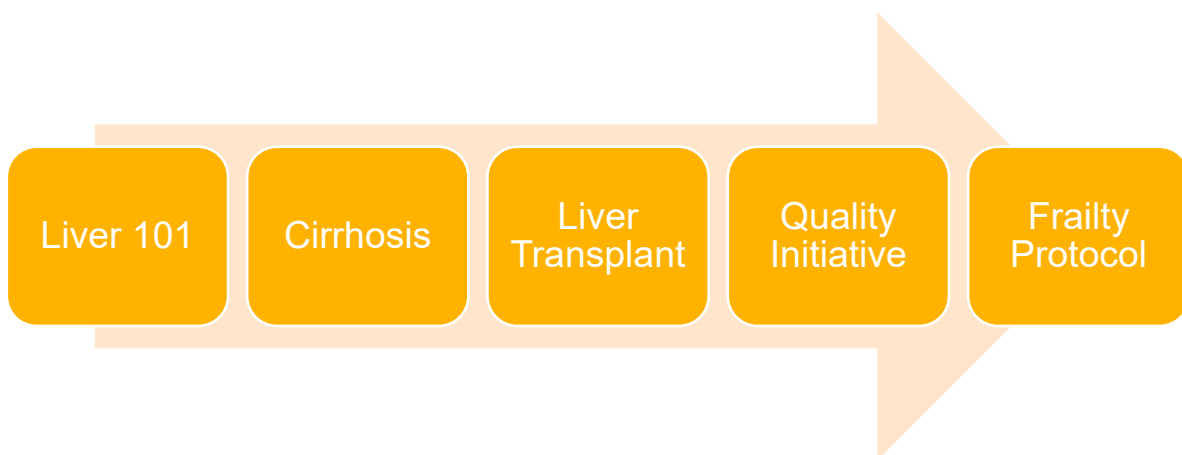
Upon completion of this educational activity, the learner will be able to:

- Describe the nutritional role of the liver and its significance in overall metabolism
- Define cirrhosis and explain the prevalence, causes, and impact of malnutrition in this population
- Assess the impact of standardized patient care guidelines on patient care and outcomes



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Agenda



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Learning Assessment Question 1

Which of the following best describes a major function of the liver and its specialized cells?

- A. Hepatic stellate cells are the primary producers of bile for fat absorption.
- B. Kupffer cells store vitamin A and synthesize plasma proteins.
- C. Hepatocytes play a critical role in protein, carbohydrate, and fat metabolism, while Kupffer cells help protect against gut-derived toxins.
- D. Hepatocytes are responsible for collagen formation following liver injury



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Learning Assessment Answer 1

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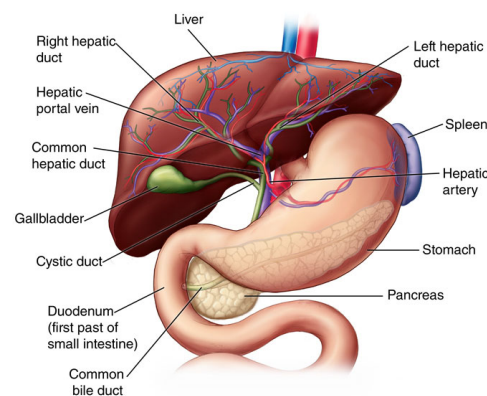
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Liver 101

- Pivotal in many metabolic processes
- Maintains considerable metabolic reserve
- Essential role for metabolism of protein, carbohydrate, fat
 - Chief site for metabolism of fatty acids
 - Produces bile for fat absorption in intestine
- Synthesizes plasma proteins, nonessential amino acids, urea, glycogen, and hormones (e.g. insulin-like growth factor 1)



Obtained from: <https://www.hopkinsmedicine.org/health/conditions-and-diseases/liver-anatomy-and-functions>

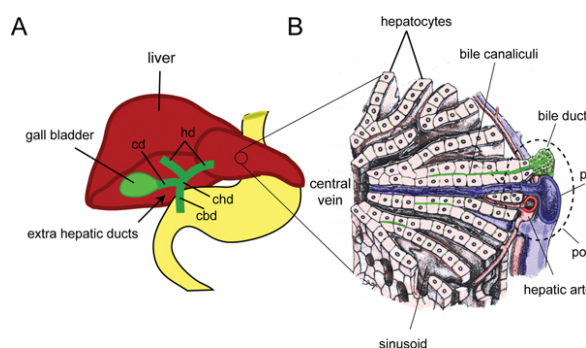


Yang N, Caravella J, Medici V, Kappus M. Chapter 29: Liver Disease. In: Chan LN, Kumpf VJ, eds. *ASPEN Adult Nutrition Support Core Curriculum*. 4th edition. American Society for Parenteral and Enteral Nutrition; 2025:765-802.

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Liver 101

- Hepatocytes (>80% total liver mass)
 - Critical role in metabolism of amino acids and ammonia
 - Detoxification of drugs, vitamin, hormones
 - Biochemical oxidation reactions
- Hepatic Kupffer cells (largest reservoir of fixed macrophages)
 - Protective role against gut-derived toxins that have escaped into portal circulation
 - Major producers of cytokines (influence nutrition status)
- Hepatic stellate cells
 - Assist with collagen formation following liver injury
 - Major storehouse for vitamin A in body



Obtained from: <https://www.ncbi.nlm.nih.gov/books/NBK27068/figure/liverdevelopment.F3/>

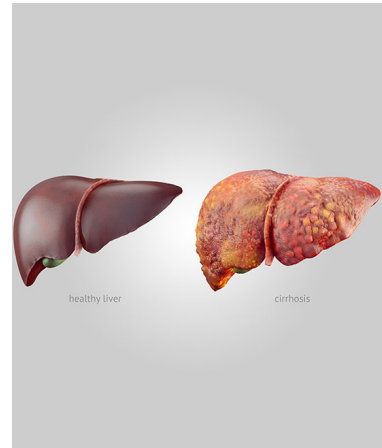


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Cirrhosis

- Late stage of progressive hepatic fibrosis
 - May lead to end-stage liver disease or hepatocellular carcinoma (HCC)
- Characterized by distortion of the hepatic architecture and the formation of regenerative nodules
- Compensated cirrhosis: cirrhosis without major complications
- Decompensated cirrhosis: cirrhosis with complications
 - Variceal hemorrhage
 - Ascites
 - Spontaneous bacterial peritonitis (SBP)
 - Hepatocellular carcinoma
 - Hepatorenal syndrome
 - Hepatopulmonary syndrome



Obtained from: <https://www.niddk.nih.gov/health-information/liver-disease/cirrhosis>

Cirrhosis

- Mortality rates rising (21.7 per 100,000 in U.S)
- Accounted for 52,6000 deaths, 8th leading cause of death in U.S. in 2023
- Potential to reverse in early stages with treatments targeting underlying cause of liver disease
- Irreversible in its advanced stages, transplant often only option

Cirrhosis Causes

Common causes

- Alcohol-associated liver disease
- Metabolic dysfunction-associated steatotic liver disease (MASLD)
- Chronic viral hepatitis (hepatitis B, C virus infection)

Less common causes

- Hemochromatosis
- Autoimmune hepatitis
- Primary biliary cholangitis
- Primary (and secondary) sclerosing cholangitis
- Wilson disease
- Alpha-1 antitrypsin deficiency
- Granulomatous liver disease
- Right-sided heart failure



Yang N, Caravella J, Medici V, Kappus M. Chapter 29: Liver Disease. In: Chan LN, Kumpf VJ, eds. *ASPEN Adult Nutrition Support Core Curriculum*. 4th edition. American Society for Parenteral and Enteral Nutrition; 2025:765-802. Uptodate. Accessed August 21, 2026. <https://www.uptodate.com/contents/cirrhosis-in-adults-etologies-clinical-manifestations-and-diagnosis>

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Learning Assessment Question 2

How many grams of alcohol consumption per day is considered harmful?

- A. >25g/day
- B. >50g/day
- C. >100g/day
- D. >200g/day



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Learning Assessment Answer 2

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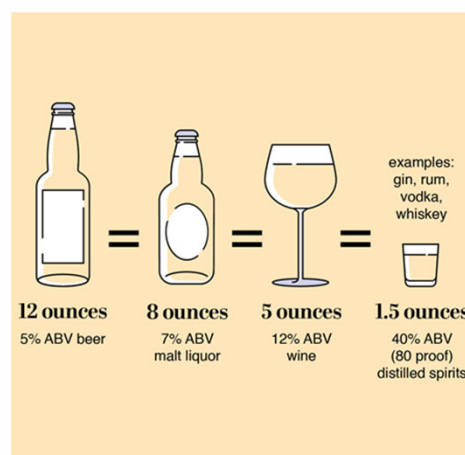


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Cirrhosis

Alcohol-Associated Liver Disease

- Liver main organ responsible for ethanol metabolism
 - Other organs (stomach) contribute to lesser degree
- Typically seen with harmful alcohol use during previous 12 months
 - Harmful use: >50g/day (female), >60g/day (male)
 - 1 standard drink = 14g alcohol
- 4% prevalence among adults in US
- Mortality estimated at 7.3 per 100,000 persons



Obtained from: <https://www.cdc.gov/alcohol/standard-drink-sizes/index.html>



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Uptodate. Accessed August 21, 2026. <https://www.uptodate.com/contents/clinical-manifestations-and-diagnosis-of-alcohol-associated-steatosis-and-cirrhosis>

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Cirrhosis

Alcohol-Associated Liver Disease

- Pathogenesis ALD complex, involves many mechanisms which are not always understood
 - Direct toxic effects of alcohol metabolites leading to imbalanced systemic inflammatory responses
 - Increased intestinal permeability resulting in translocation of bacterial degradation products from intestine to hepatocytes
 - Intestinal microbiome dysbiosis directly due to alcohol or altered bile acid profile, resulting in decreased biodiversity and proliferation of pathogenic organisms
 - Impaired hepatocyte regeneration and dedifferentiation
 - Other mechanisms which may contribute: Oxidative stress, mitochondrial dysfunction, Kupffer cell activation, dysregulated cytokine production, immune responses, genetic/epigenetic mechanisms



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Cirrhosis

Metabolic dysfunction-associated steatotic liver disease (MASLD)

- Hepatic manifestation of metabolic syndrome
 - Represents spectrum of disease (steatosis, steatohepatitis, fibrosis, ESLD, cirrhosis)
- Driven by diet
 - Linked to diets high in fat, high fructose corn syrup consumption, and low omega 3 intake
- Occurs when inappropriate hepatic management of lipids results in abdominal accumulation of fat in hepatocytes
 - Consequence of increased free fatty acid delivery to the liver from visceral sources coupled with hyperinsulinemia related inadequate formation and the export of very low density lipoproteins out of hepatocyte
- 10-20% experience inflammatory response to steatotic hepatocytes that progresses to liver cell injury, death, and fibrosis leading to cirrhosis



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Cirrhosis Signs/Symptoms

- Compensated: nonspecific symptoms
 - Anorexia, weight loss, weakness, fatigue, pruritus, muscle cramps, sexual dysfunction)
- Decompensated
 - Jaundice, signs of upper gastrointestinal bleeding, abdominal distension from ascites, confusion or altered executive function due to hepatic encephalopathy
- Laboratory abnormalities:
 - Elevated serum bilirubin, abnormal aminotransferases, elevated alkaline phosphatase/gamma-glutamyl transpeptidase, prolonged prothrombin time/elevated INR, hyponatremia, hypoalbuminemia, and thrombocytopenia



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Uptodate. Accessed August 21, 2026. <https://www.uptodate.com/contents/cirrhosis-in-adults-overview-of-complications-general-management-and-prognosis>

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Cirrhosis Signs/Symptoms

- Physical exam:
 - jaundice, spider angioma, gynecomastia, ascites, splenomegaly, palmar erythema, and asterixis.
- Liver biopsy is required to definitively confirm the diagnosis



Obtained from: <https://physicaldiagnosispx.com/gastroenterology-m/spider-angioma/>



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Learning Assessment Question 3

Which of the following is a contributing factor to malnutrition in patients with cirrhosis?

- A. Increased insulin-like growth factor-1 production and protein synthesis
- B. Enhanced nutrient absorption in the intestine
- C. Increased glycogen stores and metabolic reserve
- D. Increased nutrient requirements combined with decreased dietary intake



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Malnutrition in Cirrhosis

Sarcopenia

- Universal definition does not exist
- Age-related loss of muscle tissue
- Associated with decreased aerobic capacity, metabolic rate, and strength

Malnutrition

- Broad term that includes a deficiency, excess, or imbalance of nutrients that result in adverse consequences on clinical outcomes

Cachexia

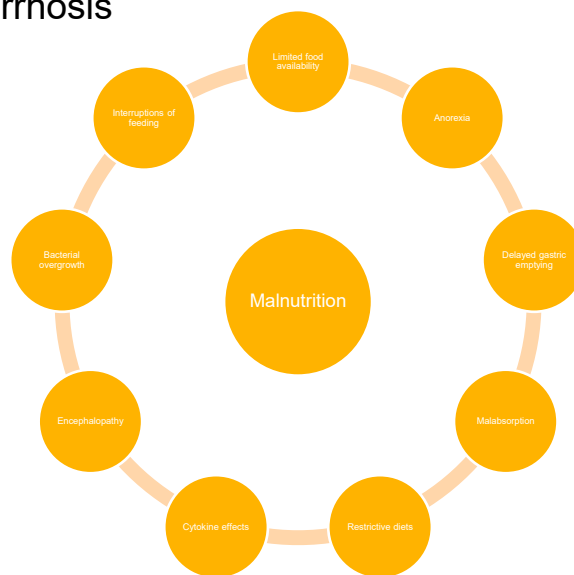
- Multifactorial syndrome, associated with inflammatory conditions
- Loss of skeletal muscle mass with or without fat wasting
- Cannot be reversed by nutrition support in the context of chronic systemic inflammation and metabolic alterations



Peterson SJ, Mozer M. Differentiating sarcopenia and cachexia among patients with cancer. *Nut in Clin Pract*. 2017;32(1):30-39. doi:10.1177/0884533616680354
Singal AK, Wong RJ, Dasarthy S, et al. ACG clinical guideline: malnutrition and nutritional recommendations in liver disease. *Am J Gastroenterol*. 2025;120(5):950-972. doi:10.14309/ajg.0000000000003379

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Malnutrition in Cirrhosis



Singal AK, Wong RJ, Dasarthy S, et al. ACG clinical guideline: malnutrition and nutritional recommendations in liver disease. *Am J Gastroenterol*. 2025;120(5):950-972. doi:10.14309/ajg.0000000000003379

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Malnutrition in Cirrhosis

- Strong positive association between the severity of liver disease and malnutrition irrespective of etiology
 - Malnutrition prevalence 20% in compensated cirrhosis and up to 60% in decompensated cirrhosis
- Associated complications: variceal bleeding, ascites, increased surgical morbidity and mortality, reduced survival, and possibly worsening liver function
- In hospitalized cirrhosis patients: higher risk of mortality (in-hospital, waitlist, and posttransplant), length of stay, complications, and infections
- Malnutrition is not always recognized in patients with liver disease
 - Weight loss masked by fluid retention
 - Sarcopenic obesity prevalent
- No gold standard for evaluating nutritional status in cirrhosis



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Cirrhosis Medical Nutrition Therapy

- Nutrition assessment
 - Early RD involvement
 - Regular follow-up
- Diet
 - Low sodium diet
 - 4-6 meals/snacks per day, include HS snack
 - ≥ 2 cups coffee per day
 - Free water restriction if retaining fluid (ascites/edema) and $\text{Na} < 126 \text{ mEq/L}$
- Nutrition Support
 - Early oral nutrition supplements or enteral nutrition
 - EN preferred over PN



Obtained from: <https://cookingwithcurls.com/2012/11/27/peanut-butter-jelly-sandwich/>



Singal AK, Wong RJ, Dasarthy S, et al. Acg clinical guideline: malnutrition and nutritional recommendations in liver disease. *Am J Gastroenterol*. 2025;120(5):950-972. doi:10.14309/ajg.0000000000003379
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Cirrhosis Medical Nutrition Therapy

- **Nutrient Requirements:**
 - Calories: $1.2\text{--}1.4 \times \text{REE}$ (kcal/day) or 20-35cal/kg based on BMI
 - Protein: 1.2-1.5g/kg/d – do not restrict
 - Fat: 30-40% nonprotein energy
- **Vitamin/Minerals**
 - Daily multivitamin, otherwise replace as needed
 - ALD: B1, B6, B12, folate, zinc
 - Cholestatic liver disease (PBC, PSC): ADEK
 - MASLD: vitamin D

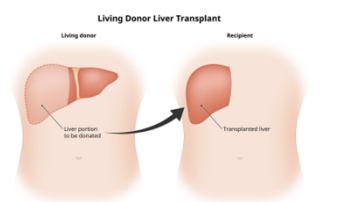


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Liver Transplant

- Treatment option for acute liver failure, end-stage liver disease, and primary hepatic malignancy
- Infrequently cures the underlying disease
 - Recurrent liver disease post transplant 0-100% depending on the disease
 - Risk-benefit analysis
- Become candidate once MELD is ≥ 15
- **Model for End-Stage Liver Disease (MELD)**
 - Numerical scale estimating how urgently a transplant is needed within next 3 months
 - 6 (less ill) $\rightarrow$ 40 (gravely ill)
- Calculated from patient sex + several labs



Obtained from: <https://www.mountelizabeth.com.sg/tests-treatments/living-donor-liver-transplant>



Uptodate. Accessed August 21, 2026. <https://www.uptodate.com/contents/model-for-end-stage-liver-disease-meld>
 Uptodate. Accessed August 21, 2026. <https://www.uptodate.com/contents/liver-transplantation-in-adults-patient-selection-and-pretransplantation-evaluation>

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Liver Transplant at VCU

- High volume transplant center (~200 liver transplants per year)
 - Perform deceased donor transplants and living donor transplants
- Many achievements in transplant
 - Virginia's first ever liver transplant
 - United State's first fully robotic living donor transplant 2025
 - World's first living donor liver retrieval
- Continue to expand volume and outcomes
 - Recent opening of a dedicated liver transplant unit
- High risk candidates often transplanted
 - Malnutrition prevalent, seemed to be associated with increase complications post-op



Obtained from: <https://www.vcuhealth.org/news/revolutionizing-living-donation-a-world-first-in-robotic-surgery/>



Redefining the future of transplant medicine at vcu health hume-lee transplant center | vcu health. October 23, 2025. Accessed August 21, 2026. <https://vcuhealth.org/news/redefining-the-future-of-transplant-medicine-at-vcu-health-hume-lee-transplant-center/>
 Revolutionizing living donation: A world first in robotic surgery | VCU Health. January 24, 2025. Accessed August 21, 2026. <https://vcuhealth.org/news/revolutionizing-living-donation-a-world-first-in-robotic-surgery/>

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Quality Initiative

Does pre-transplant nutritional status predict post liver transplant outcomes?



Primary Outcomes: Post Transplant Length of Stay, ICU Days, Ventilator Days

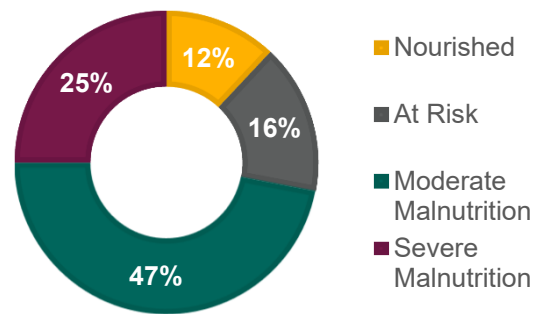


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Control Data

- n = 127
- Average MELD: 33
- 41 transplants
 - 85% transplanted during initial hospital encounter
 - 72% with malnutrition
- 16 cases received peri-op nutrition support
 - 99% malnourished
- 4 deaths post-op

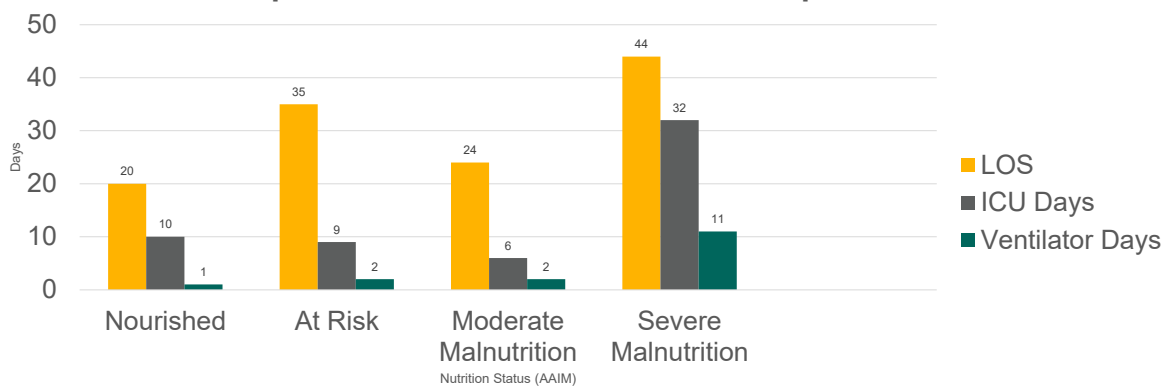
PRE-TRANSPLANT NUTRITION STATUS (AAIM)



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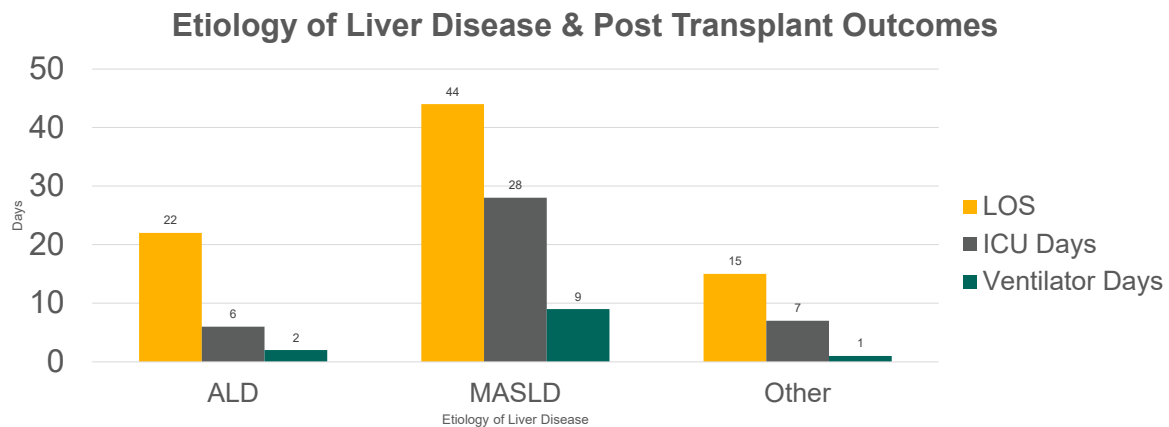
Control Data

Pre-Transplant Nutrition Status & Post Transplant Outcomes



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Control Data

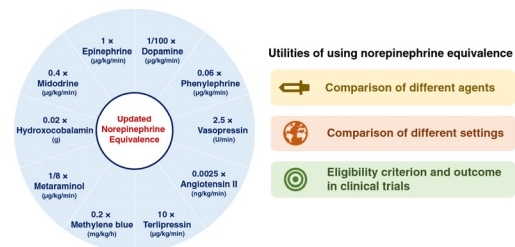


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Institution Guidelines

- Dedicated Transplant RD
- Updated order set for cirrhosis admissions
 - RD consult
 - 2g Na diet + Calorie count
 - Oral nutrition supplements
- Early escalation to enteral nutrition support
 - Unable to meet $\geq 50\%$ nutrient needs via PO within 3 days of admission
 - MELD >35
 - Refractory hepatic encephalopathy
 - Severe Malnutrition
 - BMI <18
- Liberalized criteria for enteral feeding while vasopressors are in use

An updated "Norepinephrine Equivalent" score in intensive care as a marker of shock severity



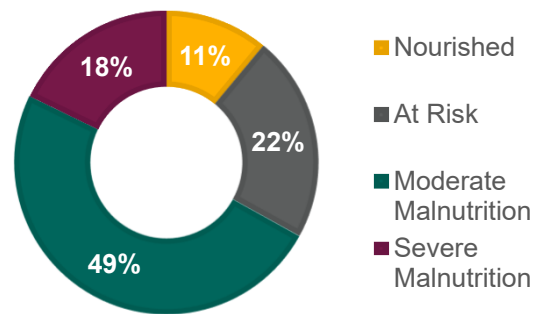
Obtained from: <https://link.springer.com/article/10.1186/s13054-023-04322-y/figures/1>

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Intervention Data

- n = 129
- Average MELD: 35
- 38 transplants
 - 79% with malnutrition
 - Time from listing to transplant: 7.6 days
 - Time from admission to transplant: 18 days
- 3 deaths post-op

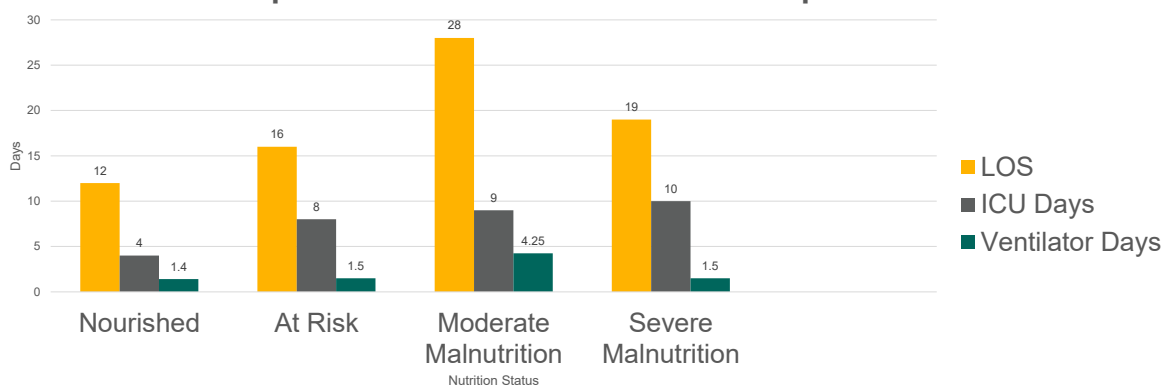
PRE-TRANSPLANT NUTRITION STATUS (AAIM)



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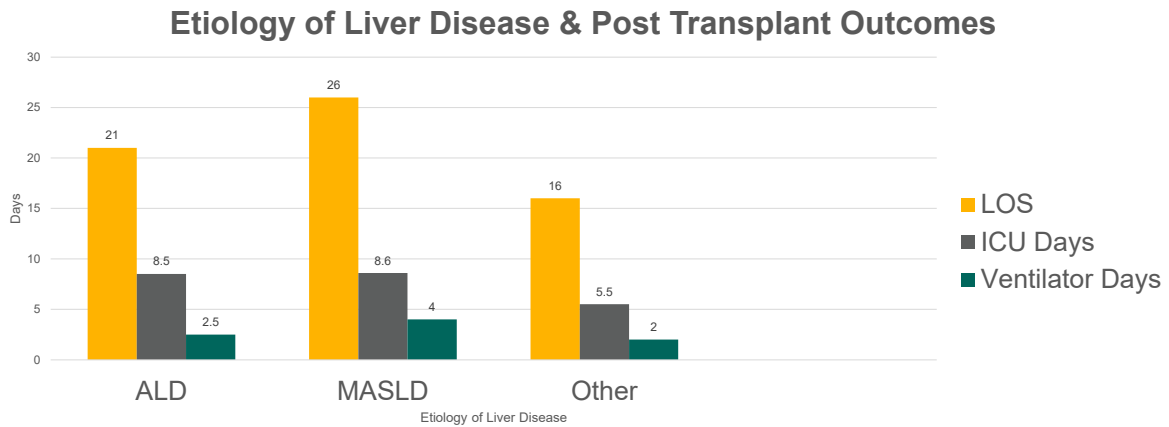
Intervention Data

Pre-Transplant Nutrition Status & Post Transplant Outcomes



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Intervention Data



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Nutrition Status Outcome Changes after Intervention

Nutrition Status	Percent Change		
	LOS	ICU Days	Ventilator Days
Nourished	↓ 40%	↓ 60%	↑ 40%
At Risk	↓ 54%	↓ 11%	↓ 25%
Moderate Malnutrition	↑ 17%	↑ 50%	↑ 100%
Severe Malnutrition	↓ 57%	↓ 69%	↓ 85%

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Etiology of Liver Disease Outcome Changes after Intervention

Etiology	Percent Change		
	LOS	ICU Days	Ventilator Days
ALD	↓ 5%	↑ 42%	↑ 25%
MASLD	↓ 41%	↓ 69%	↓ 56%
Other	↑ 7%	↓ 21%	↑ 100%

Limitations

- Quality improvement initiative ≠ controlled study
- Single center review, small sample size
- Variation in adherence to the institutional standard of care guideline
- Limitations to diagnosing malnutrition in this population

QI Take Aways

- Protocolized nutrition interventions and early escalation to enteral support improve post transplant outcomes
- Malnutrition is associated with increased LOS, ICU days and ventilator days
- Patients with ALD and MASLD cirrhosis are at the highest risk for malnutrition and experience poorer post-operative outcomes
- Liver transplantation frequently occurs within 20 days of admission
 - Early nutrition intervention is critical
 - Opportunities for nutrition optimization exist in the outpatient setting



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Learning Assessment Question 4

Which of the following statements about frailty in patients with end-stage liver disease is TRUE?

- A. Frailty is defined solely by unintentional weight loss and decreased physical activity
- B. Liver Frailty Index is calculated using serum albumin, MELD score, and BMI
- C. Liver Frailty Index includes handgrip strength, chair stands, and balance testing and is predictive of transplant waitlist mortality
- D. Liver Frailty Index score ≥ 4.5 is classified as robust.



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Learning Assessment Answer 4

Which of the following statements about frailty in patients with end-stage liver disease is TRUE?

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Frailty

- Condition characterized by declines in physiological reserve and function across multiple body systems
 - End stage organ failure particularly vulnerable to developing frailty
- Characteristics:
 - Weight loss (≥ 5 percent of body weight in last year)
 - Exhaustion
 - Weakness (decreased grip strength)
 - Slow walking speed
 - Decreased physical activity
 - All the above must exceed what might be expected based on age alone



Kobashigawa J, Dadhania D, Bhorade S, et al. Report from the american society of transplantation on frailty in solid organ transplantation. *Am J Transplant*. 2019;19(4):984-994. doi:10.1111/ajt.15198

Geng D, Wang Y, Wu X, Hu X. Impact of pre-existing frailty on survival outcomes in solid-organ transplant candidates and recipients: A meta-analysis. *Ageing Research Reviews*. 2024;99:102364. doi:10.1016/j.arr.2024.102364

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Frailty

Liver Frailty Index (LFI)

- Strongly predictive of transplant waitlist mortality
- 3 measures
 - Handgrip strength
 - Chair stands
 - Balance testing
- $LFI = (-0.330 \times \text{sex-adjusted grip strength}) + (-2.529 \times \text{number of chair stands per second}) + (-0.040 \times \text{balance time}) + 6$
 - Robust = <3.2
 - Prefrail = $3.2-4.4$
 - Frail = ≥ 4.5



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
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Implementation of Frailty Protocol

Outpatient Transplant Evaluation

- Assessment with multidisciplinary transplant team
 - Evaluate for potential barriers to transplant
- Nutrition assessment
 - Identify transplant risks (malnutrition, prohibitive BMI, diet non-compliance)
 - Individualized nutrition interventions to optimize prior to surgery
- Frailty Assessment using LFI
 - LFI ≥ 4.5 triggers 3 month reassessment (nutrition re-evaluation + repeat LFI) until LFI <4.5 or transplant



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Case Report



HPI:

Decompensated alcohol associated cirrhosis complicated by ascites and hepatic encephalopathy presenting to clinic for transplant evaluation

Current medications: Creon, multivitamin, thiamine, folic acid, lactulose, rifaximin, spironolactone, furosemide

Findings:

- Prolonged poor intake from nausea, vomiting, early satiety
- Weekly paracentesis ~5L removal
- Severe muscle wasting
- MELD 17

PMH:

Decompensated alcohol associated cirrhosis, chronic pancreatitis, HTN, depression, anxiety, GERD



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Case Report



Visit 1 (Transplant Eval):

Weight: 44.1 kg | BMI: 16.2 kg/m² | LFI: 5.79

Standard nutrition care guidelines implemented

Enrolled in home PT

Visit 2 (3 months post eval):

Weight: 48.2 kg | BMI: 17.7 kg/m² | LFI: 4.55

Improved appetite, 5 meals + HS snack, daily oral nutrition supplement

Home PT → Outpatient PT

Visit 3 (5 months post eval):

Weight: 56.8 kg | BMI: 20.97 kg/m² | LFI: 4.22

Diet patterns stable. Managing new diabetes diagnosis

Independently walking, tolerating daily 20 min walks



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Transplant Waitlist



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Questions



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References

1. Yang N, Caravella J, Medici V, Kappus M. Chapter 29: Liver Disease. In: Chan LN, Kumpf VJ, eds. ASPEN Adult Nutrition Support Core Curriculum. 4th edition. American Society for Parenteral and Enteral Nutrition; 2025:765-802.
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