Perioperative Nutrition in Liver Transplant

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Conflict of interest disclosure

I have **no**, real or perceived, direct or indirect conflicts of interest that relate to this presentation.

Background

Liver transplantation (LT) is a complex surgical procedure requiring thorough pre- and post-operative planning and care. The nutritional status of the patient before, during, and after LT is crucial to surgical success and long-term prognosis

The relation between the nutritional status of patients with advanced chronic liver disease (cirrhosis) and clinical outcomes has become increasingly evident in the last few years.

Federico Ravaioli et al. Nutrients **2023**

Goals of Nutritional Therapy in Patients With ESLD Waiting for LT

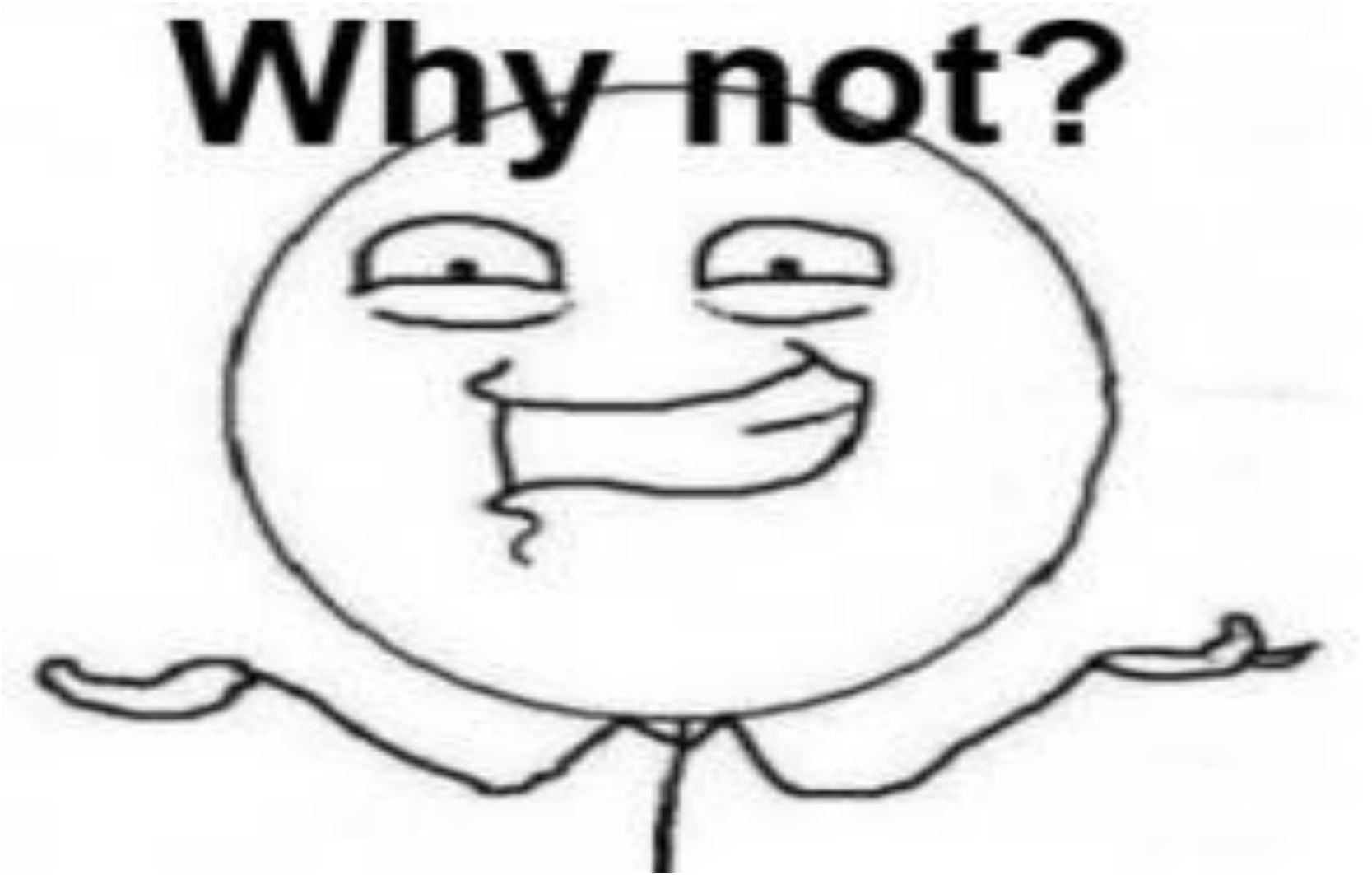
-Correct malnutrition and prevent metabolic complications.

-Educate patients and caregivers on individual plan for nutrition and level of activity.

-Reduce perioperative complications .

-Towards a strategy for a “safe & healthy living” with an organ transplant.

Why is perioperative nutrition support in hepatic patients widely accepted, but not widely practiced?



Common misconceptions in dietary advice in cirrhosis

-There are several myths regarding pathogenesis and treatment of malnutrition in cirrhosis.

-For more than half a century, protein restriction has been one of the main treatments for HE.

-Older clinical observations had been reported that high protein intake may worsen encephalopathy in patients with cirrhosis and it had become a universal practice to recommend low-protein diet to patients with cirrhosis.

Not do these patients need to be fed, but rather how to do it and when to start?

-Malnutrition usually evolves prior to clinical signs of hepatic insufficiency.

-Protein energy malnutrition (PEM) is found in 65%- 95% of patients with end stage liver disease (ESLD) awaiting transplantation and malnutrition before transplantation leads to higher rates of post-transplant complications and worse graft survival outcomes.

Antonio J LIVER TRANSPLANTATION; 2006

Zhang, and Wang Hepatobiliary Surg Nutr; 2014

Let’s Take It From The Top

A Physiology Review

Liver Functions

Removes potentially toxic byproducts of certain medications.

Prevents shortages of nutrients by storing vitamins, minerals and sugar.

Metabolizes, or breaks down, nutrients from food to produce energy, when needed.

Produces most proteins needed by the body.

Helps your body fight infection by removing bacteria from the blood.

Produces most of the substances that regulate blood clotting.

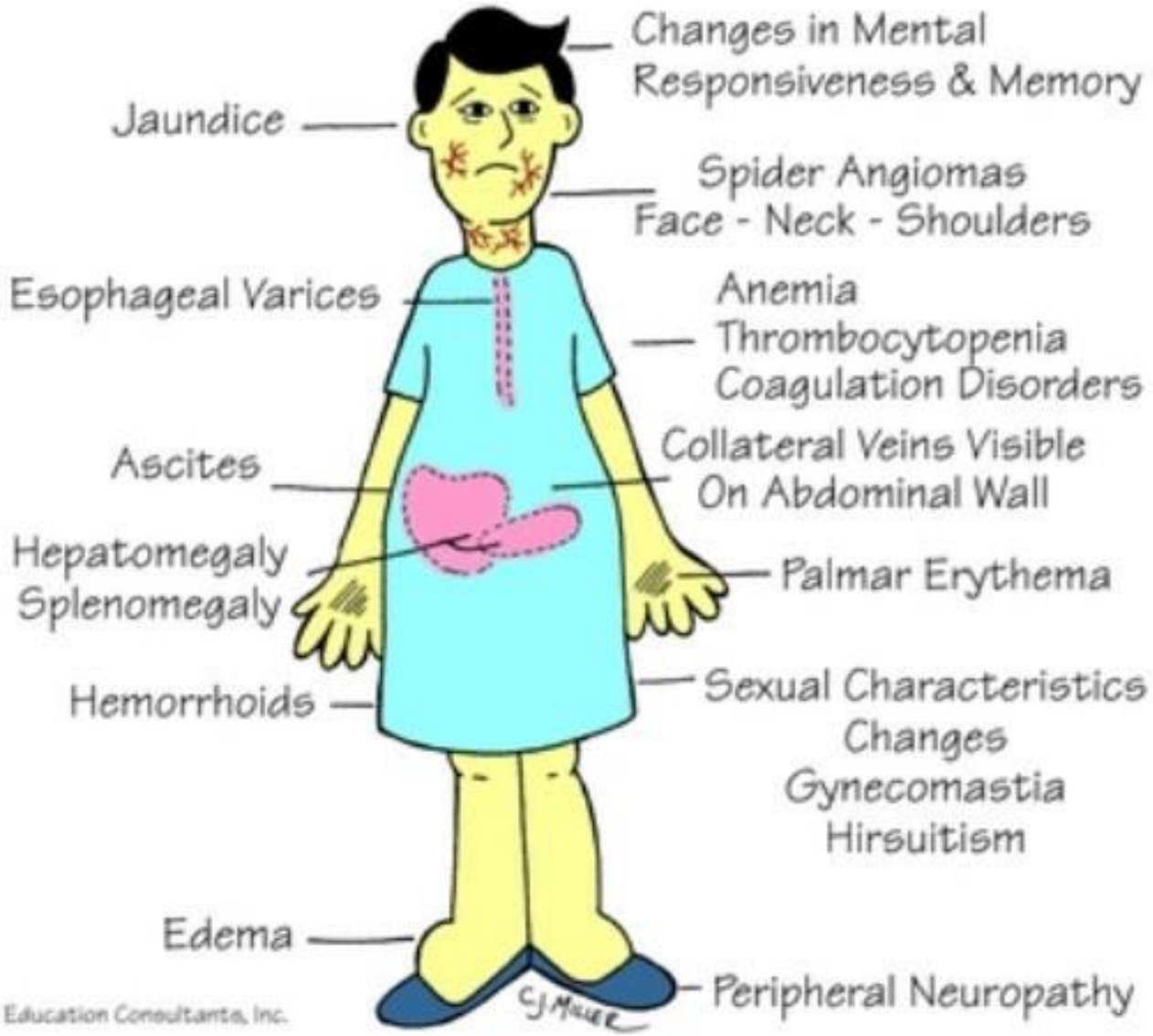
Produces bile, a compound needed to digest fat and to absorb vitamins A, D, E and K.

Decreased intake	Metabolic alterations
Anorexia-early satiety and nausea Ascites Altered mental status/ encephalopathy Altered gustatory sensation Frequent hospitalizations-unpalatable diet	Increased or decreased metabolic rate Glucose intolerance/insulin resistance Rapid postprandial gluconeogenesis Reduced glycogen stores Elevated leptin and TNF-α Decreased insulin-like growth factor Increased resting energy expenditure Increased protein requirements and protein degradation Preference for fat oxidation Decreased bile salts and Increased fat malabsorption
Decreased absorption	**Iatrogenic factors**
Inadequate bile flow Pancreatic insufficiency Bacterial overgrowth	Overzealous dietary restrictions, frequent paracentesis Diuresis (micronutrient losses), lactulose therapy

TNF-α: Tumor necrosis factor alpha

Federico Ravaioli et al., Nutrients 2023, 15, 2778

CIRRHOSIS:
LATER CLINICAL MANIFESTATIONS



NUTRITION SCREENING & ASSESSMENT

Liver cirrhosis patients scheduled for elective surgery or listed for transplantation should be screened and assessed for malnutrition timely in order to treat malnutrition prior to surgery and thereby improve body protein status. (Grade B, strong consensus, 100%)

ESPEN practical guideline 2020: “Clinical nutrition in liver disease

Nutritional screening tools to assess the risk of malnutrition in patients and specific chronic liver diseases

Nutritional Screening Tool	Variables Included	Pro	Cons
Mini Nutritional Assessment Short Form (MNA-SF) [49]	• Decrease in food intake • Weight loss • Mobility • Psychological stress/acute disease • Neuropsychological problems • BMI	• Predictive validity for adverse outcome, social functioning, mortality • Practical • Greatest sensitivity and specificity compared to the full form of the MNA	• Interrater reliability modest • Weight from fluid collections (ascites, peripheral edema) not accounted for • Disease severity not considered
Malnutrition Universal Screening Test (MUST) [50]	• Unplanned weight loss in past 3–6 months • Acutely ill and unable to eat for > 5 days • BMI	• High interrater reliability • Content and predictive validity for length of hospital stay and mortality • Practical	• Weight from fluid collections (ascites, peripheral edema) not accounted for • Disease severity not considered
Simplified Nutritional Appetite Questionnaire (SNAQ) [51]	• Unintentional weight loss • Decreased appetite • Use of supplements or tube feeding	• Practical • Facilitates identification and treatment of malnourished inpatients	• Weight from fluid collections (ascites, peripheral edema) not accounted for • Disease severity not considered
Nutritional Risk Screening 2002 (NRS 2002) [52]	• Weight loss • Food intake • BMI • Disease severity	• Content and predictive validity • Moderately reliable • Practical • Considers disease severity	• Weight from fluid collections (ascites, peripheral edema) not accounted for
Malnutrition Screening Tool (MST) [53]	• Unintentional weight loss • Quantity of weight lost • Decreased appetite	• Simple/practical • Predictive validity for length of stay • Good reliability • Highly sensitive	• Weight from fluid collections (ascites, peripheral edema) not accounted for • Disease severity not considered
Nutrition Risk in the Critically Ill (NUTRIC Score) [53,54]	• Absence of food intake, whether acute or chronic • Age • APACHE II and SOFA scores • Comorbidities • Days in hospital pre-ICU • Interleukin-6	• Externally validated	• Interleukin-6 not widely available • Requires training • Classic nutrition parameters not considered
Nutritional Risk Index (NRI) [55]	• Albumin • Weight loss	• Simple • Facilitates identification of malnourished inpatients	• Weight from fluid collections (ascites, peripheral edema) not accounted • Disease severity not considered

Nutritional screening tools to assess the risk of malnutrition in patients and specific chronic liver diseases

Liver disease-tailored

The Royal Free Hospital-Nutritional Prioritizing Tool (RFH-NPT) [56]	• Alcoholic hepatitis or tube feeding • Considers fluid overload • Dietary intake reduction • Weight loss • One option for assessing diuretic use	• Simple/practical cirrhosis-specific features • Excellent intraobserver and interobserver reproducibility • Good external validity • Predictive of clinical deterioration and transplant-free survival	• Valid in population with cirrhosis only • Impact of nutritional therapy based on screening score unknown
The Liver Disease Undernutrition Screening Tool (LDUST) [57]	• Nutrient intake • Weight loss • Subcutaneous fat loss • Muscle mass loss • Fluid accumulation • Decline in functional status	• Quick and easily • Detecting undernutrition in both inpatients and outpatients • Weight from fluid collections (ascites, peripheral edema) accounted for	• Relies on the patient's subjective judgment • A negative screen was unable to reliably rule out undernutrition

Nutritional screening tools to assess the risk of malnutrition in patients and specific chronic liver disease

NRS-2002 and MUST are validated tools to screen hospitalized patients for risk of malnutrition and are recommended by ESPEN. **The Royal Free Hospital Nutrition Prioritizing Tool** has been developed as a screening tool for malnutrition in liver disease patients. In a head-to-head comparison, the Royal Free Hospital Nutrition Prioritizing Tool was **more sensitive** than the NRS-2002 to identify liver patients at risk for malnutrition.

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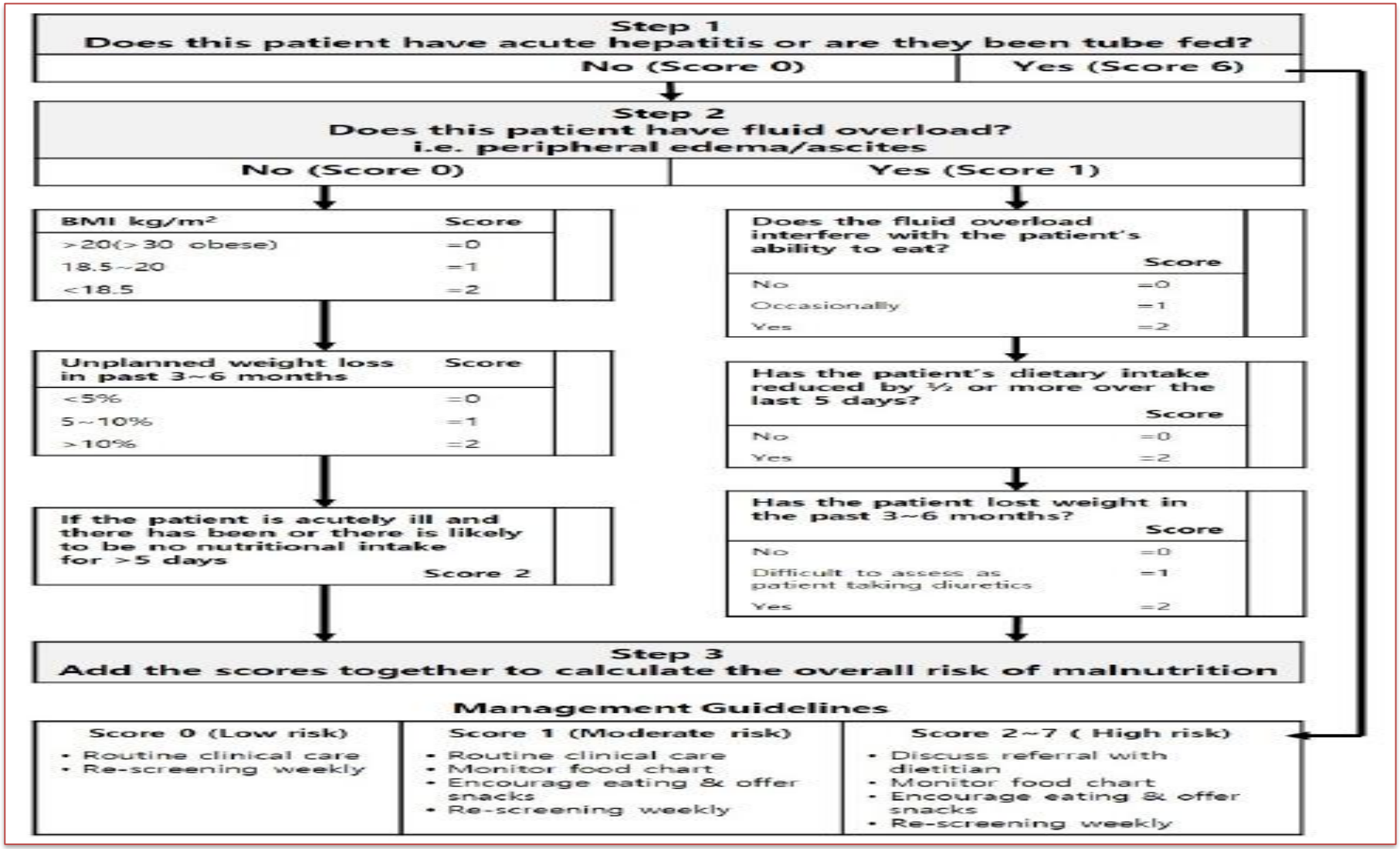
Royal free hospital-nutritional prioritizing tool (RFH-NPT



The RFH-NPT identified patients who were at high risk for malnutrition with a diagnostic sensitivity of 100% and specificity of 73%

Arora J Hepatol 2012;56 Suppl2:S241.

Subjective Global Assessment

SUBJECTIVE GLOBAL ASSESSMENT OF NUTRITIONAL STATUS

select appropriate category with a checkmark, or enter numerical value

A. HISTORY

1. Weight change: Normal weight = #_____ kg IBW = #_____ kg
Overall change in past 6 months = #_____ kg loss/gain Current weight = #_____ kg
% change in past 6 months = _____ % loss/gain %IBW = _____ %
Change in past 2 weeks: no change ↑ ↓ Amt = #_____ kg

2. Dietary intake change (relative to normal)
_____ No change _____ ↑'d intake _____ ↓'d intake
Duration of change = # _____ weeks
If intake ↓'d: Type of change _____ Suboptimal solid diet _____ Full liquid diet
_____ Hypocaloric liquids _____ Starvation

3. Gastrointestinal symptoms persisting for >2 weeks
_____ None _____ Nausea _____ Vomiting _____ Diarrhea _____ Anorexia

4. Functional Capacity
_____ No dysfunction (full capacity) _____ Dysfunction: duration = # _____ weeks
Dysfunction: _____ Working suboptimally _____ Ambulatory _____ Bedridden
Specific handicap(s):

_____

5. Disease and its relation to nutritional requirements
Primary diagnosis:

_____

Metabolic demand (stress) _____ None _____ Low _____ Moderate _____ High

B. PHYSICAL FINDINGS: 0 = normal 1+ = mild 2+ = moderate 3+ = severe
_____ loss of subcutaneous fat (triceps, chest) _____ ankle edema _____ ascites
_____ muscle wasting (quadriceps, deltoids) _____ sacral edema

C. SUBJECTIVE GLOBAL ASSESSMENT RATING (select one)

A Nourished
B Moderately malnourished
C Severely malnourished

This test has shown high specificity (96%) with a very low sensitivity (22%) for diagnosing malnutrition in patients with alcoholic liver disease. However, it has been found to be a reliable tool to evaluate nutritional status in liver transplant patient

Eleni T. Tsiaousi 2008

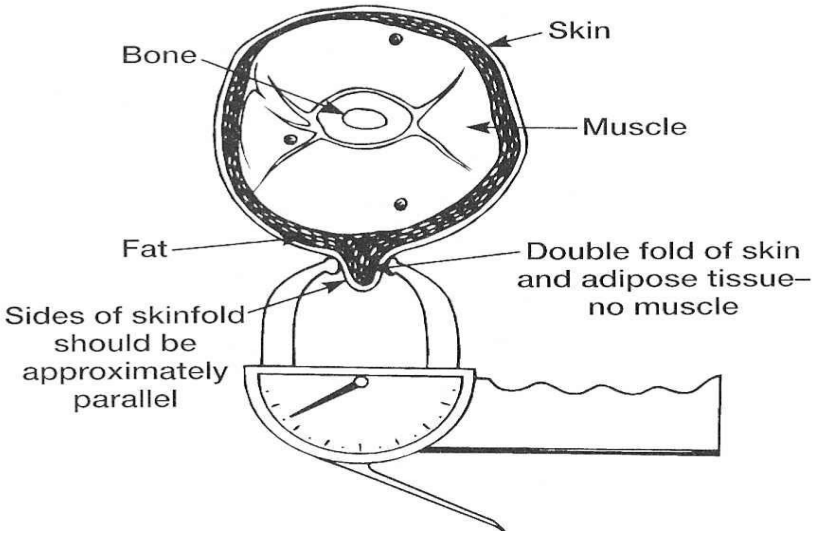
Anthropometry, laboratory values, body composition analysis, and handgrip (HG) strength are tools that the clinician can use to help determine a patient's nutritional status. Early detection and interventions to correct nutritional deficits in patients with liver disease may help improve their morbidity and mortality.

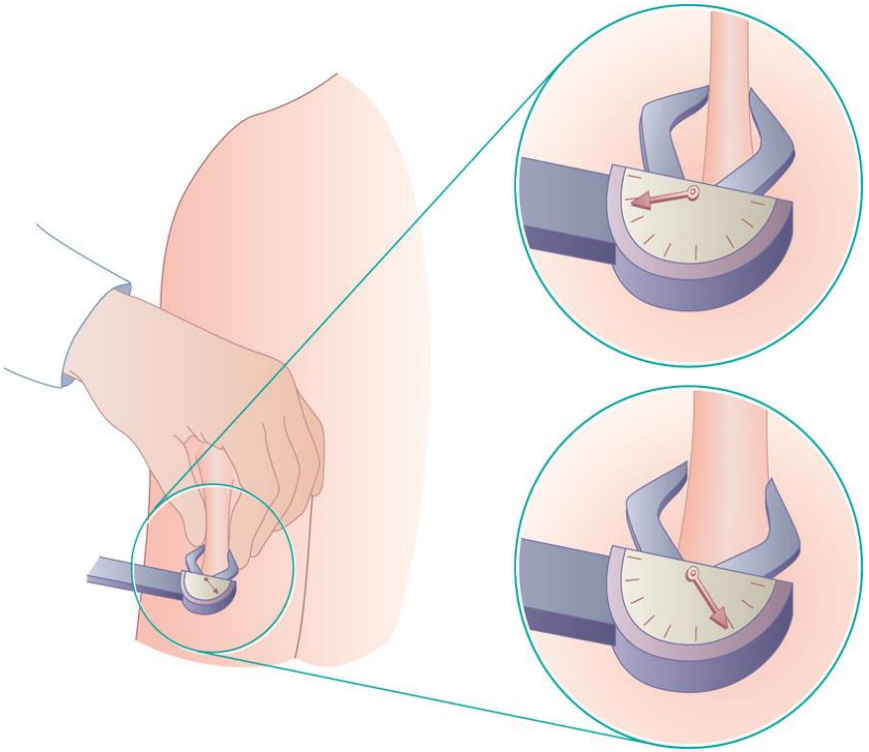
MacDonald AA. Top Clin Nutr. 2010

BMI with cut-off values of **< 22 kg/m^2** in non-ascitic patients, **< 23 kg/m2** in patients with mild ascites and **< 25 kg/m2** in patients with tense ascites is a simple and adequate tool to detect malnutrition in cirrhotic patients. **Peripheral edema and removal of ascites do not significantly affect the validity of the method**

Bernard Campillo Gastroentérologie Clinique et Biologique 2006

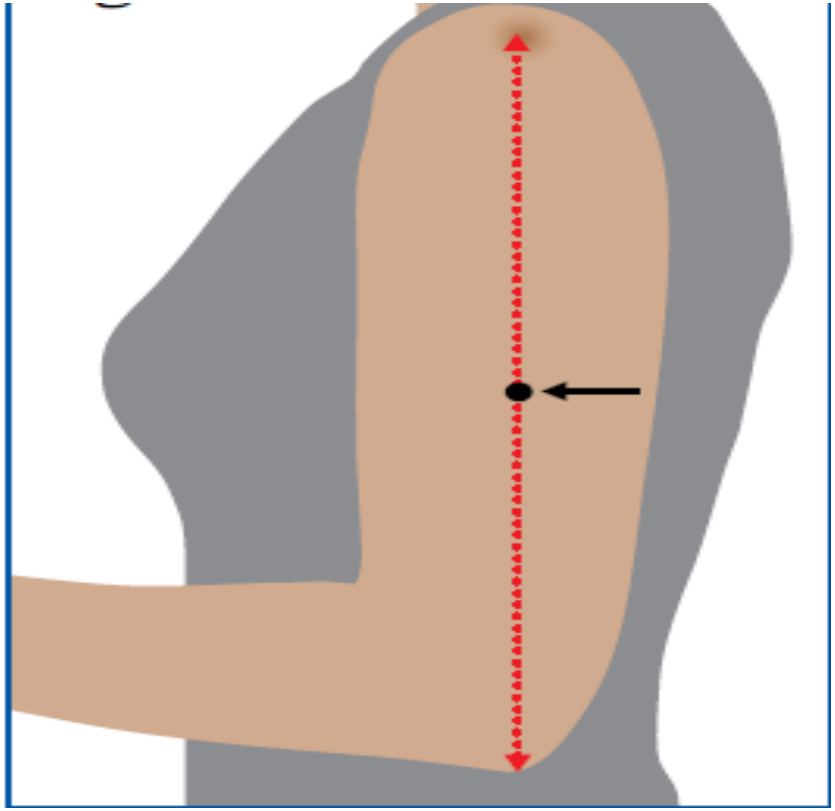
Triceps Skinfold Thickness

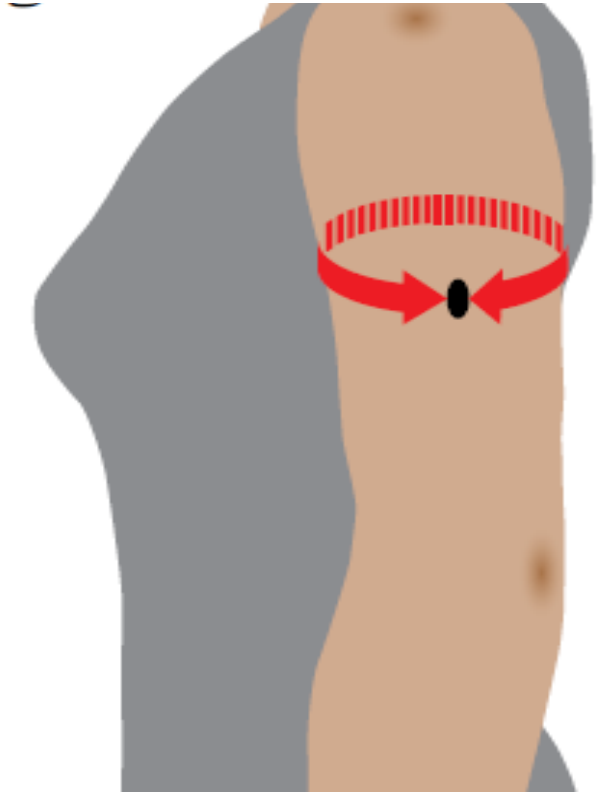




Fat mass is calculated and lean mass is derived by subtracting the fat mass from the total mass.

Midarm circumference





Body Circumferences and Areas

Midarm muscle circumference (MAMC): determined from the MAC and triceps skinfold (TSF)

MAMC = MAC – (3.14 X TSF)

Mean values for MAMC decreased by 30% in males and by 40% in females with moderate to severe liver failure

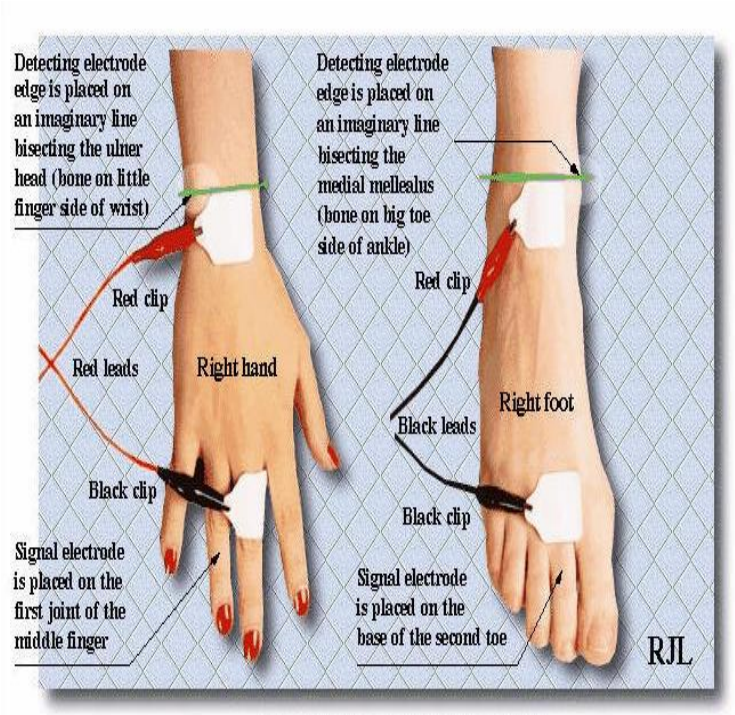
Mid-arm muscle circumference and handgrip strength measurements appear to be sensitive markers of body cell mass depletion

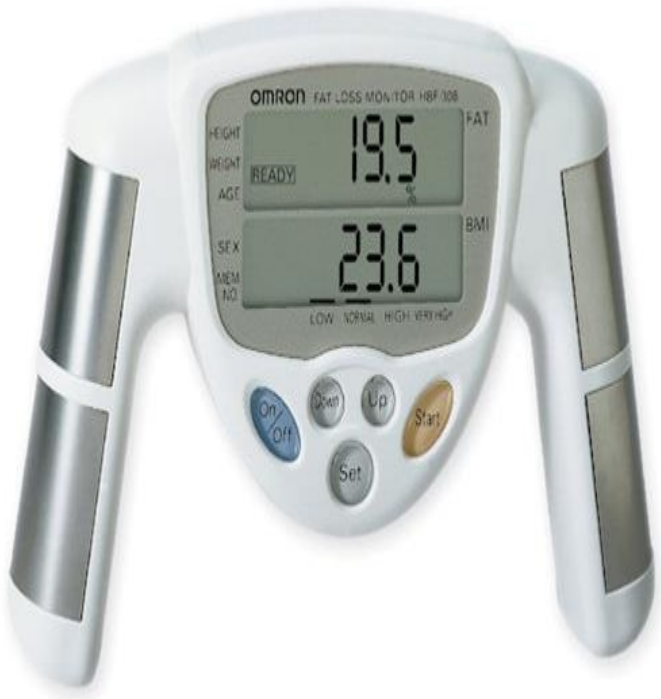
Figueiredo FA, et alLiver Transpl 2000;6:575-581.

Bioelectrical Impedance Analysis (BIA)

Measures electrical conductivity through water in difference body compartments

The use of BIA increased the prevalence of malnutrition by >60% in Child's classes A and B patients and by >20% in Child's class C patients





Dual-energy X-ray absorptiometry

(DEXA) of the whole body is a method utilized to quantify bone mineral density, as well as fat and fat-free mass in patients with chronic liver disease. However, it is less precise than a CT scan and not recommended for instances of fluid retention, which can lead to an underestimation of sarcopenia.

Strauss, B.J.G et al, Total Body Dual X-RayAbsorptiometry Is a Good Measure of Both Fat Mass and Fat-Free Mass in Liver Cirrhosis Compared to “Gold-Standard”Techniques. Ann. N. Y. Acad. Sci. 2000, 904, 55–62.

HAND GRIP STRENGTH PROCEDURE

Lateral and anterior view: the correct positioning when performed hand grip test

Female (Age)	Needs Improvement	Fair	Good	Very Good	Excellent
15-19	< 54	54-58	59-63	64-70	> 70
20-29	< 55	55-60	61-64	65-70	> 70
30-39	< 56	56-60	61-65	66-72	> 72
40-49	< 55	55-58	59-64	65-72	> 72
50-59	< 51	51-54	55-58	59-64	> 64
60-69	< 48	48-50	51-53	54-59	> 59

Male (Age)	Needs Improvement	Poor	Fair	Good	Excellent
15-19	< 84	84-94	95-102	103-112	> 112
20-29	< 97	97-105	106-112	113-123	> 123
30-39	< 97	97-104	105-112	113-122	> 122
40-49	< 94	94-101	102-109	110-118	> 118
50-59	< 87	87-95	96-101	102-109	> 109
60-69	< 79	79-85	86-92	93-101	> 101

HG seems to be a simple, inexpensive, and effective method to detect PEM, or at least nutritional risk.

HG lacked specificity and had a positive prediction value of only 38% and the negative value was 100%.

Bakshi N et al Indian J Crit Care Med. 2014

Circulating concentrations of visceral plasma proteins

Produced by the liver

Affected by protein deficiency, but also renal and hepatic disease, wounds and burns, infections, zinc and energy deficiency, cancer, inflammation, hydration status, and stress

Albumin (T½).....20 days

Transferrin (T½).....8 -10 days

Prealbumin(T½).....2-3 days

Retinol binding protein (T½)...10 hours

Impact of Sarcopenia on Liver Transplantation

Sarcopenia identifies a loss of muscle mass and function due to age or acute or chronic diseases, including cirrhosis; it is a significant component of malnutrition and a persistent complication in cirrhosis, negatively impacting survival, quality of life, and survival after LT

The proportion of cirrhotic patients presenting sarcopenia ranges from 30 to 80%

The gold standard for diagnosing sarcopenia is measuring skeletal muscle mass on cross-sectional imaging, and it can be obtained through various techniques such as the calculation of the psoas or the dorsal muscle area and the skeletal muscle index (SMI)

Marasco, G. et al. Clinical Impact of Sarcopenia Assessment in Patients with Liver Cirrhosis. Expert Rev. Gastroenterol. Hepatol. 2021, 15, 377–388

Van Vugt, J.L. et al 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, 2277–2292.

Impact of Sarcopenia on Liver Transplantation

A recent study has developed a model called "Sarco-Model2" which combines sarcopenia and MELD-Na and has shown good diagnostic ability in predicting the risk of dropping out after three months in sarcopenic patients with a MELD-Na < 20. However, for sarcopenic patients with a MELD-Na of 35–40, the model suggests a high graft loss risk and recommends "futile" transplantation.

Existing studies on sarcopenic obesity in cirrhotic patients are limited, the estimated the prevalence to be around 20–35%, with a 1.5-fold increase in mortality compared to cirrhotic patients without SO.

Lai, Qet al. SarcoModel: A Score to Predict the Dropout Risk in the Perspective of Organ Allocation in Patients Awaiting Liver Transplantation. Liver Int. 2021, 41, 1629–1640.

. Montano-Loza, A.J et al. Sarcopenic Obesity and Myosteatosis Are Associated with Higher Mortality in Patients with Cirrhosis: Sarcopenic Obesity and Myosteatosis in Cirrhosis. J. Cachexia Sarcopenia Muscle 2016, 7, 126–135.

Accepted: 19 February 2018

DOI: 10.1111/ctr.13226

REVIEW ARTICLE

WILEY Clinical TRANSPLANTATION
The Journal of Clinical and Translational Research

Both sarcopenia and frailty determine suitability of patients for liver transplantation—A systematic review and meta-analysis of the literature

Judith Kahn[1,2] | Doris Wagner[3] | Nicole Homfeld[1,2] | Helmut Müller[1,2] | Daniela Kniepeiss[1,2] | Peter Schemmer[1,2]

Frailty is a clinical syndrome in which 3 or more of the following criteria occur: 1. Unintentional weight loss, 2. Self-reported exhaustion, 3. Weakness (by grip strength), 4. Slow walking speed and 5. Low physical activity

6 studies published between 2014-2017

Kahn J. Clin Transplant. 2018:e13226

Recommendations for nutritional therapy in patients prior to liver transplant

MNT in chronic Liver Disease

- **Poor Dietary Intake**
  - Due to poor appetite, early satiety with ascites
    - Small frequent meals-
    - Aggressive oral supplementation
    - Zinc supplementation (50 mg of elemental zinc taken with a meal)
- **Nutrient Malabsorption**
  - Due to ↓ bile, failure to convert to active forms
    - ADEK supplementation
    - Calcium + D supplementation
    - Folic Acid Supplementation (400 and 1,000 mcg daily)
    - Early supplement of thiamine before glucose in alcoholic hepatitis (5-300 mg daily)

MNT in chronic Liver Disease

- **Calories**

Most patients are malnourished so supplementing full calories

refeeding syndrome

Malnourished patients	Begin with reduced caloric level for the first 2 -3 day
Patients with ascites	Calculate calories according to euvolemic weight (**IBW**) to prevent overestimated energy

Caloric requirement/kg of estimated euvolemic weight

Refeeding risk	15 to 20 kcl/kg
Maintenance	25 to 30 kcl /kg
anabolism	30 to 35 kcal /kg

Carbohydrates

Complex Carbohydrates

Starches

- Good sources are potatoes, bread, etc.
- Glucose

Dietary Fiber

- Insoluble Fiber (good sources are All Bran, Branflakes, etc)
- Glucose
- Soluble Fiber (good sources are lentils, beans, oatmeal, psyllium)
- Glucose

Simple Carbohydrates

Sugars

- Disaccharides = 2 sugars (Sucrose, Maltose, Lactose
- Sucrose = glucose + fructose
- Lactose = glucose + galactose
- Maltose = 2 glucoses
- Monosaccharides = 1 sugar (Glucose, Fructose, Galactose)

Complex carbohydrates

Complex carbohydrates provide vitamins, minerals, and fiber

Foods such as breads, legumes, rice, pasta, and starchy vegetables contain complex carbohydrates

A.D.A.M.

Simple carbohydrates

Simple carbohydrates are found in foods such as fruits, milk, and vegetables

Cake, candy, and other refined sugar products are simple sugars which also provide energy but lack vitamins, minerals, and fiber

A.D.A.M.

BCAA Supplementation
Effective or Not?

Patients with ESLD have an imbalance of branched-chain amino acids (leucine, isoleucine, and valine) and aromatic amino acids (phenylalanine, methionine, and tyrosine).

The expected ratio should be 3.5:1; however, this ratio falls to 1:1 in patients with ESLD allowing increased cerebral uptake of aromatic amino acids, promoting the synthesis of false neurotransmitters (octopamine, phenylethylamine, and phenylethanolamine) which in turn may affect neurocognitive function by competing with endogenous neurotransmitters.

Antonio J et al 2006 LIVER TRANSPLANTATION 12:1310-1316.

Long-term oral BCAA supplements (0.25 g·kg_{i1}·d_{i1}) should be prescribed in patients with advanced cirrhosis in order to improve event-free survival or quality of life (Grade B, consensus 89%)

In adults, for preoperative nutrition standard nutrition regimens shall be used, since specialized regimens (e. g. BCAA-enriched, immune-enhancing diets) were not superior to standard regimens regarding morbidity or mortality.
(Grade A, strong consensus 100%)

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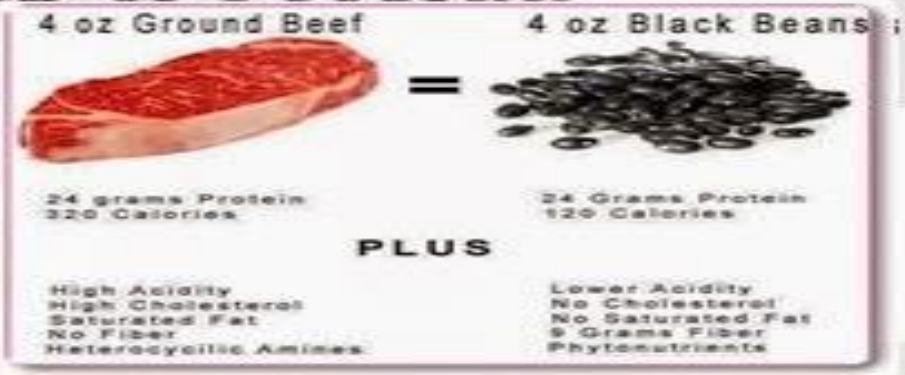
If patients are able to eat more than 70 g protein/d without deterioration of mental status, no modification of their diet is necessary or effective. In patients with borderline protein intolerance (60-70 g protein/d) a vegetable diet, or a diet rich in fiber may help to prevent hepatic encephalopathy.

ESPEN guidelines for nutrition in liver disease 2020

Vegetarian Sources of Protein©

g=grams



Vegetables (1 cup cooked)	Protein (g)
Split peas	16.35g
Baked potato (7 oz)	8.7g
Green peas, frozen	8.24g
Spinach	5.97g
Artichokes	5.85g
Brussels sprouts	5.64g
Asparagus	5.31g
Mixed vegetables, frozen	5.21g
Broccoli	4.65g
Beet Greens	3.7g
Beets	2.86g
Parsnips	2.06g
Tomatoes	1.53g
Green cabbage	1.53g
Peppers	1.25g
Red cabbage, raw	0.97g
Leeks	0.84g

Dried Fruit (peices)	Protein(g)
Raisins, (1 cup)	4.67g
Dried apricots, (5)	1.19g
Figs, (2)	1.16g
Prunes, (5)	1.1g
Dates, (5)	0.8g
Dried apples, (5)	0.3g

Fruit (1 medium fruit unless stated)	Protein(g)
Papaya	1.85g
Melon (1 cup)	1.41g
Orange	1.23g
Banana	1.22g
Mango	1.06g
Grapes (1 cup)	1.06g
Blackberries (1 cup)	1.04g
Blueberries (1 cup)	0.97g
Cherries, sweet, raw (10)	0.82g
Grapefruit, white (1/2)	0.81g
Kiwi fruit	0.75g
Grapefruit, pink (1/2)	0.68g
Peach	0.69g
Pear	0.61g
Apricot	0.49g
Apple	0.26g

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Evaluation of serum taurine as a prognostic marker for graft function in adult Egyptian patients undergoing living donor liver transplant

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ABSTRACT

Background: Taurine has been investigated as a potential screening marker for early diagnosis of hepatocellular carcinoma and other liver diseases. This study was conducted to evaluate serum taurine as a potential prognostic marker for graft function in Egyptian patients undergoing living donor liver transplant.

Methods: A prospective cohort study was conducted during August 2019 to May 2020. We measured serum taurine levels using high-performance liquid chromatography in patients with end-stage liver disease who were candidates for living donor liver transplant before transplant, then on the 7th, 14th, and 30th day post-transplant. Patients were followed up to detect graft dysfunction, Seventh Day Syndrome, and the 30-day mortality.

Results: Sixty patients were enrolled in this study. Preoperative serum taurine levels did not correlate significantly with liver function tests, and its predictive performance for primary graft dysfunction and 30-day mortality was poor (area under curve [AUC] = 0.662; $p = 0.038$ and AUC = 0.642; $p = 0.202$, respectively). Serum taurine level at the 7th post-transplant day had good diagnostic performance for primary graft dysfunction (AUC = 0.827; $p < 0.001$) and good predictive performance for 30-day mortality (AUC = 0.888; $p < 0.001$). Only two patients with taurine level <30 μmL^{-1} developed Seventh Day Syndrome.

Conclusion: Preoperative serum taurine level had poor prognostic value for primary graft dysfunction or 30-day mortality. However, its serum level at the 7th day post-transplant had good diagnostic value for primary graft dysfunction and good prognostic value for 30-day mortality. Future research should investigate the potential predictive value of taurine levels regarding primary graft dysfunction and Seventh Day Syndrome.

ARTICLE HISTORY
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KEYWORDS
Biomarkers; end-stage liver disease; graft rejection; prognosis; taurine; transplant

EN should be used when patients with severe ASH cannot meet their caloric requirements through normal food and/or ONS in order to improve survival and infectious morbidity. (Grade B, strong consensus 100%)

Protein intake should not be restricted in cirrhotic patients with hepatic encephalopathy as it increases protein catabolism. (Grade B, strong consensus 100%)

Oral diet of cirrhotic patients with malnutrition and muscle depletion should provide 30-35 kcal·kg_{i1}·d_{i1} and 1.5 g protein·kg_{i1}·d_{i1}. (Grade B, strong consensus 100%)

Non-malnourished patients with compensated cirrhosis should ingest 1.2 g·$kg_{i.}d_{i1}$ protein. (Grade B, strong consensus 100%)

Periods of starvation should be kept short by small and frequent meals (every 3–4 h) a day and a late evening snack should be recommended to improve total body protein status (Grade B, strong consensus 100%)

ESPEN practical guideline 2020: "Clinical nutrition in liver disease

Obese cirrhotic patients, however, according to the American Association for the Study of Liver Disease (AASLD), daily caloric targets should be stratified by BMI: 25–30 kcal/kg of ideal body weight in patients with a BMI of 30–40 kg/m2 and 20–25 kcal/kg of ideal body weight in those with a BMI 40 kg/m2. A high protein intake (1.2–1.5 g/kg of ideal body weight) must be maintained

Lai, J.C.; Tandon, P.; Bernal, W.; Tapper, E.B.; Ekong, U.; Dasarathy, S.; Carey, E.J. Malnutrition, Frailty, and Sarcopenia in Patients with Cirrhosis: 2021 Practice Guidance by the American Association for the Study of Liver Diseases. .Hepatology 2021

Vitamin E (800 IU a-tocopherol daily) should be prescribed to non-diabetic adults with histologically confirmed NASH aiming for improvement of liver enzymes and histology. (Grade B, strong consensus 100%)

Nutritional supplements containing selected probiotics or synbiotics can be used to improve (liver enzymes in NAFL/ NASH patients. (Grade 0 , consensus 89 %

The daily consumption of 300 g of a probiotic containing yoghurt was reported to improve liver enzymes in NAFLD patients compared to conventional yoghurt

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Non-alcoholic fatty liver (NAFL)/NASH patients shall be advised to exercise in order to reduce hepatic fat content, but there are no data regarding the efficacy of exercise in improving necroinflammation. (Grade A, strong consensus 100%)

Walking 30–40 min three to four times per week, and lifting light weights such as hand weights two to three times per week. Exercise intervention should be patient-tailored

Overweight and obese NAFL/NASH patients shall follow a weight reducing diet to reduce the risk of comorbidity and to improve liver enzymes and histology (necroinflammation). Grade A, strong consensus 100%

In normal weight NAFL/NASH patients, increased physical activity to improve insulin resistance and steatosis can be recommended. (Grade GPP, strong consensus 100%)

A Mediterranean diet (MedD) should be advised to improve steatosis and insulin sensitivity. (Grade B, strong consensus 100%)

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Mediterranean diet

Foods to include or limit

EAT AT EVERY MEAL.

Fruits, veggies, whole grains, extra virgin olive oil

EAT AT LEAST 3 SERVINGS A WEEK.

Fish/seafood, nuts, legumes

LIMIT TO 1 SERVING A DAY.

Poultry, low-fat dairy, eggs

LIMIT TO 1 SERVING PER WEEK.

Red meat, sweets

Cleveland Clinic

In the immediate preoperative period, liver cirrhosis patients should be managed according to the ERAS approach in order to prevent unnecessary starvation. ERAS protocol improves morbidity and length of stay when among other measures patients are given carbohydrate containing clear liquid until 2 h preoperatively, early feeding and mobilization (Grade GPP, strong consensus 100%)

Preoperatively, a total energy intake of 30- 35 kcal·kg_{i1}·d_{i1} and a protein intake of 1.2-1.5 g·kg_{i1}·d_{i1} should be aimed for. These ranges cover recommended intakes depending on treatment goals, i.e. maintenance or improvement of nutritional status. (Grade GPP, strong consensus 100%)

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Nutritional Management Strategies after LT

In the event of primary non function or graft rejection, many of the pre-LT nutritional alterations will persist, but even in a well-functioning graft, some nutritional disturbances and body composition alterations will not fully normalize over the long term despite the recovery of liver function.

The liver–gut–brain axis is linked to this concept and acts as a nutritional factor after LT, the liver become isolated from the nervous autonomic regulatory control, suggesting that this isolation could influence nutrient absorption, glucose and lipid homeostasis, appetite signalling, and eating behavior.

In fact, after LT surgery, energy and protein requirements remain elevated for weeks resulting in the persistence of sarcopenia for up to a year or longer.

Federico Ravaioli et al. Nutrients **2023**

- After LTx, normal food and/or EN should be initiated within 12-24 h postoperatively to reduce infection rate.

(Grade B, strong consensus 100%).

- In early postoperative phase suffer from hyperglycemia:

----Diabetogenic potential of tacrolimus

----Disturbed glucose metabolism and presence of insulin resistance

-These patients have negative nitrogen balance up to 28 days post op so they need increase supplementation of protien and amino acids up to 2 g/kg/day

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-Immediately following LT (in the first 6 hours) glucose utilization by the graft is impaired until mitochondrial redox potential improves.

-During this period, the liver preferentially uses fatty acid oxidation for ATP generation.

-After 6 hours, if transplanted livers have normal function, substrate utilization shifts from fat to glucose.

Ozaki N, Ringe B, Bunzendahl N et al.Clin Transplant 1991; 5:48-54.

Post transplant nutritional guidelines

Nutrient	Short-Term Recommendations	Long-Term Recommendations
Calories	The total daily energy intake until the third postoperative day (POD) is 10–15 kcal/kg and gradually increases to25–35 kcal/kg	Maintenance — 120-130% BEE depending on activity level
Protein	1.3-2 g/kg/day	1-1.5 g/kg/day
Carbohydrate	50-70% of calories	50-70% of calories **Restrict simple sugars**
Fat	30% of calories	<30% of total calories
	Up to 50% of calories with severe hyperglycemia	<10% of calories as saturated fat
Calcium	800-1200 mg/day	1000-1500 mg/day (consider the need for estrogen or vitamin D supplements)
Sodium	2-4 g/day	3-4 g/day
Magnesium & Phosphorus	Encourage intake of foods high in these nutrients	Encourage intake of foods high in these nutrients
	Supplement as needed	Supplement as needed
Potassium	Supplement or restrict based on serum potassium levels	Supplement or restrict based on serum potassium levels
Other Vitamins and Minerals	Multivitamin/mineral — supplement to RDA levels	Multivitamin/mineral — supplement to RDA levels

Jeanette Hasse **The Benefits of Nutrition Therapy in the Liver Transplant Patient 2013**

Nutritional side effects of immunosuppressive medications and proposed nutrition therapy

Drug	Possible Side Effects	Proposed Nutrition Therapy
Cyclosporine	Hyperlipidemia	Limit fat and simple carbohydrate
	Hyperglycemia	Limit simple carbohydrate
	Hypomagnesemia	Magnesium supplements
	Hyperkalemia	Decrease potassium intake
	Catabolism/impaired wound healing	Increase protein intake
Glucocorticoids	Hyperlipidemia	Limit fat and simple carbohydrate
	Hyperglycemia	Limit simple carbohydrate
	Sodium retention	Reduce sodium intake
	Hyperphagia	Avoid overeating
	Increased calciuria	Increase calcium intake or take supplements
Tacrolimus	Hyperglycemia	Limit simple carbohydrate
	Hyperkalemia	Decrease potassium intake
	Nausea and vomiting	Adjust food/meals as needed, monitor intake
Mycophenolate mofetil	Diarrhea	Replace lost fluid

Food safety and hygiene

Recommendations: AVOID

- Drinking unpasteurized milk, fruit or vegetable
- Eating cheeses made with unpasteurized milk
- Eating raw or undercooked eggs
- Eating raw or undercooked meat, poultry or fish.
- All raw or undercooked seafood
- Ingesting raw seed sprouts
- Uncooked pate.

Carefully wash lettuce and vegetable products even when labeled as “prewashed.”

Nutrition Status of Donors: Does it Matter?

Animal data indicate that the balanced nutrition of a brain dead liver donor, using moderate amounts of carbohydrate, lipid (long chain fatty acids and possibly fish oil) and amino acids, is associated with improved function of the transplanted organ, The value of donor or organ conditioning which aims to reduce ischemia/ reperfusion damage in humans by provision of high doses of arginine or glutamine is currently unknown.

No recommendations can be made regarding donor or organ conditioning by use of specific nutrition regimens, such as i. v. glutamine or arginine, with the object of minimizing ischemia/reperfusion damage. (Grading GPP, strong consensus 100%)

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Recommendations

-Malnutrition and sarcopenia are essential for patients with liver cirrhosis and their complications.

-All patients scheduled for a liver transplant must implement screening strategies for these conditions.

-Nutritional management is crucial for weight management and the correct and appropriate introduction of micronutrients/macronutrients.

-Appropriate nutritional management of the pre-transplant patient can reduce the risk of recurrence and/or the development of post-LT metabolic disorders.

-Nutritional management must begin immediately after surgery and continue during the postoperative period.


Thank You!