Acta Scientific Gastrointestinal Disorders (ISSN: 2582-1091)

Volume 4 Issue 8 August 2021

Review Article

Nutrition Therapy a Cardinal and Unmapped Aspect in Liver Transplantation: A Review

Neha Bakshi[1]* and Kalyani Singh[2]

[1]*Assistant Professor, Lady Irwin College, University of Delhi, India*

[2]*Former Associate Professor, Lady Irwin College, University of Delhi, India*

***Corresponding Author:** Neha Bakshi, Assistant Professor, Lady Irwin College, University of Delhi, India.

Received: June 23, 2021

Published: July 23, 2021

Abstract

Managing nutrition status is challenging among Liver transplant patients. Symptoms of liver failure like ascites and low albumin levels represent demor in nutrition status assessment. Despite this, malnutrition is prevalent in more than 80% of pre-LT patients. Malnutrition has been associated with poor surgical outcomes; therefore, the need for aggressive nutrition therapy before and after the liver transplant is crucial. Hence, this review aims to accentuate the need for nutrition interventions to devise a nutrition therapy plan in all the phases of Liver transplant.

Keywords: Nutrition Therapy; Liver Transplantation; Malnutrition

Abbreviations

AAA: Aromatic Amino Acid; BCAA: Branched Chain Amino Acid; BIA: Bioelectrical Impedance Analysis; BMI: Body Mass Index; CTP: Child Turcotte and Pugh; DEXA: Dual Energy Xray Absorptiometry; ESLD: End Stage Liver Disease; ESPEN: European Society of Parenteral and Enteral Nutrition; LT: Liver Transplantation; MELD: Model for End Stage Liver Disease; MNT: Medical Nutrition Therapy; REE: Resting Energy Expenditure; SGA: Subjective Global Assessment; TPN: Total Parenteral Nutrition

Introduction

LT in India is a relatively recent medical achievement for patients with liver failure, after the year 1990. The degree of ESLD in India is not available [1]. By the 1990's India was perceived as a growing health economy. By 2007, in India 318 Liver Transplants were performed [2]. There is no separate LT registry; hence, there is a lack of data but each LT passes through various authorization before the surgery, so the data exists but has not been complied after the year 2007 [1].

According to the global burden of disease of deaths, the deaths from cirrhosis have increased from 1.74% to 2.87% from the year 1990 to 2019 among the Indian population [3]. Liver transplantation (LT) is considered the sole treatment for patients suffering from End-Stage Liver Disease (ESLD) irrespective of disease etiology. LT is a complicated, time-consuming surgery procedure. The goal of critical care management for LT patients is to provide improved quality of life to ESLD patients [4].

Malnutrition is highly prevalent among patients undergoing LT and has a multi-factorial etiology (Figure 1). These factors further deteriorate the dietary intake of the patients. In addition, the liver has a crucial role in the metabolism of various nutrients. Different metabolic factors like increased BMR, fat malabsorption, and impaired glycogen stores lead to malnutrition in liver disease. A proper nutrition program is incomplete without addressing all these nutrition-related issues in liver diseases [5].

Malnutrition among ESLD patients have been associated with poor surgical outcomes, high morbidity and mortality [6-9]. Child

and Turcotte in 1964 developed the first prognostic score, nutrition was considered as a prime variable to assess the disease severity [10]. Patients with ESLD frequently manifest metabolic abnormalities of macronutrients like carbohydrate, protein and lipid metabolism, which can cause gradual deterioration of their conditions [5].

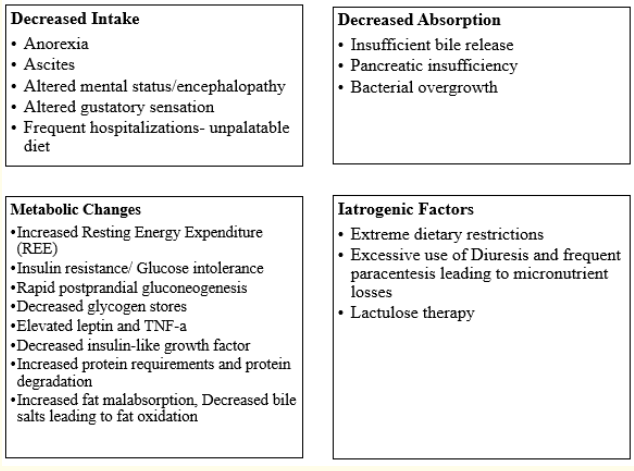

Figure 1: Etiology of end-stage liver disease.

The LT treatment is considered in two phases, pre and post-liver transplant phases. The post-transplant phase is divided into the acute post- liver transplant and chronic/long-term post-liver transplant phase. Likewise, the nutrition therapy of LT patients in each phase has varied challenges and objectives. This review aims to provide an integrative nutrition approach for patients undergoing LT.

Nutrition assessment

Nutrition definitely is paramount in treatment of liver disease but, the nutrition status assessment is difficult among ESLD patients. It is challenging to precisely assess the nutrition status of cirrhotics, because of various complications like fluid retention, hypoalbuminemia and hypoproteinemia. Hence, liver disorders affect the conventional nutritional markers such as serum protein levels (albumin, transferrin, retinol-binding protein) which are synthesized by the liver and other immunological dysfunction tests. Anthropometric measurements (Body Mass Index (BMI), skinfold thickness (biceps, triceps, subscapular, suprailiac, and Mid Arm Muscle Circumference) are simple, quick, cheap and non-invasive methods of estimating the nutrition status by analyzing weight-for-height, subcutaneous fat and somatic protein stores [10]. BMI as a nutrition status indicator for LT patients has been criticized for its false high scores [11], but the use of ascites adjusted cut-offs by BMI for ascites is more reliable [15]. Sarcopenia before LT is prevalent in > 50% of cirrhotic patients [7,8]. Hypercatabolism in ESLD patients causes skeletal muscle tissue to break down eventually leading to sarcopenia [8]. Dual-energy X-ray absorptiometry (DEXA) and Bioelectrical impedance analysis (BIA) can be used to obtain information on the level of sarcopenia. Even BIA and DEXA present erroneous results due to ascites. Table 1 illustrates the challenges in nutrition status assessment of LT recipients by different tools. Subjective global assessment (SGA) has been the most recommended tool for ESLD patients. Studies have shown SGA as an independent predictor for outcomes of LT [19,20]. Also phase angle as a nutrition status indicator has recently gained a lot of importance as a prognostic tool in various clinical situations, such as renal disease [12], cancer [13] and liver cirrhosis [6,14-17].

Approaches	Methods	Problem in ESLD
Anthropometry	Weight, BMI	False weight
Biochemical parameters	Serum Albumin, Total Protein, transferrin, RBP	Not true indicators
Clinical signs and symptoms	Jaundice, Ascites, edema	Very subjective
Dietary approach	24 hr dietary recall	The present state of dietary intake
Biophysical	Handgrip strength	Low specificity and have positive prediction value
Body composition	BIA, phase angle	Ascites, edema
Prognostic Nutritional Index (PNI)	Serum levels of albumin and transferrin, DTH, and triceps skinfold	Expensive and impractical for routine preoperative use
Instant Nutritional Index (INI)	Serum Albumin and TLC	Low sensitivity and specificity
Subjective Global Assessment (SGA)	Weight loss history, GI symptoms, physical examination, functional capacity, usual dietary intake	Highly specific (96%) but with very low sensitivity (22%)

Table 1: Challenges in nutrition status assessment of LT recipients by different tools [15].

Regardless of these challenges, malnutrition can be identified in 20% of compensated liver disease patients and > 80% in patients with decompensated liver disease [16]. Hence; till now any gold standard has not been established to assess the nutrition status of LT patients (Table 1). Guidelines by ESPEN - European Society for Parenteral and Enteral Nutrition on LT recommends easy and simple bedside assessment methods such as anthropometry parameters and/or Subjective Global Assessment (SGA) to diagnose patients with poor nutritional status and BIA (Bio electrical Impedance Analysis) can be used to appraise malnutrition despite certain limitations of these techniques in patients with ascitic decompensation [16,18].

Considering the level of malnutrition and the challenge in analyzing the nutrition status, different nutrition assessment tools were explored by the researchers to identify the most appropriate and accessible nutrition assessment tools for LT patients. Recent studies are also focusing on new assessment tools like biophysical methods using Hand Grip Strength analysis [6,15] and body composition analysis by a phase angle of the whole body [17].

A previous study by authors reconsidered all the commonly used nutrition assessment tools to identify the ideal tool for LT recipients. The study on 54 LT patients concluded that body phase angle only out of 9 different assessment tools showed moderate agreement with SGA ($\kappa = 0.444$) [6].

Malnutrition among ESLD patients as assessed by SGA was significantly ($p < 0.05$) associated with various prognostic and clinical factors like disease etiology, tense ascites, CTP grade C, lower hemoglobin levels, higher functional inability, fatigue, and lower grades of Performance Status and Quality of Life, higher blood loss and blood product usage during the surgery. Also, it has been associated with other nutritional factors like higher fat mass, normal triceps levels and body fat%, lower fat-free mass and muscle mass, lower calorie intake and higher weight loss [6,14,19].

The significance of nutrition status assessment in LT patients has been voiced by various researchers but none have come up with a conclusion for directing a validated tool for analyzing the level of malnutrition in LT patients. It is crucial to provide holistic nutrition evaluation of patients suffering from ESLD and to recognize the prospective areas for nutrition intervention. A recent review suggested that appropriate nutritional assessment will consist of combining tools like SGA, anthropometry (skinfold thickness), BIA, and Hand Grip strength [15].

Nutrition therapy

Pre-liver transplant phase

Nutrition intervention is crucial for recovery of malnourished pre-LT patients and it is cost-effective before LT, as malnourished patients are at high risk for nutritionally mediated complications. Also, the potentiality to meet the nutrient needs of patients is difficult because of the catabolic nature of the disease and the common occurrence of various symptoms leading to poor oral intake [20].

The nutritional condition of a patient awaiting LT will decline unless nutrition therapy is provided. Nutrition therapy includes the provision of adequate nutrients like calories, protein, minerals, vitamins, electrolytes and fluid, without precipitating or aggravating symptoms of ESLD such as encephalopathy or ascites. The nutrient requirements are as follows:

1. **Energy:** Studies have shown higher resting energy expenditure (REE) in 18% to 34% of patients with liver failure which further increases with complications, such as high volume ascites, acute hepatic failure, or presence of carcinoma. In liver disease, increased gluconeogenesis leads to a preferential fat metabolism than carbohydrate metabolism. Energy requirement can be computed with the help of the Harris and Benedict equation. The total energy expenditure in cirrhotic patients is 130% of basal metabolic rate, diet-induced thermogenesis and the cost of physical activity energy is usually stable [22]. About 50 - 60% of calorie intake from carbohydrates and 30% of fat is crucial for the protein-sparing effect [23].

   Medium-chain triglycerides absorption in body do not require bile salts, hence can be supplemented administered through either oral, enteral, or parenteral routes [24]. Synthesis of essential fatty acids is impaired among ESLD patients. n-3 fatty acids supplementation helps to delay progression of liver cirrhosis [25].

   However, excess of calories from carbohydrates promotes hepatic lipogenesis, liver dysfunction, and increased carbon dioxide production leading to increased work of breathing [25].

2. **Protein:** increased protein breakdown along with low glycogen stores among liver disease patients led to gluconeogenesis from amino acids and resultant amino acid loss [26]. Branched-chain amino acids (BCAA) such as leucine, isoleucine, and valine do not require liver for their metabolism and are thus preferred in liver failure, whereas aromatic amino acids (AAA) such as phenylalanine, tryptophan, and tyrosine are not properly metabolized in liver failure and accumulate in excess in body fluids. This leads to an increase in the circulating AAA and reduction in the BCAAs. This imbalance between the AAA and the BCAA plays an crucial role in hepatic encephalopathy by creating weak false neurotransmitters, further aggravating the disease severity [27].

3. **Guidelines for energy:** ESPEN 1997 recommends 35 - 40 kcal/kg/d and 1.6 g/kg/d of protein. In liver disease, patients' actual body weight and dry body weight can result in erroneous REE; hence ideal body weight is recommended to calculate energy needs [28]. In encephalopathy, small protein restrictions for a shorter duration are recommended. Oral supplementation (BCAA enriched) is used to meet the requirements. Patients in coma Encephalopathy III-IV° stage can safely be given Total Parenteral Nutrition (TPN) providing 25 - 30 kcal/kg/d and 1.0 g/kg/d BCAA-enriched amino acid solutions [28].

ESPEN guidelines (2006) on enteral nutrition for liver disease (Table 2) also recommends 30-35 kcal/kg/day for maintenance of body weight in the pre-LT phase. 35 - 40 kcal/kg body weight/day is recommended for malnourished patients. The patients are recommended higher protein of about 1.5 g/kg/day - 2.0 g/kg/day for decompensated liver disease [16,29].

ESPEN 2020 recommendations for liver transplantation and surgery advocated energy intake of 30 - 35 kcal/kg/day and 1.2 - 1.5 g/kg/day of protein for maintenance or improvement of nutrition status. For obese patients calorie intake of 25 kcal/kg/day, 2.0 - 2.5 g/kg/day of proteins to be administered enterally/parenterally is recommended [18].

Administration of pre-operative nutrition therapy is crucial to improve LT outcomes. It has been recommended that fasting periods should not exceed 6 hours as there are low glycogen reserves in malnourished cirrhotic patients. TPN should only be recommended when both oral and enteral feeding are unsuitable [28].

Nutrient	General Recommendations
Calorie*	For maintenance and improvement: 30 - 35 kcal/kg dry weight (Dry Bodyweight)/day For Obese patients: 25 kcal/kg/day (Enterally/parenterally)
Protein	For maintenance and improvement: 1.2 - 1.5 g/kg dry weight (BCAA-enriched) For Obese patients: 2 - 2.5 g/kg dry weight (BCAA-enriched)
Fat	< 30% of calories (In steatorrhea- medium-chain triglycerides)
Carbohydrates	50 - 60% of calories (simple carbohydrates to be restricted if glucose intolerance)
Fluid	1000 - 1500 ml/day
Sodium	2 - 4 g/day depending upon the level of fluid retention
Vitamins and Minerals	Daily Dietary Allowance
*Actual body weight and dry body weight can result in erroneous REE; hence ideal body weight is recommended to calculate energy needs	

Table 2: Nutrition recommendations in Pre-liver transplantation [16,18,28,29].

Abbreviations: BEE: Basal Energy Expenditure; BCAA: Branched Chain Amino Acid; RDA: Recommended Dietary Allowances.

Requirements of micronutrients: 10 to 50% of cirrhotic patients have micronutrients deficiency [18]. For micronutrient requirements no systematically analyzed guidelines are available hence patients must be monitored for deficiencies with normal intake [16,18]:

- Water-soluble vitamins, vitamin B12, and folic acid are more frequently deficient in patients with alcoholic cirrhosis and fat-soluble vitamins are usually deficient in patients with cholestatic diseases [30,31].

- Decreased intake and absorption of folate leads to its deficiency, as well as renal excretion and poor hepatic storage. Alcohol intake, with subsequent folate deficiency can lead to megaloblastic (macrocytic) anemia [32].

- Vitamin B6 (pyridoxine) deficiency occurs because of decreased intake or altered metabolism and storage [32].

- Vitamin A supplementation improves the sense of taste and dietary intake of the patients [43]. Serum vitamin E levels are typically decreased in alcoholic cirrhotics (Table 2); vitamin E is also reduced in those patients with pancreatitis or fat malabsorption [33].
- Zinc deficiency is common in both non-alcoholic and alcoholic liver disease [33] and has been associated with neurological symptoms [34].
- Lower serum calcium levels are common and multifactorial. Low calcium levels may be related to lower serum albumin and magnesium levels. Adequate calcium of about 800 - 1200 mg/day is essential for bone health; hypocalcemia increases the risk for bone loss in alcoholics [31].
- Serum iron levels are commonly elevated among alcoholic liver disease patients but blood losses can lead to its deficiency [33].
- Pre-LT patients are at higher risk of hypomagnesemia, with potentially deleterious effects [35].
- The complicated liver disease leads to disrupted sodium and fluid levels. The fluid volume expansion and impaired renal perfusion can cause hyponatremia [36]. A dietary sodium restriction of 2 g/day appropriately balances the need for adequate nutrition and the need to manage fluid status (Table 2).

The guidelines by ESPEN 2020 recommend such high requirements of nutrients [18]. But, there are very few studies that have focused on analyzing the nutrition intake of the pre-LT patients. Use of probiotics, enteral and parenteral routes, oral supplementation, and nocturnal meals can aid in meeting the nutritional requirements [15]. Two previous case reports (Table 3) depicted lower percent calorie and protein intake of patients in the pre-LT phase [37,38].

Case report	Case	Pre-LT phase		Acute Post-LT phase		Chronic Post-LT phase	
		% calorie	% protein	% calorie	% protein	% calorie	% protein
Case report 2015 (No. of Cases = 3)	1	78.5%	82.9%	61.7%	75.6%	87.9%	82%
	2	40.7%	34.7%	76.4%	103%	83.9%	103.8%
	3	43.4%	65.2%	57.5%	69.2%	67.4%	95.5%
Case report 2016 (No. of Cases = 1)	1	57.6%	34.7%	76.4%	103%	83.9%	103.8%

Table 3: Case reports on nutrition therapy in liver transplantation [37,38].

Hence, early nutrition intervention by replenishing nutrients and treating nutrient deficiency can, improve Quality of Life, prolong life expectancy, contract complications and prepare them for a more successful LT [38].

Immediate/acute post transplant phase

Acute post-Liver Transplant is the following phase after LT. It is a hypercatabolic phase, anti-inflammatory administration of corticosteroids, and use of immunosuppressive drugs which inhibit the action of cytokines [30]:

1. **Energy requirements:** Studies revealed that hypermetabolism in liver disease is associated with unfavorable LT outcomes and reduced event-free survival [39]. The recommended calorie intake are depicted in table 4.
2. **Protein requirements:** Expert guidelines recommended protein intake of 1.2 - 1.5 g/kg body weight, to compensate for the significant loss of nitrogen because of the excretion of large amounts of urinary nitrogen [18].
3. **Other nutrients:** These metabolic alterations after LT entail special attention to nutrient requirements in the acute post-transplant phase. These needs are summarized in table 4.
    - In acute post-LT phase, alterations in electrolytes are common such as sodium losses can occur through nasogastric tube, urine, bile T-tube, and abdominal drains.
    - The levels of serum potassium, phosphorus, and magnesium tend to deplete in the acute post- Liver Transplant phase due to the use of diuretics and refeeding syndrome. Hyperkalemia also results due to use of Cyclosporin and kidney insufficiency.

- It is recommended to provide multivitamin supplement daily with weekly supplementation of vitamin K.
- Other vitamins may be required for nutrition support which can be met by using supplemental nutrition. Also, n-3 fatty acids supplementation reduces injury as well as it has been shown to decrease infectious morbidities [25].
- Patients who are capable of eating within a few days do not require any strict nutrition intervention but continuous nutrition monitoring is needed [40].

Nutrient	Acute Post-LT Phase	Chronic Post-LT phase
Calories	30-35 kcal/kg/day	Depending on activity level
Protein	1.2-1.5 g/kg/day	Daily Dietary Allowance
Carbohydrate	50-60% of calories	50 - 60% of calories with restriction of simple sugars
Fat	30% of calories	< 30% of calories
	≤ 50% of calories	< 10% of calories from saturated fat
Calcium	800 - 1200 mg/day	1000 - 1500 mg/day
Sodium	2 - 4 g/day	3 - 4 g/day
Other Vitamins and Minerals	Daily Dietary Allowance	

Table 4: Post-transplant nutritional guidelines [18,41-43].

Hence according to ESPEN guidelines (Table 4) patients are recommended higher levels of dietary protein/Kg body weight; energy requirement is not that significantly increased if there are no major complications. The patients' ability to consume the recommended diets is defined by their route of feeding with a focus on small frequent meals. Patients are continuously monitored in this phase to identify any other complications (infections, GI symptoms, psychological symptoms, etc.) which can hinder the gradual improvement of the patient's condition [41].

Patients should be gradually progressed from artificial nutrition support to oral/normal diets as soon as possible after LT. Early satiety, medication side effects and altered taste are common patient complaints. Small and frequent feedings of high protein foods help patients achieve adequate nutrient requirements. Tube feeding can be scheduled in a cyclic manner or nocturnal feeds have been useful. Tube feeding should be continued till patients are able meet $2/3^{rd}$ to $3/4^{th}$ of their estimated requirements consistently [42,43].

Two case reports (Table 2) recorded the energy and protein intake of the patients in the acute post-LT phase, which depicted lower calorie intake but adequate protein intake among acute post-LT patients [36,37]. Also, a previous study by authors showed that in acute post-LT patients, a significant decrease in weight status ($P < 0.001^{**}$) was observed. The nutrient intake of patients showed significantly lower intake of calorie, protein, fats, calcium ($P < 0.05$) and also lower % adequacy of other nutrients as compared to the recommendations by ESPEN 2006 guidelines [44].

There is a lack of data on nutrition monitoring protocol and nutrition therapy interventions in the acute post-LT phase focusing on meeting the recommended nutrition requirements, nutrition progression, and factors affecting patient intake.

Long term/chronic post transplant phase

The focus of nutrition intervention in the acute post-transplant phase is to replenish lost nutritional stores; the aim of chronic medical nutrition therapy is prevention. The recommendation in the chronic post-transplant phase is depicted; energy requirements are to maintain the body weight, protein requirements are decreased in the chronic post-transplant phase; < 30% of fat is recommended with about < 10% from saturated fatty acids, and other vitamins and minerals are recommended according to the RDA of a normal person [41].

Several metabolic complications which are common in patients after LT are:

- Overweight and obesity: Higher weight status is common among recipients after LT because of the administration of immunosuppressive drug regimens. Richardson., *et al*. (2001) showed a strong association between weight gain and energy economy is because of the loss of hepatic metabolic integration and is accelerated by increased energy intake [45].
- Osteoporosis: In the few months after LT, there is an increased risk spontaneous fractures due additional bone loss. Treatment with corticosteroids, cyclosporine, and prolonged bed rest is claimed to be contributors to early post-transplantation bone loss [46].

- Hyperlipidemia: In post-LT patients because of overnutrition can result in hypercholesterolemia which is a risk factor for cardiovascular disease.

- Hypertension: It occurs in most LT recipients maintained on an immunosuppressive regimen (cyclosporine). Hypertension was more prevalent in obese (89%) than in non-obese (75%) LT recipients [45].

- Diabetes: The incidence of onset of diabetes mellitus after LT ranges between 7 to 33%.[75] It occurs more in HCV-related infections and patients > 45 years.

The overt nutrition aspect of the chronic post-LT phase has been well known [18,42,43]. But, there is a dearth of data on the actual nutrient intake of chronic post-LT patients, which can help formulate the blueprint for future intervention in controlling the problem of overnutrition in the chronic postoperative phase. The information of energy and protein intake from the case reports showed deranged levels of energy and protein in the chronic post-LT phase (Table 3).

Role of dietician in liver transplantation treatment

Considering the significance of nutrition in LT recipients, the dietician becomes an integral part of the LT Team. Meeting the nutrition requirements of these patients poses various challenges as described in figure 2. Hence, it is important to recognize and ameliorate nutritional deficiencies in pre-LT patients and provide an optimal nutritional intervention during all phases of LT [47].

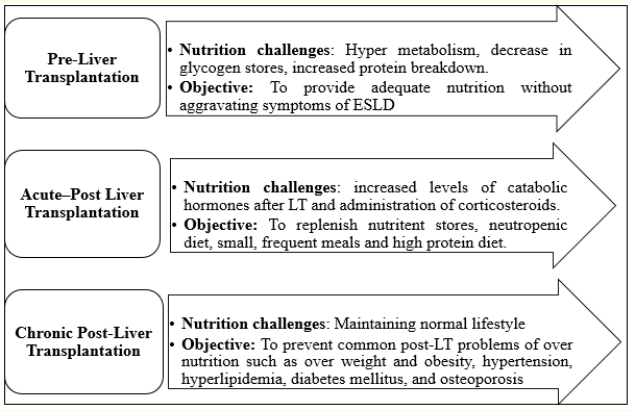

Figure 2: Nutrition challenges in all stages of LT [15,18,48].

The nutrition needs of LT patients depends upon various factors like transplant stage, disease severity, pre-existing nutritional deficiency, physiological stress, successful surgery, presence of infections, blood parameters (kidney function test, liver function test, etc.), the effect of medications and intestinal function (Table 2 and 3). All these factors are responsible for planning and modifying the nutrition care plan for LT patients.

The dietician assesses the nutrition status and nutrition problems of the patient before and after the transplant. This involves interviewing a patient for his/her disease condition, appetite, nutrition concerns, GI problems, functional ability, and food likes and dislikes. The dietician has to appropriately analyze the route of feeding and type of diet recommended to the patient according to the patients requirements. Hence, the diet should be individualized and tailor-made according to the patient's needs [48].

Nutritional challenges are common in LT like altered blood levels of glucose, sodium, potassium, magnesium, and fluid retention in the pre and acute post-LT phase. High lipids levels, excessive weight gain, and osteoporosis are common chronic post-transplant problems. Hence, continuous nutrition monitoring is required by a trained dietician to execute proper nutrition plans at different stages of LT. The functions of a dietician are:

1. To perform nutrition status assessment at regular intervals to analyze the patient's nutrition condition.

2. To provide adequate and appropriate nutrients according to the disease state and patient's condition.

3. To provide regular nutrition counseling to the patient, to improve his/her nutritional status, and also to prevent complications.

The dietician's contribution to the liver transplant team is vital. Active involvement by a dietitian can contribute to a successful LT [48].

Conclusion

In summary, ESLD patients suffer from nutritional and metabolic disorders that deteriorate the patient's condition in all three phases of LT. Medical nutrition therapy (MNT) is crucial and advantageous during all phases of LT for improved surgical outcomes and Quality of Life. Nutrition monitoring/evaluation and intervention

by a registered dietician play an integral and least studied aspect in the management of patients undergoing LT. Hence, emphasis should be given to chalk out the focal points of nutrition monitoring in all the phases of LT for providing appropriate nutrition therapy.

Bibliography

1. Kumaran Vinay. "Liver Transplantation in India". Textbook of Surgical Gastroenterology Volumes 1.2 (2016): 1172.

2. Kakodkar Rahul., *et al*. "Liver transplantation in India: its evolution, problems and the way forward". (2007): 53-56.

3. Institute of Health Metrics, Evaluation Global Burden of Disease. GBD 2010 Leading Causes and Risks by Region Heat Map; 1990 and (2019).

4. Gopal Palepu B., *et al*. "Critical care issues in adult liver transplantation". *Indian Journal of Critical Care Medicine: Peer-Reviewed, Official Publication of Indian Society of Critical Care Medicine* 13.3 (2009): 113.

5. Kerwin Andrew J and Michael S Nussbaum. "Adjuvant nutrition management of patients with liver failure, including transplant". *Surgical Clinics* 91.3 (2011): 565-578.

6. Bakshi Neha and Kalyani Singh. "Nutrition assessment and its effect on various clinical variables among patients undergoing liver transplant". *Hepatobiliary Surgery and Nutrition* 5.4 (2016): 358.

7. Tandon Puneeta., *et al*. "Severe muscle depletion in patients on the liver transplant wait list: its prevalence and independent prognostic value". *Liver Transplantation* 18.10 (2012): 1209-1216.

8. Masuda Toshiro., *et al*. "Sarcopenia is a prognostic factor in living donor liver transplantation". *Liver Transplantation* 20.4 (2014): 401-407.

9. Child CG and Turcotte JG. "Surgery and portal hypertension". *Major Problems in Clinical Surgery* 1 (1964):1.

10. Campillo Bernard., *et al*. "Validation of body mass index for the diagnosis of malnutrition in patients with liver cirrhosis". *Gastroentérologie Clinique et Biologique* 30.10 (2006): 1137-1143.

11. Merli Manuela., *et al*. "Malnutrition is a risk factor in cirrhotic patients undergoing surgery". *Nutrition* 18.11-12 (2002): 978-986.

12. Johansen Kirsten L., *et al*. "Longitudinal study of nutritional status, body composition, and physical function in hemodialysis patients". *The American Journal of Clinical Nutrition* 77.4 (2003): 842-846.

13. Toso Silvia., *et al*. "Bioimpedance vector pattern in cancer patients without disease versus locally advanced or disseminated disease". *Nutrition* 19.6 (2003): 510-514.

14. Fernandes Sabrina Alves., *et al*. "Nutritional assessment in patients with cirrhosis". *Arquivos de Gastroenterologia* 49.1 (2012): 19-27.

15. Bakshi Neha and Kalyani Singh. "Nutrition assessment in patients undergoing liver transplant". Indian journal of critical care medicine: peer-reviewed, official publication of Indian Society of Critical Care Medicine 18.10 (2014): 672.

16. Plauth M., *et al*. "ESPEN guidelines on enteral nutrition: liver disease". *Clinical Nutrition* 25.2 (2006): 285-294.

17. Wagner D., *et al*. "Serum albumin, subjective global assessment, body mass index and the bioimpedance analysis in the assessment of malnutrition in patients up to 15 years after liver transplantation". *Clinical Transplantation* 25.4 (2011): E396-E400.

18. Bischoff Stephan C., *et al*. "ESPEN practical guideline: Clinical nutrition in liver disease". *Clinical Nutrition* 39.12 (2020): 3533-3562.

19. Bakshi Neha and Kalyani Singh. "Effect of malnutrition on health related quality of life (HRQoL) of patients awaiting liver transplantation". *Indian Journal of Transplantation* 2.9 (2015): 62.

20. Bakshi Neha and Kalyani Singh. "Diet and nutrition therapy in pre-liver transplant patients". *Hepatoma Research* 2 (2016): 207-215.

21. Müller MJ., *et al*. "Are patients with liver cirrhosis hypermetabolic?". *Clinical Nutrition* 13.3 (1994): 131-144.

22. Campillo Bernard., *et al*. "The thermogenic and metabolic effects of food in liver cirrhosis: consequences on the storage of nutrients and the hormonal counterregulatory response". *Metabolism* 41.5 (1992): 476-482.

23. Plauth Mathias., *et al*. "ESPEN guidelines on parenteral nutrition: hepatology". *Clinical Nutrition* 28.4 (2009): 436-444.

24. Akbar Samina., *et al*. "Polyunsaturated Fatty Acids: Impact on Health and Disease Status". *Life and Science* 2.2 (2021): 12-12.

25. Ginanni Corradini Stefano., *et al*. "Plasma fatty acid lipidome is associated with cirrhosis prognosis and graft damage in liver transplantation". *The American Journal of Clinical Nutrition* 100.2 (2014): 600-608.

26. Swart GR., *et al*. "Effect of a late evening meal on nitrogen balance in patients with cirrhosis of the liver". *British Medical Journal* 299.6709 (1989): 1202-1203.

27. Nielsen Klaus., *et al*. "Long-term oral refeeding of patients with cirrhosis of the liver". *British Journal of Nutrition* 74.4 (1995): 557-567.

28. Plauth Merli., *et al*. "ESPEN guidelines for nutrition in liver disease and transplantation". *Clinical Nutrition* 16.2 (1997): 43-55.

29. Weimann A., *et al*. "ESPEN guidelines on enteral nutrition: surgery including organ transplantation". *Clinical Nutrition* 25.2 (2006): 224-244.

30. Sanchez Antonio J and Jaime Aranda-Michel. "Nutrition for the liver transplant patient". *Liver Transplantation* 12.9 (2006): 1310-1316.

31. Schenker Steven and Glenn A Halff. "Nutritional therapy in alcoholic liver disease". Seminars in liver disease. by Thieme Medical Publishers, Inc 13.2 (1993).

32. Leevy Carroll M and Şerban A Moroianu. "Nutritional aspects of alcoholic liver disease". *Clinics in Liver Disease* 9.1 (2005): 67-81.

33. Barbara Mary and Ayse L Mindikoglu. "The role of zinc in the prevention and treatment of nonalcoholic fatty liver disease". *Metabolism Open* (2021): 100105.

34. Pîrvu Daniel-Cristian., *et al*. "The Role Of Zinc In Chronic Liver Disease". *Research and Science Today* 1 (2021): 79A-89.

35. Bennett MW., *et al*. "Alterations in plasma magnesium concentrations during liver transplantation". *Transplantation* 56.4 (1993): 859-861.

36. Ansari Asad Jamal., *et al*. "An Insight to Hyponatremia in Cirrhosis: Pathophysiology and Management Approaches" (2021).

37. Bakshi N., *et al*. "Nutrition in Liver Transplant Recipients: Case Series". *Open Journal of Clinical and Medical Case Reports* 1 (2015): 15.

38. Bakshi N and Singh K. "Nutrition Profile of a Liver Transplant Recipient: A Case Report". *Hepatoma Research* 2 (2016): 98-102.

39. Mathur Sachin., *et al*. "Hypermetabolism predicts reduced transplant-free survival independent of MELD and Child-Pugh scores in liver cirrhosis". *Nutrition* 23.5 (2007): 398-403.

40. Figueiredo Fatima., *et al*. "Impact of nutritional status on outcomes After liver transplantation1". *Transplantation* 70.9 (2000): 1347-1352.

41. Plauth Mathias., *et al*. "Weight gain after transjugular intrahepatic portosystemic shunt is associated with improvement in body composition in malnourished patients with cirrhosis and hypermetabolism". *Journal of Hepatology* 40.2 (2004): 228-233.

42. Campos Antonio CL., *et al*. "Nutritional aspects of liver transplantation". *Current Opinion in Clinical Nutrition and Metabolic Care* 5.3 (2002): 297-307.

43. Hasse Jeanette M. "Nutritional implications of liver transplantation". *Henry Ford Hospital Medical Journal* 38.4 (1990): 235-240.

44. Bakshi Neha and Kalyani Singh. "Nutrition management of acute postliver transplant recipients". *Indian Journal of Critical Care Medicine: Peer-Reviewed, Official Publication of Indian Society of Critical Care Medicine* 22.11 (2018): 773.

45. Hasse JM., *et al*. "The effect of nutritional status on length of stay and clinical outcomes following liver transplantation". *Journal of the American Dietetic Association* 94.9 (1994): A38.

46. Hay JE. "Bone disease in liver transplant recipients". *Gastroenterology Clinics of North America* 22.2 (1993): 337-349.

47. Figueiredo Fátima AF., *et al*. "Comparison of three methods of nutritional assessment in liver cirrhosis: subjective global assessment, traditional nutritional parameters, and body composition analysis". *Journal of Gastroenterology* 41.5 (2006): 476-482.

48. Alberino Franca., *et al*. "Nutrition and survival in patients with liver cirrhosis". *Nutrition* 17.6 (2001): 445-450.

Volume 4 Issue 8 August 2021