Feeding the Critically Ill Mechanically Ventilated Patient during the Covid-19 Epidemic

Nutrition Guidelines for Dietitians

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Introduction

New challenges have arisen in the area of nutrition care in hospitals due to the recent outbreak of the coronavirus epidemic. It is most likely that the proportion of patients requiring respiratory support will increase and therefore, so will the proportion of patients needing specialized feeds, enteral, and parenteral nutrition. The principles of nutritional therapy for these patients are based on well-known guidelines for nutritional care for acute respiratory patients, the current state of the art, and strict adherence to the prevention of infection.

The purpose of this document is to train dietitians rapidly in treating mechanically ventilated patients, who have been infected with COVID-19, by concentrating the most up-to-date information and principles of nutritional care of acute respiratory patients.

What is known so far about the characteristics of the critically ill patient infected with COVID-19?

Corona virus disease 2019 (COVID-19) is an infectious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-COV-2) and was first classified by the WHO in February 2020. The disease first broke out in Wuhan, China in late December 2019 and spread widely worldwide. Clinical characteristics range from asymptomatic infection to severe pulmonary failure and even mortality (1,2). Common symptoms include fever, fatigue, dry cough, muscle pain, and difficulty breathing. Less common symptoms include wet cough, headaches, diarrhea, and taste and smell changes (1).

According to data from the Chinese Center for Disease Control and Prevention, 5% of patients with COVID-19 were defined as critical (respiratory failure, septic shock, and/or multi-system organ failure) and required hospitalization in intensive care units (2). Patients hospitalized in intensive care units tend to be older (median age – 60 years old) and 40% of them have a history of co-morbidities, especially diabetes, heart disease, and hypertension (4). From data that was gathered by the Intensive Care National Audit and Research Center on 196 patients with COVID-19 that were hospitalized in intensive care units, it was reported that 33% had a body mass index (BMI) of 30-40 kg/m^2 and 7% had a BMI greater than 40 kg/m^2 (5).

The median time from the onset of symptoms to ICU (intensive care unit) admission is 9-10 days, which indicates slow progression of disease in most cases (4,5,6). This data demonstrates that about 2/3 of these patients will need respiratory support within 24 hours of admission into the unit (5). In addition, about 2/3 of ICU patients with COVID-19 develop Acute Respiratory Distress Syndrome (ARDS), and about 1/3 of them have septic shock (7). A high percentage of patients develop specific organ failure, such as acute renal injury (29%), acute cardiac injury (23%), and liver dysfunction (29%) (6).

The mortality rate in these critically ill patients varies from 22% to 62%, with the main cause of death still unknown, but is most probably attributed to progressive hypoxia and multi-system organ failure (4).

Information gathering and staff behavior during the coronavirus epidemic

Gathering information and sharing it among the various staff members is a challenge that needs to be addressed at this time. Due to the high risk of infection, there are a reduced number of staff members who come into direct contact with patients who have the coronavirus. It is preferable that the staff avoids entering the area with the sick patients and obtains all necessary information remotely through medical records, telephone communication, and video or through discussions. The goal is to have continuous and daily communication with the team members.

In view of expected larger patient loads, routine work policies, such as nutritional screening, will not be carried out as expected. In addition, obtaining a medical history from the patient and his family, such as weight, weight changes, food sensitivities or restrictions, may be incomplete. In order to enable optimal nutritional assessment despite this challenge, it is helpful to have telephone conversations with the family and/or patient (classified as mild-to-moderately ill) to complete this essential information. If information about the existing weight cannot be obtained in the above situation, it is recommended that desirable body weight be estimated according to the height documented in the chart or reported by the staff or family.

Metabolism of the Critically Ill Patient

Critically ill patients are considered to be in a hypercatabolic state. Different phases of critical morbidity and their effect on the dosage and timing of nutrition support have been addressed in the most recent ESPEN guidelines (8). The metabolic process is divided into three parts:

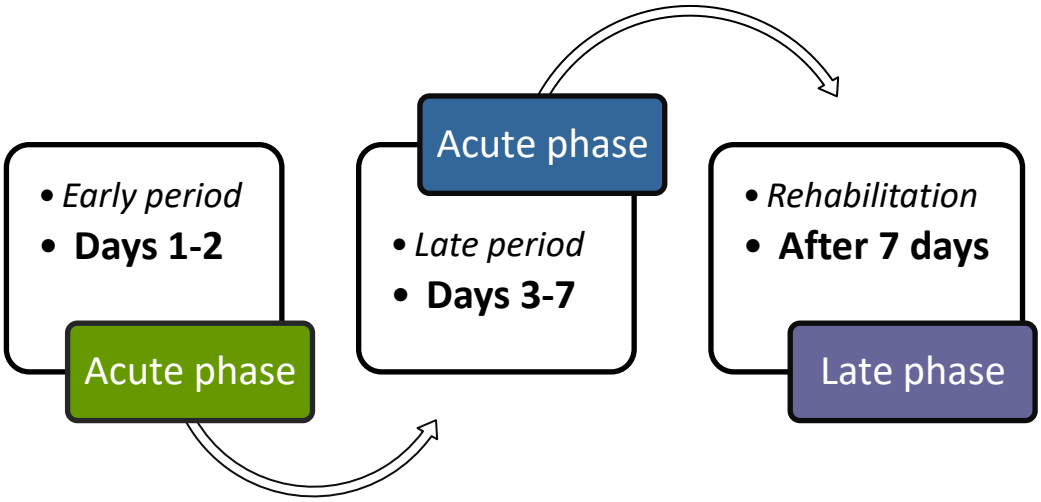


Figure 1 - The Metabolic Response to Stress, taken from the ESPEN guidelines (9)

The first part, the Acute Phase - Early Period, is characterized by metabolic instability and increased catabolism. During the second stage, the Acute Phase - Late Period, there are large losses of muscle mass, but with stabilization of the metabolic disturbances. Finally, in the Late Phase, the patient starts to improve, is no longer considered catabolic, and there starts to be rehabilitation of all tissues.

Nutritional Status and Evaluation

Malnutrition is a common problem that is widespread in hospitals and is very prevalent in hospitalized patients in the intensive care units. Some studies have shown that the incidence of malnutrition in hospitalized patients ranges from 40-50% (10). Malnutrition can adversely affect treatment outcomes of patients by increasing the risk of morbidity and infections, prolonging length of stay and increasing mortality rates (11).

Nutritional evaluation of the ICU patient is mostly based on parameters, which include co-morbidities, medical and nutritional history, information on weight loss and functional ability

prior to the hospitalization, BMI, digestive function, and physical examination to assess loss of muscle mass and fat stores. Biochemical parameters such as CRP, albumin, and prealbumin are affected by the inflammatory process and therefore are not indicators of malnutrition (8). If possible, it is recommended to use validated screening tools such as the NUTRIC score (12) (Appendix 1), and for further assessment, SGA (13) (Appendix 2), and GLIM criteria (14) (Appendix 3).

In general, every person who is hospitalized for more than 48 hours in the ICU is at nutritional risk. Among ventilated patients with COVID-19, it is expected that there will be a relatively higher proportion of older patients with co-morbidities, sarcopenia, and fragility, and therefore they will be at increased nutritional risk. It is also known that the prevalence of gastrointestinal symptoms (diarrhea, abdominal pain and vomiting) is significant and ranges from 5-40%. These symptoms, together with changes in taste and smell, may result in decreased dietary intake even prior to admission to the ICU (2,15).

Early Enteral Nutrition (EEN)

EEN should be initiated within 48 hours in patients in whom oral intake is not possible. EEN is associated with benefits such as preserving function and structure of the GI tract, activation of the immune system, and modulating the metabolic response. In addition, EEN has been found to improve survival. According to the recommendations of the ESICM (European Society of Intensive Care Medicine), EN should be delayed if shock is uncontrolled and hemodynamic and tissue perfusion goals are not reached. In this case, in order to prevent ischemia, EN should start at a low dose as soon as shock is controlled with fluids and vasopressors. For patients expected to be ventilated for a period of few hours it is not recommended to start enteral nutrition (16).

Patients who are malnourished prior to hospitalization or those who have eaten very little for a few days, combined with the metabolic stress caused from acute illness, are at increased risk of developing refeeding syndrome. The accepted treatment for this is to start gradual feeds with close monitoring of potassium, phosphorus, magnesium levels and to give thiamin, in accordance with the criteria given by the National Institute for Clinical Excellence (NICE) (17).

Table 1: Recommendations for Energy and Protein requirements

Day of Hospitalization	**Energy Requirements**	**Protein Requirements**	**Comments**
Acute Phase - Early Period (days 1-2 of hospitalization in the ICU)	Start feeds gradually: up to 70% of goal feeds 25 kcal/kg ≥ 1.3 g/kg of protein		Evaluate risk of refeeding syndrome
Acute Phase – Late Period (days 3-7 of hospitalization in the ICU)	Advance gradually to goal feeds measured by Indirect calorimetry or calculated by 25 kcal/kg	≥ 1.3 g/kg of actual body weight In the elderly population: 1.5-2 g/kg	It is important to take into consideration additional energy sources, such as dextrose and propofol and avoid overfeeding. Aim to provide at least 80% of goal feeds if measured by Indirect calorimetry and up to 70% of goal if calculated by equations. In cases of severe intolerance to feeds and malnutrition, consider a combination of Enteral Nutrition (EN) and Supplemental Parenteral Nutrition. It is important to avoid giving more than 110% of nutritional needs.
	BMI > 30 25 kcal/kg adjusted body weight BMI > 50 22-25 kcal/kg adjusted body weight	BMI > 35 1.2 g/kg actual body weight OR 2.0-2.5 g/kg ideal body weight	
Late Phase (after 7 days in the ICU) AND Rehabilitation & Recovery (outside of the ICU unit)	25-30 kcal/kg BMI > 30 – use adjusted body weight	1-1.5 g/kg BMI > 30 – use adjusted body weight	When transitioning from EN to oral feeds, it is important to re-evaluate nutritional needs again and to have close follow-up

* Based on ESPEN (8) & ASPEN (18) guidelines

Choosing a Nutrition Formula

When choosing the optimal formula to meet the needs of the patient, it is important to consider his medical and nutritional status by looking at his urinary output, fluid balance, digestive function and in the manner that the feed is provided.

Many studies have shown that providing feeds rich in protein is associated with a better survival rate in the critically ill patient (19,20). Therefore, it is advisable to choose a suitable supply of protein by prioritizing the use of formulas high in protein. In situations where it is difficult to reach the goal amount of protein, it is recommended to supplement with protein powders that are dissolved in water (either by bolus or as an addition to the ongoing nutrition feeds).

Concentrated formulas (1.5-2 kcal/ml) are recommended for patients who are fluid overloaded, are anuric, or have any other type of situation that requires fluid restriction. Feeding with formulas rich in fat and low in carbohydrates in order to decrease the respiratory quotient (RQ) and carbon dioxide accumulation have not been proven effective (18).

(see Appendix 5 - Nutrition Composition of Formulas and Appendix 6 – Examples of Feeding Plans).

Nutrition Follow-up

Enteral feeds should be started gradually with the goal of meeting nutritional needs within 3-4 days. It is important to continue to monitor the feeding process to ensure that nutrition needs are providing optimal tolerance of feeds and for the prevention of complications. The frequency of follow-up will vary depending upon the condition of the patient and will include attention to the following parameters (21):

1. Gastrointestinal symptoms - These include abdominal pain, abdominal distention, nausea and vomiting, constipation and diarrhea, and dysphagia in patients who were weaned from ventilatory support.

Monitoring gastric residual volume (GRV) is common and is helpful in assessing feeding tolerance. A residual of 500 ml or more within 6 hours is considered to be significant (8). In this situation, it is advisable to consider prokinetic medications (mostly metoclopramide and/or erythromycin)

and/or the insertion of a post-pyloric feeding tube. It is important to note that the clinical significance for checking the GRV is controversial, as studies have not shown a difference between the rates of pneumonia among patients where residuals were checked compared to those where they were not checked (21,22).

2. Blood and urine tests – It is recommended to monitor changes in labs and trends.

- Monitor electrolyte levels (sodium, phosphorus, potassium, chloride, and magnesium) with special attention to phosphorus levels. Hypophosphatemia may be associated with higher doses of insulin, refeeding syndrome, and continuous renal replacement therapy (CRRT).

- Liver function – There are many reasons for liver function test abnormalities in the critically ill patient, such as shock and sepsis. In certain instances, this can also be a result of overfeeding.

- Triglycerides – An increase in the levels of triglycerides is likely to be due to giving excess lipids: by treatment with propofol and/or at times in combination with providing lipids as part of the parenteral nutrition solution.

- Renal function and urinary output

- Albumin and prealbumin as prognostic indicators

3. Achieving nutritional goals – Many studies have shown that there is a discrepancy between the feeding plan and actual consumption, which can result in under- or overfeeding.

- Underfeeding – Underfeeding is extremely common in this situation (23) and can result in harm to the immune system, muscle breakdown, and damage to the cardio-respiratory system. Efforts must be made to gradually achieve the nutrition goals.

- Overfeeding – Overfeeding is likely to result in hyperglycemia, greater oxidative stress, increased risk of infections and in respiratory distress. Overfeeding, (that is, giving more than 110% of nutritional needs) (8) is likely to be caused by providing energy from non-nutritional sources (for example, sedation from propofol, which provides an additional 1.1 kcal/ml, and from dextrose solutions, which provides 4 kcal/g) and is much more common when giving parenteral nutrition.

In situations where it is not possible to reach nutrition goals via enteral nutrition, ~~we~~ one should consider Supplemental Parenteral Nutrition (SPN). However, the appropriate timing of this combination is controversial. Although adding SPN to meet nutritional goals between days 4-8 was shown to result in a decrease in the rate of infectious complications (24), ASPEN recommends initiating parenteral nutrition only after 7-10 days in which the patient receives less than 60% of nutritional needs for calories and protein (18). Therefore, before starting SPN, one should consider the patient's nutritional condition, with special attention placed on patients with poor nutritional status.

4. Glycemic control – Hyperglycemia and hypoglycemia are associated with an increased risk of morbidity and mortality in the ICU (8). However, there is no consensus regarding the optimal range of glucose levels. While ASPEN recommends a target range of 140-180 mg/dl (18), ESPEN states that a target goal of 6-8 mmol/l (110-145 mg/dl) is associated with positive results. In addition, other organizations recommend maintaining blood glucose levels at less than 180 mg/dl (21).

Glycemic control requires individualized treatment, with an emphasis on identifying changes in trends and causes of lack of glycemic control (infection, steroids, overfeeding, etc.). The primary treatment for hyperglycemia is providing insulin, as needed. Additional techniques used to prevent hyperglycemia and hypoglycemia during the time of nutrition support include avoiding solutions that contain high levels of dextrose (more than 3-4 mg/kg/min) and adjusting the amounts of feeds and carbohydrates when high levels of insulin (more than 6 units/hr) are needed for more than 24 hours. In rare instances only, it is acceptable to consider decreasing the amounts of feeds (8). There is no widespread recommendation for the use of a formula low in carbohydrates compared to a standard formula in order to achieve glycemic control (18).

(See Appendix 6 – Nutritional Follow-up Form for Monitoring the Critically Ill Patient)

ARDS – acute respiratory distress syndrome

ARDS is a syndrome that is characterized by acute and sudden onset of respiratory distress and pulmonary edema. This is primarily expressed as a failure in blood oxygenation so that oxygen is

no available to be supplied to all organ systems. This syndrome can be caused by infection, viral pneumonia, aspiration, embolism, sepsis, and trauma (25).

A study that investigated hospitalized patients in the ICU with COVID-19 found that about 2/3 of the patients developed ARDS (7). The principles of ARDS treatment due to COVID-19 include adherence to a conservative fluid management program, early treatment of empiric antibiotics (in case of bacterial pneumonia), the consideration of early mechanical ventilation, respiratory strategies to protect the lungs, prone position during respiratory support, and if needed, treatment with extracorporeal membrane oxygenation (ECMO) (4).

There are significant major studies, such as EDEN (26), PERMIT (27), INTACT (28) and post hoc INTACT (29), which looked at the effect of feeds supplying about 25-50% of goal (tropic feeds) compared to full feeds on the clinical outcomes in mechanically ventilated patients. The patient populations in the EDEN, INTACT and post hoc INTACT studies were those with ARDS and acute lung injury (ALI). There were conflicting results from these studies, and the topic still remains controversial. In these individuals, it is recommended to follow the ESPEN guidelines for the critically ill patient by providing calories and protein amounts, similar to the recommendations outlined in this paper.

Prone position

One of the treatment options for patients with severe ARDS is to place them on their stomach in the prone position.

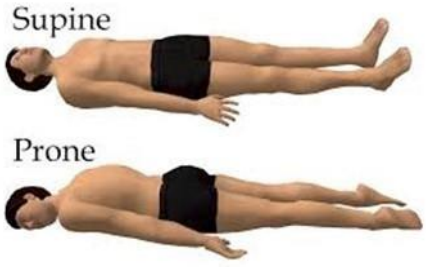


Figure 2 –– prone position

There is limited evidence evaluating the safety and tolerability of enteral nutrition provided to patients in a prone position. Among the studies that have been published it was found that ~~E~~enteral nutrition provided to patients does not seem to increase the risk for aspiration, vomiting or additional gastrointestinal symptoms (29, 30). When feeding in this position, it is important to pay special attention to gastrointestinal symptoms (such as GRV and vomiting) (31). In order to reduce feeding intolerance, it may be necessary to consider using a prokinetic agent or placing a post-

pyloric feeding tube (32). Even in the prone position, ESPEN guidelines recommends starting early **enteral** feeding in a controlled manner.

ECMO – Extracorporeal Membrane Oxygenation

One of the treatments for severe ARDS involves connecting the patient to an ECMO machine, which is used to support patients with severe heart failure and/or extreme respiratory distress. This device acts as an artificial external lung. To provide ECMO, blood is drained from the great veins, is passed through a gas exchange membrane that adds oxygen and removes carbon dioxide and then the blood is returned to the circulation into the main artery. This action allows the respiratory system to rest and recover.

According to a review article by Danielle Bear, EEN within 24 hours was reviewed in seven observational studies and most showed no adverse gastrointestinal side effects (33). Recommendations for energy and protein needs in these patients were identical to critical care ICU patients on respiratory support. Some of the studies suggest that these patients have higher protein needs, and in patients with a BMI < 30 kg/m^2 it is recommended to give 1.5-2 g/kg of protein and in those with a BMI > 30 g/m^2, it is recommended to give protein at 2-2.5 g/kg of IBW (ideal body weight).

Pharmaconutrition

The concept of pharmaconutrition advocates investigating the effects of pharmacologic doses of individual nutrients on immune function and clinical outcomes (34). Vitamin C and omega-3 fatty acids are the two nutrients which have been primarily studied in patients with respiratory failure.

Vitamin C

Vitamin C is a water-soluble vitamin with a variety of antioxidant, anti-inflammatory, and microvascular effects. Vitamin C levels are known to be decreased in critical illness (35). Mechanical ventilation, extracorporeal membrane oxygenation and hemodialysis produce oxidative stress, a state defined by high level of reactive oxygen species, which negatively impacts morbidity and causes oxidative damage to proteins, lipids, and DNA (8). Evidence suggests that short-term high-dose vitamin C in selected patients may improve hemodynamic parameters,

decrease fluid resuscitation requirements, reduce the incidence of perioperative atrial fibrillation, improve pain and potentially reduce sepsis-associated mortality (36).

Approximately 70%–90% of vitamin C is absorbed at moderate intakes of 30–180 mg/day. However, at doses above 1 g/day, absorption falls to less than 50%, and the unmetabolized ascorbic acid is excreted in the urine (37). Therefore, the protocols that are used recommend giving vitamin C intravenously. High levels of vitamin C can cause the formation of urinary oxalate stones, which can lead to decreased renal function. Thiamin has been shown to lessen this effect. In addition, it appears that corticosteroids can increase the absorption of vitamin C into the cells. For that reason, various medical protocols recommend administering vitamin C together with thiamin and corticosteroids. These protocols give 1.5 g of vitamin C intravenously every 6 hours over a period of 4 days, 50 mg of IV hydrocortisone every 6 hours over 7 days, and 400 mg of IV thiamin every 12 hours over 4 days (38).

The existing research investigating the use of IV vitamin C in patients with respiratory failure use different methodologies and therefore there is no consensus on the results. Current guidelines for the critically ill patient, do not recommend vitamin C supplementation without proven deficiency.

Omega – 3

Acute respiratory distress syndrome (ARDS)~~,~~ is defined as the acute onset of noncardiogenic edema and subsequent gas exchange impairment due to a severe inflammatory process. ARDS patients showed significantly higher levels of eicosanoids than a reference group of healthy subjects. ~~i~~It has been suggested that supplementation with omega 3 fatty acids may modulate this inflammatory response in ARDS. Omega-3 fatty acids are alpha-linolenic acid (ALA), eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA), and are found to reduce the inflammatory response as they compete with omega 6 fatty acids and minimize the synthesis of proinflammatory eicosanoids (39).In meta-analysis studies assessing the effect of omega-3 fatty acids (as enriched formulas or administered separately)~~,~~ on ARDS patients, no improvement in ventilator-free days and ICU-free days at day 28 were found, although the results were inconsistent (40, 41). This could be related to the use of different methodologies. Current

guidelines do not recommend giving omega-3 fatty acids as a bolus, but EN enriched with omega-3 FA within nutritional doses can be given (8)

Transitioning to oral feeding post extubation

Dysphagia is often present even after short periods of intubation (<48 hours) and is a major risk factor for aspiration and ICU acquired pneumonia. Other risk factors for dysphagia include muscle weakness and neurological disorders (22).

Early removal of the feeding tube may result in improved patient comfort, but it can have a negative impact on dietary intake. The decision of removing the feeding tube should be done after discussion with the patient and the medical team.

During the early recovery period (during the first 7 days after tracheal extubation), patients do not achieve their calorie targets, and consume fewer than 50% of their estimated protein requirements. Poor appetite during this period has been shown to be an important barrier to eating. Optimal nutritional support for ICU survivors is therefore crucial to post-ICU recovery (42).

To prevent malnutrition, it is important that clinicians monitor the oral intake of awake patients. ~~o~~Options to promote nutritional intake in patients with poor appetite include offering small frequent meals, providing energy-dense foods and using formulas (ONS) (43).

References

1. He F, Deng Y, Li W. Coronavirus disease 2019 (COVID-19): What we know? J Med Virol 2020 Mar 14.(Epub ahead of print doi: 10.1002/jmv.25766).
2. Zhou F, Yu T, Fan G et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. Lancet 2020;395 (10229): 1054-62.
3. Wu Z, McGoogan JM. Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China: Summary of a report of 72,314 cases from the Chinese Center for Disease Control and Prevention. JAMA 2020 feb 24 (Epub ahead of print; doi: 10.1001/jama.2020.2648).
4. Murth S, Gomersall CD, Fowler RA. Care for critically ill patients with COVID-19. JAMA 2020 Mar 11 (Epub ahead of print doi: 10.1001/jama.2020.3633).
5. Mahase E. Covid-19: Most patients require mechanical ventilation in first 24 hours of critical care. BMJ 2020 Mar 24 (Epub ahead of print; doi: 10.1136/bmj.m1201).
6. Yang X, Yu Y, Xu J, et al. Clinical course and outcomes of critically ill patients with SARS-CoV-2 pneumonia in Wuhan, China: A single-centered, retrospective, observational study. Lancet Respir Med 2020 Feb 24 (Epub ahead of print; doi: 10.1016/S2213-2600(20)30079-5).
7. Wang D, Hu B, Hu C et al. Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus–infected pneumonia in Wuhan, China, JAMA 2020 Feb 7 (Epub ahead of print; doi: 10.1001/jama.2020).
8. Barazzon R, Bischoff SC, Krznaric Z et al. ESPEN expert statements and practical guidance for nutritional management of individuals with sars-cov-2 infection. Clin Nutr 2020 March 24
9. Singer P, Blaser AR, Berger MM et al. ESPEN guideline on clinical nutrition in the intensive care unit. Clin Nutr 2019;38:48-79.
10. Mundi MS, Patel JJ, Martindale R. Body composition technology: Implications for the ICU. Nutr Clin Prac 2019;34:48-58.
11. Mogensen KM, Robinson MK, Casey JD et al. Nutritional status and mortality in the critically ill. Crit Care Med 2015;43:2605-15.
12. Hasan RA, Martin AR, Heyland DK et al. Identifying critically-ill patients who will benefit most from nutritional therapy: Further validation of the “modified NUTRIC” nutritional risk assessment tool. Clin Nutr 2016;35:158-62.
13. Hirsch S, de Obaldia N, Petermann M, et al. Subjective global assessment of nutritional status: Further validation, 1991, 7(1):35-7, PMID: 1802183.

14. Jensen JL, Cederholm T, Correia I et al. GLIM criteria for the diagnosis of malnutrition: A consensus report from the global clinical nutrition community. JPEN 2019;43:32-40.
15. Zhang G, Dong X, Cao Y et al. Clinical characteristics of 140 patients infected with SARS- CoV-2 in Wuhan, China. Allergy 2020 Feb 2 (Epub ahead of print; doi: 10.1111/all.14238).
16. Blaser, Annika Reintam, et al. "Early enteral nutrition in critically ill patients: ESICM clinical practice guidelines. Intensive Care Med 2017; 43:380-398.
17. NICE guidelines (National Institute for Health and Care Excellence), Nutrition support for adults: oral nutrition support, enteral tube feeding and parenteral nutrition (CG32), Aug 2017.
18. McClave SA, Taylor BE, Martindale GR et al. Guidelines for the provision and assessment of nutrition support therapy in the adult critically ill patient: Society of Critical Care Medicine (SCCM) and American Society for Parenteral and Enteral Nutrition (A.S.P.E.N.). JPEN 2016;40:159-211.
19. Alberda C, Gramlich L, Jones N. The relationship between nutritional intake and clinical outcomes in critically ill patients: Results of an international multicenter observational study. Intensive Care Med 2009;134:1567-74.
20. Weijes PJ, Looijaard WJ, Beishuizen A et al. Early high protein intake is associated with low mortality and energy overfeeding with high mortality in non-septic mechanically ventilated critically ill patients. Crit Care 2014;18:701**.**
21. Berger MM, Reintam-Blaser A, Calder PC et al. Monitoring nutrition in the ICU. Clin Nutr 2019; 38:584-93.
22. Lewis K, Alqahtani Z, Mcintyre L et al. The efficacy and safety of prokinetic agents in critically ill patients receiving enteral nutrition: a systematic review and meta-analysis of randomized trials. Crit Care 2016;20:259.
23. Villet S, Chiolero R, Bollmann M, et al. Negative impact of hypocaloric feeding and energy balance on clinical outcome in ICU patients. Clin Nutr 2005;24:502.
24. Heidegger CP, Berger MM, Graf S et al. Optimisation of energy provision with supplemental parenteral nutrition in critically ill patients: a randomised controlled clinical trial. Lancet 2013;381:385-93.
25. Diamond M, Peniston Feliciano HL, Sanghavi D, and Mahapatra S. Acute Respiratory Distress Syndrome (ARDS), StatPearls Publishing LLC. Copyright © 2020.
26. Rice TW, Wheeler AP, Thompson BT, et al. Initial trophic vs full enteral feeding in patients with acute lung injury: the EDEN randomized trial. JAMA 2012;22:795-803.
27. Arabi YM, Aldawood AS, Haddad SH, et al. Permissive underfeeding or standard enteral feeding in critically ill adults. N Engl J Med 2015;372:2398–2408.

28. Braunschweig CA, Sheean PM, Peterson SJ, et al. Intensive nutrition in acute lung injury: a clinical trial (INTACT). JPEN. 2015;39:13-20.
29. Peterson SJ, Lateef OB, Freels S et al. Early exposure to recommended calorie delivery in the intensive care unit is associated with increased mortality in patients with acute respiratory distress syndrome. JPEN J Parenter Enteral Nutr. 2018;42(4):739-747.
30. Saez de la Fuente I, Saez de la Fuente J, Quintana Estelles MD et al. Enteral nutrition in patients receiving mechanical ventilation in a prone position. JPEN.2016; 40:250-255.
31. Linn DD, Beckett RD, Foellinger K. Administration of enteral nutrition to adult patients in the prone position. Intensive Crit Care Nurs. 2015;31:38-43.
32. Sams VG, Lawson CM, Humphrey CL et al. Effects of rotational therapy on aspiration risk of enteral feeds. Nutr Clin Pract. 2012;27(6):808-11.
33. Bear de Smith E, Barrett NA. Nutrition support in adult patients receiving extracorporeal membrane oxygenation. Nutr Clin Pract. 2018;33(6):738-746.
34. Pierre JE, Heneghan AF, Lawson CM et al. Pharmaconutrition review: physiological mechanisms. JPEN 2013;37 (Supp 5):51S-65S.
35. Zhang M, Jativa DF. Vitamin C supplementation in the critically ill: A systematic review and meta-analysis. SAGE Open Med 2018; 6: 2050312118807615.
36. Nabzdyk, C, Bittne EA. Vitamin C in the critically ill-indications and controversies. World J Crit Care Med 2018; 7:52-61.
37. Hediger MA. New view at C. Nat Med 2002;8: 445-446.
38. Kim WY, Jo EJ, Eom JS et al. Combined vitamin C, hydrocortisone, and thiamine therapy for patients with severe pneumonia who were admitted to the intensive care unit: Propensity score-based analysis of a before-after cohort study. J Crit Care 2018; 47:211-18.
39. Garcia de Acilu M, Leal S, Carait B et al. The role of omega-3 polyunsaturated fatty acids in the treatment of patients with acute respiratory distress syndrome: a clinical review. BioMed Res Int 2015; 2015;2015:653750.
40. Dushianthan A, Cusack R, Burgess V et al. Immunonutrition for acute respiratory distress syndrome (ARDS) in adults. Cochrane Database Syst Rev 2019; CD012041.
41. Langlois,PL, D'Aragon F, Hardy J et al. Omega-3 polyunsaturated fatty acids in critically ill patients with acute respiratory distress syndrome: A systematic review and meta-analysis. Nutrition 2019; 61: 84-92.
42. Lambell KJ, Tatucu-Babet OA, Chapple LA et al. Nutrition therapy in critical illness: a review of the literature for clinicians. Crit Care 2020; 24:35.

43. Merriweather JL, GriffithDM, Walsh TS et al. Appetite during the recovery phase of critical illness: a cohort study. Eur J Clin Nutr 2018; 72:986-992.

Appendices

Appendix 1 - NUTRIC score (Nutrition Risk in the Critically Ill)

Table 1: NUTRIC Score variables

Variable	Range	Points
Age	<50	0
	50 - <75	1
	≥75	2
APACHE II	<15	0
	15 - <20	1
	20-28	2
	≥28	3
SOFA	<6	0
	6 - <10	1
	>10	2
Number of Co-morbidities	0-1	0
	≥2	1
Days from hospital to ICU admission	0 - <1	0
	≥1	1
IL-6	0 - <400	0
	≥ 400	1

Table 2: NUTRIC Score scoring system: if IL-6 available

Sum of points	Category	Explanation
6-10	High Score	➢ Associated with worse clinical outcomes (mortality, ventilation). ➢ These patients are the most likely to benefit from aggressive nutrition therapy.
0-5	Low Score	➢ These patients have a low malnutrition risk.

Table 3. NUTRIC Score scoring system: If no IL-6 available*

Sum of points	Category	Explanation
5-9	High Score	➢ Associated with worse clinical outcomes (mortality, ventilation). ➢ These patients are the most likely to benefit from aggressive nutrition therapy.
0-4	Low Score	➢ These patients have a low malnutrition risk.

*It is acceptable to not include IL-6 data when it is not routinely available; it was shown to contribute very little to the overall prediction of the NUTRIC score.

Appendix 2 - SGA (Subjective Global Assessment)

SUBJECTIVE GLOBAL ASSESSMENT RATING FORM

Patient Name: **ID #:** **Date:**

HISTORY

WEIGHT/WEIGHT CHANGE: ***(Included in K/DOQI SGA)*** — **Rate 1-7**

1. **Baseline Wt:** _____(Dry weight from 6 months ago)
   Current Wt: _____(Dry weight today)
   Actual Wt loss/past 6 mo: _____ **% loss:**_____(actual loss from baseline or last SGA)
2. **Weight change over past two weeks:** _____No change _____Increase _____Decrease

DIETARY INTAKE No Change_____(Adequate) No Change_____(Inadequate)

1. Change: Sub optimal Intake: _____ Protein _____ Kcal _____ Duration_____
   Full Liquid: _____ Hypocaloric Liquid _____ Starvation _____

GASTROINTESTINAL SYMPTOMS ***(Included in K/DOQI SGA-anorexia or causes of anorexia)***

Symptom:	**Frequency:***	**Duration:+**
_____ None	_____	_____
_____ Anorexia	_____	_____
_____ Nausea	_____	_____
_____ Vomiting	_____	_____
_____ Diarrhea	_____	_____

Never, daily, 2-3 times/wk, 1-2 times/wk > 2 weeks, < 2 weeks

FUNCTIONAL CAPACITY — b

Description	**Duration:**
_____ No Dysfunction	_____
_____ Change in function	_____
_____ Difficulty with ambulation	_____
_____ Difficulty with activity (Patient specific "normal")	_____
_____ Light activity	_____
_____ Bed/chair ridden with little or no activity	_____
_____ Improvement in function	_____

DISEASE STATE/COMORBIDITIES AS RELATED TO NUTRITIONAL NEEDS

Primary Diagnosis_____Comorbidities_____

Normal requirements ____Increased requirements____ Decreased requirements _____

Acute Metabolic Stress: _____None _____Low _____Moderate _____High

PHYSICAL EXAM

_____ Loss of subcutaneous fat (Below eye, triceps, biceps, chest) ***(Included in K/DOQI SGA)*** ____Some areas _____All areas

_____ Muscle wasting (Temple, clavicle, scapula, ribs, quadriceps, calf, knee, interosseous ***(Included in K/DOQI SGA)*** ____Some areas _____All areas

_____ Edema (Related to undernutrition/use to evaluate weight change)

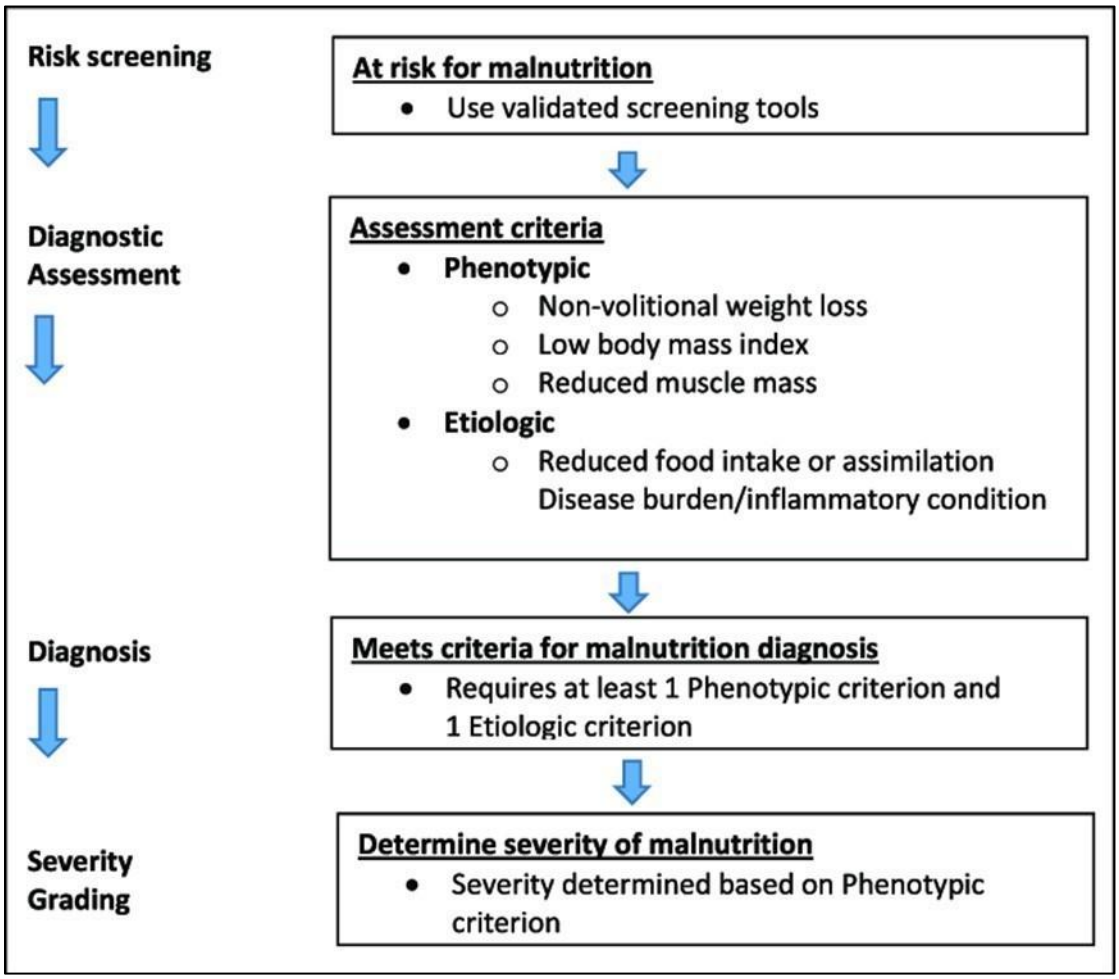
OVERALL SGA RATING

Very mild risk to well-nourished=6 or 7 most categories or significant, continued improvement.

Mild-moderate = 3, 4, or 5 ratings. No clear sign of normal status or severe malnutrition.

Severely Malnourished = 1 or 2 ratings in most categories/significant physical signs of malnutrition.

Appendix 3 - GLIM (Global Leadership Initiative on Malnutrition) Criteria



Appendix 4 - NICE Guidelines

National Institute for Clinical Excellence (NICE) Guidelines for Management of Refeeding Syndrome	
Patients at risk for refeeding syndrome	
ONE or more of the following: -OR-	TWO or more of the following:
BMI < 16 kg/m^2	BMI <18.5 kg/m^2
Unintentional weight loss of >15% in the previous 3-6 months	Unintentional weight loss of >10% in the previous 3-6 months
Little or no nutritional intake for >10 days	Little or no nutritional intake for >5 days
Low levels of potassium, phosphorus, or magnesium before refeeding	History of alcohol abuse or drugs including insulin, chemotherapy, antacids, or diuretics

~~Appendix 5 -~~ Appendix 5 - Nutrition Composition of Formula

Formula	Kcal per 100 ml	Protein (g) per 100 ml	Water (ml) per 100 ml	Kcal/ml
Jevity	106	4.4	83.5	1.06
Jevity Plus	150	6.4	76	1.5
Nepro HP	182	8.1	73.2	1.8
Nutren 2	200	8.4	69.2	2
Osmolite HN	106	4.5	84.2	1.06
Peptamen Prebio	100	4.0	84.4	1.0
Peptamen AF	152	9.4	78	1.52

Appendix 6 - Examples of Feeding Plans

Table 1 – Example of a Feeding Plan for 1500 kcal

Formula	Volume for 1500 kcal (ml)	Pro (g)	Water (ml)	Kcal/ml	Feeding Rate over 24 hours
Jevity	1415	62.3	1175	1.06	60
Jevity Plus	1000	63.8	760	1.5	40
Nepro HP	825	66.8	604	1.8	35
Nutren 2	750	63	520	2.0	30
Osmolite HN	1415	63.7	1192	1.06	60
Peptamen Prebio	1500	60	1269	1.0	65
Peptamen AF	987	93	770	1.52	40

Table 2 – Example of a Feeding Plan for 2000 kcal

Formula	Volume for 2000 kcal (ml)	Pro (g)	Water (ml)	Kcal/ml	Feeding Rate over 24 hours
Jevity	1887	83	1576	1.06	80
Jevity Plus	1333	85	1013	1.5	55
Nepro HP	1097	89	807	1.8	45
Nutren 2	1000	84	692	2.0	40
Osmolite HN	1887	85	1589	1.06	80
Peptamen Prebio	2000	80	1692	1.0	85
Peptamen AF	1316	124	1027	1.52	55

Appendix 7 - Nutritional Follow-up Form for Monitoring the Critically Ill Patient

Date: _____ **Patient's ID: _____**

Current formula and rate

Nutren 2	Osmolite	Jevity	Jevity Plus	Nepro HP	Peptamen AF	Other:
Rate:	Rate:	Rate:	Rate:	Rate:	Rate:	Rate:

The patient is not fed ☐

Additional parameters for nutrition follow-up (use data from the previous day):

Fluid Balance	**Additional Calories to Consider**	**Current Feeding Tolerance**
Volume (ml):	Volume or rate providing daily propofol (ml):	Glycemic values:
Urinary output (ml):	Volume of IV dextrose 5%:	Bowel movements: None / Normal / Diarrhea
Fluid restriction (ml):	CRRT with trisodium citrate: Yes / No	GRV (gastric residual volume):
PCO2: Arrhythmias: Yes / No Pulmonary Edema: Yes / No	Enteral feeds combined with: PO / TPN	Tympanic abdomen: Yes / No Vomiting: Yes / No Electrolyte imbalance: Yes / No
Prone Position: Yes / No		

*1 ml propofol = 1.1 kcal from lipids

*5% dextrose in 1 liter has 50 grams dextrose compared to 4 kcal/g

* CRRT with trisodium citrate provides 0.59 kcal/mmol or 3 kcal/g

Additional comments:

_____

_____