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Nutrition Management and Recommendations for Improving the Outcomes of Coronavirus Disease 2019-A Narrative Review

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Abstract

Context: Nutritional management of Covid-19 (Coronavirus Disease 2019) patients can serve as a tool to strengthen the patient's immune system and provide sufficient physiological resources to maintain vital functions during the fight between the virus and the body.
This review aimed to highlight available recommendations for the nutritional management of Covid-19 patients based on previous treatments used in similar diseases.
Evidence Acquisition: For this narrative review, a comprehensive search was performed in three databases, including PubMed, Scopus, and Web of Science databases from January 2020 to 7th December 2021, in the English language. The articles that focused on nutrition, diet, food, immunity, and coronavirus were searched. The titles and abstracts of all imported articles were screened. Only systematic and narrative reviews, commentary, opinion, prospective, and original articles, which related to the study question, were included. Studies which investigated the role of nutrition in the prevention of Covid-19 were excluded.
Conclusion: Due to the unique nature of Covid-19 and the role of nutrition in immunity and prognosis of Covid-19, the nutritional needs of patients with Covid-19 differ from others. Accordingly, the provision of these specific nutrient requirements and paying attention to the use of effective food supplements when adjusting the diet plan of patients with Covid-19 can be effective in improving patients' conditions. Therefore, more studies in this field can be helpful.

Keywords: Coronavirus, Macronutrient, Micronutrient, Nutrition management, Nutrition recommendations

1. Context

Since December 2019, the (Coronavirus disease 2019) Covid-19 has spread rapidly across the globe (1). By the end of 2022, the Covid-19 pandemic resulted in more than 636 million confirmed cases and more than 6.6 million deaths worldwide (2). Rapid exacerbation and the need for hospitalization and mechanical ventilation have motivated researchers to find evidence-based treatment regimens (2, 3). Although many prospective drugs, such as hydroxychloroquine, chloroquine, ribavirin, remdesivir, and favipiravir, have been used to treat COVID-19, no therapies have been shown effective to date (4). Therefore, strengthening the patient's immune system, enhancing the host's ability to support an extensive flow of catabolic cytokines, and providing sufficient physiological resources to maintain vital functions during the fight between the virus and body have been used as effective strategies to increase the host's ability to fight infection and reduce the burden of Covid-19 severity (5). Nutritional management of Covid-19 patients can serve as a tool to achieve this therapeutic strategy (6).

Nutrition affects innate and adaptive immune responses. Many micronutrients are effective in boosting the host's immune system against infections, including vitamins B, C, E, and D, iron, selenium, and zinc (7, 8). Chronic diseases, risk factors for severe Covid-19, are often associated with energy protein malnutrition (disease-related malnutrition) (9). Malnutrition is a major cause of immunodeficiency worldwide (10). Malnutrition disrupts the activation of immune cells, increases the shelf life of the virus, and ultimately increases the chances of transmitting inflammatory cells to the lungs (11). Hyperthermia and excessive nitrogen depletion increase mortality in Covid-19 patients, and malnourished people are more affected by this metabolic change due to the lack of body reserves. Strong evidence confirms that the outcome of Covid-19 depends on the patient's nutritional status (12, 13). If proper nutritional care is not provided, the patient's body reservoirs can easily drain, leading to increased virus-induced damage (12). In addition, Covid-19 is an acute inflammatory process; therefore, critically ill patients with Covid-19 must resist the effects of the resulting inflammatory storm, which manifests as loss of appetite and weight loss as an inevitable process (14). Decreased intake of nutrition products and increased digestive losses worsen the prognosis of Covid-19(15); therefore, these manifestations require nutritional interventions.

Due to the urgent need for information on how to provide nutritional Support to patients with Covid-19, several guidelines for clinical practice have been published. Nonetheless, the large and growing volume of this information has confused the healthcare community (16). In light of the aforementioned issues, the present review article aimed to summarize the clinical practice recommendations for medical nutrition therapy in hospitalized and critically ill patients with Covid-19. This review aimed to highlight available recommendations for the nutritional management of Covid-19 patients based on previous treatments used in similar diseases.

2. Evidence Acquisition

For this narrative review, a comprehensive query was conducted on Medline (PubMed), Scopus, and Web of Science databases from January 2020 up to 7th December 2021, using the following keywords: ((((NUTR*[Title/Abstract]) OR (DIET* [Title/Abstract])) OR (FOOD[Title/Abstract]))) AND ((COVID[Title/Abstract]) OR (CORNAVIRUS [Title/Abstract]))" AND ((RECOMMENATIONS [Title/Abstract]) OR (ADVISE [Title/Abstract]))." To identify additional studies, we also manually reviewed the reference section of primary articles and relevant reviews.

Titles and abstracts of all imported articles were screened according to the specific inclusion and exclusion criteria. Systematic and narrative reviews, commentary, opinion, perspective, and original articles were included. The studies were excluded if (1) were not related to the study question (2); the role of nutrition in the prevention of Covid-19 had been considered (3); the target group of studies had another disease, apart from Covid-19 (4); they were case report, case series, editorial, and communication letters. The study protocol was approved by the Ethics Committee of the faculty of nutrition and food technology, National nutrition and food technology research institute, Shahid Beheshti university of medical sciences, Tehran, Iran.

3. Discussion

Included studies were from Netherlands, Greece, Canada, Italy, Spain, the UK, France, Poland, Switzerland, and the USA, and most of them were cross-sectional.

3.1. Malnutrition management

More than 70% of Covid-19 patients were malnourished (17, 18). Considering that inadequate nutrition leads to a weak immune response (8), malnutrition is associated with a poor prognosis of Covid-19. The reduction in food intake due to nausea, diarrhea, anorexia, and management strategies (e.g., ventilation) is proposed as a reason for this finding (18, 19). The presence of previous chronic disease in Covid-19 patients can lead to a decrease in the nutritional level of patients. Immobility associated with Covid-19 induces sarcopenia that can also increase the risk of malnutrition in Covid-19 patients (20). It is also well-known that advanced age is deeply related to the risk of malnutrition (21). Most people with Covid-19 are over 70 years old or more, explaining the high prevalence of malnutrition in people with Covid-19. Weight loss over the course of hospitalization and obesity is highly prevalent in patients with Covid-19, both of which increase the risk of malnutrition in Covid-19 patients (22). Low pre-albumin levels as a marker of malnutrition can predict the progression to respiratory failure in Covid-19 patients (23). Another marker of malnutrition, lymphopenia, is a negative prognostic factor in patients with Covid-19 (23, 24); therefore, the prevention, diagnosis, and treatment of malnutrition must be regularly included in the management of hospitalized Covid-19 patients to reduce complications and negative outcomes.

The European Society for Clinical Nutrition and Metabolism (ESPEN) Covid-19 guidance recommends that Covid-19 patients, especially obese and older ones, should be screened for nutritional risk using a nutrition risk screening form (NRS 2002) (25). Nonetheless, in a Chinese cohort study, the modified nutrition risk in critically ill (mNUTRIC) score was accepted as a good tool for the identification of nutrition in Covid-19 patients (26). Among the screening tools, mNUTRIC has better specificity for Intensive Care Unit (ICU) patients, while Mini nutritional assessment (MNA) demonstrates better validity for prolonged hospitalization (27). Global leadership initiative on malnutrition (GLIM) has a strong association with mortality and longer duration of ICU stay (28).

In addition, nutritional assessment should be performed for all patients with Covid-19 within the first 24-48 hours of hospitalization, and this evaluation should be repeated at specified intervals frequently. The ESPEN guidance does not recommend a specific tool for nutritional assessment but encourages the use of validated tools, including the MNA criteria validated for geriatric patients and the NUTRIC score criteria for ICU patients. Another index of malnutrition, the geriatric nutritional risk index (GNRI), has been proposed as a predictive factor for Covid-19 prognosis (29). The assessment of calf circumference, muscle strength, and albumin, attention to inadequate food intake, and recent unintentional weight loss before hospitalization will be helpful when the physical measurement of weight and height is not possible. Many people with high body mass index (BMI) are hidden malnourished individuals. Early detection of malnutrition can improve outcomes at a lower cost (17).

The following principles should be considered for the management of malnutrition in patients infected with Covid-19. Early nutritional interventions in critically and non-critically Covid-19 patients are critical since most patients rapidly progress from cough to admission to ICU (30). The ESPEN guidance recommends feeding within 48 h of ICU admission, while ASPEN/SCCM recommends EN (Enteral Nutrition) provided within 24-36 h admission to ICU or within 12 h of intubation (25, 31). Energy expenditure increased due to fever, mechanical ventilation, the exacerbated activity of breathing muscles, and hypercatabolism. Therefore, high calorie and protein diet in a variety of different textures and consistencies with highly digestible food and snacks are desirable for non-critical patients (who are not even at nutritional risk). In critical patients, a standard high-protein polymeric iso-osmotic enteral formula is recommended (31)

Insufficient intake due to decreased appetite, dyspnea, mechanical ventilation, and impaired consciousness is common; therefore, in cases where oral intake is less than 50% of the planned amount, scheduled oral nutritional supplements (ONS) are required (18), and 400-600 kcal of energy can be met through ONS (32). If the patient's food intake for a week is between 50% and 75% usual intake, two servings of ONS in addition to meals plus supplementation with a multivitamin, magnesium, phosphorus, as well as vitamins B9, B1, and D, are prescribed. When food intake is below 50% of the usual intake, intravenous supplementation of micronutrients plus three servings of ONS is recommended (23). A rapid intravenous administration of whey proteins, vitamins, and minerals (if insufficient) has been proposed for noncritical Covid-19 patients (18).

It is recommended to initiate enteral feeding within 24-36 hours of admission in the ICU and within 12 hours of intubation. Early enteral nutrition (EN) in Covid-19 patients nourishes the bacterial flora of the gut and avoids systemic inflammation in these patients (33). Early parenteral nutrition (PN) (within 3-7 days) should be started in hospitalized patients with gastrointestinal symptoms, shock, and life-threatening hypoxemia, patients who use non-invasive positive pressure ventilation, and patients who are malnourished and expected to have prolonged ICU stay (34). The threshold for switching to PN in Covid-19 patients needs to be lower than in other critically ill patients (31). Post-pyloric feeding should be avoided and discouraged in shock patient receiving vasopressors. This simultaneous consumption can increase the risk of bowel ischemia, emesis, or abdominal pain (25).

3.2. Energy and Macronutrients requirement

Daily Energy and micronutrient requirements in non-critical and critical patients with Covid-19 were summarized in Table 1. Both ASPEN/SSCM

Table 1. Daily Energy and macronutrient requirements in non-critical and critical patients with Covid-19

	Non-critical patients	**Critical patients in ICU**
Energy requirement	Old patient >65y: 27kcal/kg BW(25) Underweight: 30kcal/kg BW(25) 25- 30 kcal/kg BW 20.7-30.11 KJ/Kg/day (35) kcal/kg BW(12)27-30 (17)	In the first few days: 10-15 kcal/kg BW(36) In first week if BMI ≤50 kg/m² : 15-20 kcal/kg BW In first week if BMI >50 kg/m²: 15-20 kcal/kg IBW In second week if BMI=20-25 kg/m²: 25-30 kcal/kg IBW In second week If BMI =25-30 kg/m²: 21 kcal/kg BW In second week If BMI =30-50 kg/m²: 11-14 kcal/kg BW In second week If BMI >50 kg/m²: 22-25 kcal/kg IBW
Protein requirement	Old patient >65y: 1gr/kgBW Polymorbid inpatient ≥1gr/kgBW 1.5gr/kgBW(32)	In patients with normal weight: 1.3 g/kg BW(37) In obese patients: 1.3 g/kg ABW ≥20% TEE In patients with normal weight: 1.2-2g /kg ABW(38) In obese patients: 1.2-2 g/kg IBW(38) In the first week 1.2-2g /kg ABW after that 2.0-2.5 g/kg IBW 1.5-2.0 g/kg (36) In patients undergoing RRT if BMI < 30:2-2.5 g/kg BW In patients undergoing RRT if BMI ≥30: 2.5 g/kg IBW
Carbohydrate requirement	2 gr/kgBW, Less than 150 gr/day (39) Low glycemic index Carbohydrate	Carbohydrate to fat ratio in subjects with no respiratory deficiency: 70/30(40) Carbohydrate to fat ratio in subjects with respiratory deficiency: 50/50 (40)
Lipid requirement	1.5 gr/kgBW (39)	1.5 gr/kg/day (41) Carbohydrate to fat ratio in subjects with no respiratory deficiency: 70/30(40) Carbohydrate to fat ratio in subjects with respiratory deficiency: 50/50 (40) In enteral feeding: 500 mg of EPA+DHA (36) In parenteral feeding: 0.1-0.2 g/kg (36)

ABW: Adjusted body weight, IBW: Ideal Body Weight, Covid-19, EPA: Eicosapentaenoic acid, DHA: Docosahexaenoic acid. RRT: Renal replacement therapy and ESPEN nutrition intervention recommend-dations should be based on the stage and type of respiratory therapy implemented in Covid-19 patients (31). Accurate estimation of calorie needs is important, and overfeeding or underfeeding should be avoided. A cumulative energy deficit of 8005 kcal leads to complications in the patient, and the patient may die with more than 10006 kcal cumulative energy deficit (42). Determination of energy requirement by indirect calorimetry is not recommended during the Covid-19 pandemic since using this technology requires disconnection from the ventilator, which leads to contamination of equipment and transmission of Covid-19 to healthcare providers; therefore, estimation of energy requirement by weight-based equation seems logical.

Most recommendations in ICU are based on providing a hypocaloric diet in the first week ≤)70% energy requirement) in the first few days and 80%-100% after seven days) and then progressing to iso-caloric nutrition during the second week. Progress to iso-caloric nutrition in patient requiring mechanical ventilation and stabilization should be performed with caution. The energy obtained by receiving medications, such as propofol, should be considered in estimating the energy requirement in ICU. Propofol can provide 1.1 kcal/ml and can supply 25% of the energy expenditure in mechanically ventilated sedated patients. This point is especially important in patients with refeeding syndrome who need a gradual introduction of energy. For each degree of fever in patients with Covid-19, energy consumption increases by 10%.

Under inflammatory circumstances, pro-inflammatory cytokine storm on skeletal muscles results in loss of muscle mass and cachexia (43); therefore, in addition to increasing the total protein intake, increasing the supply of branched-chain amino acids to 50% can reduce this catabolic state (44, 45). A non-protein calorie-to-nitrogen ratio of 100:11 to 150:11 is considered an adequate intake for Covid-19 patients. It is also recommended that protein requirements do not include energy expenditure during the anabolic phase of the disease in the ICU. In one protocol in Italy, 20 grams/day of whey protein is given to all non-critical patients admitted to the hospital (34). In another study, whey protein is recommended only in critical patients with gastroparesis. Whey protein is a highly digestible protein that acts as an antioxidant and regulator of the immune system and has both anabolic and antiviral properties, all of which can justify its clinical benefits.

The consumption of protein extract from whey and peas can increase beneficial bacteria in the intestine and, at the same time, reduce pathogenic bacteria (34, 46). There is no need to reduce protein, phosphorus, and potassium intake in Covid-19 patients with a history of acute renal failure due to the importance of preventing energy protein malnutrition in people with Covid-19 (47). Each mole of carbohydrate produces equal CO2 (48). It is recommended to limit carbohydrate intake in Covid-19 patients with respiratory failure to reduce CO2 production (49). Covid-19 can induce new-onset diabetes (50); therefore, screening for hyperglycemia and intensive glycemic control is essential in people with Covid-19.

The amount of fat required in critically ill patients is 1.5 gr/kg/day, of which 0.5 gr/kg/day is provided by receiving sedatives in lipid solution (51). Death rates of Covid-19 in Southern regions of Germany, which traditionally have a high-fat diet, were higher than elsewhere in Germany (52). The consumption of a low-fat diet can also increase the number of beneficial bacteria in the intestine (53); therefore, it makes sense to limit total fat intake in people with Covid-19. A high-saturated fat diet increases angiotensin-converting enzyme serum concentrations (54), while SARS-Cov-2 binds to ACE2 to reach host cells in the respiratory tract epithelium; therefore, reducing saturated fatty acid intake is desirable. Giving priority to the use of medium and long-chain fatty acids, such as omega 3 and omega 9, is recommended. Reducing pro-inflammatory cytokines, improving oxygenation, metabolizing various mediators that have anti-inflammatory properties, weakening the proliferation of viruses, reducing NF-KB activation, ameliorating the outcome of Covid-19, reducing the length of ICU stay and the number of days spent on ventilation are some of the mechanisms that could justify daily consumption of 1000 mg omega-3 daily Covid-19 patients (55). In the first week of ICU stay, it is recommended to limit the use of soy (a source of omega-6 fatty acids and an inflammatory oil) based lipid emulsions in PN.

3.3. Micronutrients and fluid requirement

Prescribing a number of micronutrients can theoretically help manage Covid-19. Evidence confirming their prescription is summarized in Table 2. Without studies specific to Covid-19, the dosing and timing of micronutrient supplementation is unknown. When there is no deficiency, patients should continue to consume these micronutrients in accordance with the recommended daily allowance and avoid taking more of them which can be associated with complications. Dehydration is common in critical Covid-19 patients due to fever, mouth breathing, acute gastrointestinal injury, depression, intubation, and sedation (52); therefore, the patient's hydration status should be assessed. Recommended daily fluid intake for stable Covid-19 patients is 30 ml/kg/day for adults and 28 ml/kg/day for elderlies. It is also recommended to consume a fluid intake of 35 ml/kg for each 1°C in body temperature (56).

Table 2. Recommended doses of micronutrients and evidences confirming the prescription of them in Covid-19 patients

Vitamin	Recommended dose of supplementation	Evidence confirming the prescription
Vitamin D	If the level is <12.5 ng/ml 100.000 IU within a week for a maximum of 500.000 IU(45) High dose (57, 58) 300000Unit IM (59) 400-4000 IU oral(60)	Reducing viral replication and production of IL-6 (58, 59) Promotion of monocytes differentiation to macrophages (58, 61) Having a role in the process of antigen presentation (37) Reducing mortality (58, 59, 62) Maintain cell physical barrier integrity (37) Having anti-inflammatory behavior (37) Reducing acute respiratory tract infection (63) Associate low vitamin D levels with risk of ARDS (63) High prevalence of vitamin D deficiency in Covid-19 patients (64)
Vitamin C	3-5 gr (74) Intravenous injection 24 g/day for 7 days (65)* 10 000-20 000 mg/d (6)	Regulation of innate B and T cell proliferation (80) Promotion of antibody production (80) Shorten the use time of booster drugs and ventilators (65) Reducing mortality from ARDS (65) Shorten mean hospital length of stay of Covid-19 patients (6) Depletion of Vitamin C during ARDS (66)
vitamin E	600 IU daily intramuscularly(76)	Decreasing APACHE II score in ARDS patients (67), Stimulation of T cell function (51), Protection against upper respiratory tract infection (68),
Vitamin A	-**	Having a role in epithelial barrier generation and in immune cell homeostasis (69)
Thiamin	100 mg IM every 24 hours for five days from 8th-10th day of hospitalization (14, 31)	Thiamine deficiency has been observed to be common in critically ill patients (70)
Folate	-**	Induction of retroviruses attack on themselves (71)
Zinc	between 60 and 90 mg/day(72)	Prevention of viral replication (73), inhibition of virus attachment to the nasopharyngeal mucous (74), Having a role in proliferation, differentiation, and maturation of leukocytes (75), Modifying the effect of several respiratory pathogens, Increasing activity of natural killer cell and T cell (76, 77), Reducing the occurrence of Ventilator-associated pneumonia(72), Reducing diarrhea (78)
Selenium		Reducing viral replication, Reducing viral-induced oxidative stress (79), Mild pathogenic viruses become highly virulent in selenium deficiency (79)

* This clinical trial is not completed, **No dosage is recommended for these micronutrients, IM: Intramuscular, APACHE II :"Acute Physiology and Chronic Health Evaluation II, ARDS : Acute respiratory distress syndrome

3.4. Nutrition after extubation

After extubation, these points should be considered: Firstly, the nutritional Support promotes the patient's recovery and rehabilitation and should be continued until the patient resumes sufficient oral intake. Secondly, approximately 24% of elderly patients require EN, in addition to their oral food intake. Thirdly, post-extubation swallowing disorders are frequent in 10%-67% of patients; therefore, the nutrition management must be adapted according to certain situations, such as dysphagia, and finally, the energy and protein intake must be adapted to the needs (25).

3.5. Nutraceuticals

In severe forms of Covid-19, severe alveolar inflammation extends to the pulmonary vasculature. Intra-pulmonary inflammation can lead to severe local vascular dysfunction, including micro-thrombosis and pulmonary intravascular coagulopathy; therefore, substances that have anti-inflammatory, antioxidant, or anti-platelet aggregation activity is effective in preventing this process. Some of these nutraceuticals are mentioned as follows (80). Among polyphenols, curcumin can bind to the target receptors of SARS-CoV-2 and inhibit the effect of the virus. In a study by Chen et al. (81), a combination of vitamin C, curcumin, and glycyrrhizic promotes interferon production and can help to fight against the virus. Epigallo catechin 3 gallate is another polyphenol that suppresses inflammatory cell infiltration into the lungs (82). Arginine may be beneficial to the treatment of Covid-19 infections due to its effects on the immune system and synthesis of nitric oxide (83). Glutamine can decrease the production of pro-inflammatory cytokines and preserve gut function which is compromised in Covid-19 infection (34). Flavonoids inhibit NF-KB translocation, which can improve the outcome of patients with Covid-19 (84)

3.6. Food

According to studies, serum urate concentrations in patients with a viral infection increase in response to increased cell turnover. In addition, coronaviruses need purine nucleotides to promote RNA synthesis; therefore, it is reasonable to advise Covid-19 patients to consume fewer purine sources. Food sources with high purine concentrations include alcoholic beverages, sweetbreads, anchovies, sardine, liver, kidney, brains, herring, mackerel, and scallops. Washing foods with water before cooking can reduce the purine content of food (85). Foods that activate peroxisome proliferator-activated receptors exert an inhibitory effect on pro-inflammatory cytokines and promote immune cell differentiation. These foods include seafood, pomegranate, and spices (35).

Angiotensin-converting enzyme inhibition has been largely found in a variety of foods, such as milk, eggs, fish, meat, soybean, beans, sunflower, rice, corn, wheat, buckwheat, broccoli, mushroom, garlic, spinach, fermented cabbage, fermented milk, and grapes (86). Fava beans contain chemical compounds similar to quinine, such as hydroxychloroquine (87); therefore, we can use them in people infected with Covid-19. The consumption of foods with antioxidant properties, such as cabbage, and food sources of resveratrol may effectively reduce mortality from Covid-19 (88, 89). The supplementation of some fish proteins can act as inhibitors against Covid-19 and can be helpful for these patients. Sulfoxide in garlic can suppress tumor necrosis factor-α (TNF- α), C-reactive protein, and expression of pro-inflammatory cytokines; accordingly, garlic can be helpful in reversing some signs and symptoms in Covid-19 patients (90, 91).

3.7. Probiotics and prebiotics

Under normal circumstances, following the production of inflammatory cytokines(e.g., TNFα, interleukin (IL)-6, IL-1), anti-inflammatory cytokines (e.g., IL-10, IL-13, IL-15) are produced; therefore, inflammation is self-limiting. Cytokine storm occurs in Covid-19 as a result of an imbalance between pro- and anti-inflammatory cytokines. Higher plasma levels of pro-inflammatory cytokines increase mortality. Probiotics are able to balance the equilibrium between pro-inflammatory and anti-inflammatory cytokines (92).

The presence of diarrhea in some Covid-19 patients suggested that SARS-COV2 might change the composition of the gut microbiota via the gut-lung axis. Loss of gut bacteria diversity can lead to a non-optimal immune system (excessive immune reactions) which results in more severe clinical complications, such as sepsis and respiratory distress syndrome, in people with Covid-19 (93). Some probiotics are effective in correcting changes made by Covid-19 in the composition of gut microbiota and consequently improving lung immunity. This finding is especially useful in elderly patients whose intestinal microbes are less diverse and who have lost beneficial microorganisms, such as bifidobacterium (94).

Taking probiotics can increase the proportion of mononuclear leukocytes and natural killer (NK) cell activity (95). It has also been reported that probiotics can disable the virus by binding directly to the virus and inhibiting the attachment of the virus to the host cell. Probiotic supplementation can reduce gastrointestinal symptoms of Covid-19, such as diarrhea (96, 63). Prebiotics (such as fiber, resistance starch, and inulin) and probiotics (Lactobacillus and bifidobacterium in fermented food, such as yogurt) can be thoughtfully administered to accelerate recovery and improve clinical outcomes in patients affected with Covid-19, especially in elderly, immune-compromised patients, and patients on antibiotic therapy with a gastrointestinal symptom. Daily supplementation with fiber and probiotic organisms is warranted (31). In critical patients, the fiber-containing formula should be used when the status of patients improves. The standard iso-osmotic formula with high protein is recommended before the patient's condition improves (31).

3.8. Nutritional considerations

Pulmonary fibrosis, long-term intubation, and the existence of comorbidities in Covid-19 patients may impair swallowing act; therefore, more than 90% of Covid-19 patients need modified diets and ONS to manage dysphagia (17). Inability to protect the airway, mechanical ventilation, age>70 years, and supine position leads to increased risk of aspiration in Covid-19 patients; therefore, a semi-liquid diet or post-pyloric feeding are strategies that can be used to reduce aspiration following oral or enteral nutrition respectively (32). Nearly half of the critically ill patients with Covid-19 experience EN intolerance due to ileus or bowel ischemia or high use of sedatives or opioids (97); therefore, it is essential to monitor the signs of EN intolerance carefully, and sometimes early initiation of PN is needed. Continuous EN delivery rather than bolus can reduce diarrhea (98).

In response to cytokine storm and/or receiving propofol secondary hemophagolymphocytic, histiocytosis occurs that can lead to elevated serum triglyceride levels; therefore, monitoring serum triglycerides in critical patients with Covid-19 is recommended (31). Most Covid-19 patients do not get enough food before being admitted to the hospital; therefore, monitoring refeeding syndrome and its associated complications is important (98).

4. Conclusion

Covid-19 can be mild to moderate (Flu-like symptoms up to mild pneumonia), severe (dyspnea, hypoxia, or >50% lung involvement on imaging), and critical (respiratory failure, shock, or multi-organ system dysfunction. Patients with a mild to moderate presentation may not initially require hospitalization, and home quarantine is sufficient for them. Nutritional screening and early intervention to treat possible malnutrition are very important for these patients. Medical staff should monitor oral intake and encourage prescribing ONS for patients without sufficient intake. A high-calorie, high-protein, easy-to-digest, easy-to-swallow diet is recommended. Ventilator-independent patients with bilateral pneumonia are hospitalized in the ward. The ratio of carbohydrate to fat intake should also be reduced in the nutritional management of these patients; moreover, other points mentioned in mild cases should be considered. For critical patients with Covid-

19, energy and protein targets by weight-based equations should be defined. Early enteral or parenteral feeding at trophic doses, slow advancement to energy and protein goals over the first week, and close monitoring of biochemical tests are the basic principles of critical care nutrition. For all Covid-19 patients, repletion of micronutrients (especially those that improve immunity) and fiber supplementation is reasonable.

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Footnotes

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