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Nutrition for Critically Ill Patients With COVID-19

This article discusses the nutritional implications for critically ill patients admitted to intensive care for the management of COVID-19, and considers the inflammatory metabolic processes, nutrition-impacting symptoms, medical therapy, and the impact of a pandemic on staff resourcing and remote practice.

Introduction

The global pandemic caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is predicted to result in 5-10% of infected patients requiring admission to intensive care (Grasselli et al. 2020a; Poston et al. 2020). It is likely that patients will be at significant nutritional risk, as a result of catabolism and significant nutritional deficits, which may result in poor functional recovery if not well managed.

This review provides perspective on the nutritional implications and management of coronavirus disease 2019 (COVID-19), the resulting illness from SARS-CoV-2, by drawing on available clinical data for patients with COVID-19, as well as the literature from Acute Respiratory Distress Syndrome (ARDS). It considers the implications of a global pandemic on caseload, resourcing, supply chain shortages, and the logistics of managing highly infectious patients.

Clinical Characteristics, Medical Therapy and Nutritional Implications

Risk factors for ICU admission

Patients most likely to require ICU support tend to be older (~60 years) (Guan et al. 2020; Livingston and Bucher 2020), ~25-40% have at least one comorbidity such as hypertension, diabetes, heart disease, or chronic obstructive pulmonary disease (Guan et al. 2020; Huang et al. 2020; Zhou et al. 2020), and almost 75% are overweight or obese (ICNARC 2020). The most common reason for admission to ICU is respiratory failure, with around two-thirds of patients meeting criteria for a diagnosis of ARDS (Wang et al. 2020; Murthy et al. 2020). Additionally, data suggests that patients are admitted to the ICU approximately 10 days after the onset of initial symptoms (Huang et al. 2020) and; therefore, patients may have sustained nutritional deficits prior to admission.

Metabolic processes

COVID-19, as a respiratory condition, has a number of metabolic sequelae that may influence nutritional care. Around 95-98% of patients present with fevers (Guan et al. 2020; Huang et al. 2020; Zhou et al. 2020), with case series data suggesting temperatures of between 37.5-39.0 °C are common (Guan et al. 2020). This may have implications on metabolic rate, with an increase in metabolic demand of ~10-13% per every 1°C increase in body temperature due to heat production (Del Bene 1990). An aggressive pro-inflammatory immune response is also expected, leading to an increase in glucocorticoid and catecholamine production, increased insulin sensitivity, poor glycaemic control and protein catabolism (Prompetchara et al. 2020).

Medical therapy

Critically ill patients with COVID-19 present with declining respiratory function and in severe cases can have shock, respiratory and multi-organ failure. The highly transmittable nature of COVID-19 means that intermediate therapies to support lung function, such as non-invasive ventilation, are aerosol-producing and hence are not recommended (ANZICS 2020). There is general international consensus that patients should be intubated early (where

Clinical features and medical management	Nutritional implication	Nutrition management strategies
Clinical Features		
Metabolism alterations	Insulin resistance Protein catabolism	Blood glucose control Higher protein EN
Highly transmittable virus	Bedside practices limited Staff sickness Impact on food service and menu selection	Remote consults Team planning Upskill non-ICU dietitians
Medical Management		
High flow nasal oxygen therapy	Dry mouth Shortness of breath Fatigue Fasting for potential intubation	High energy/high protein diet Oral nutrition supplements Early escalation to EN
Deep sedation	Delayed gastric emptying Non-nutrition calorie contribution from propofol	1.25-1.5kcal/ml EN Prokinetics for GI intolerance Post-pyloric feeding or PN Account for propofol calories in nutrition prescription if >110% is being provided by nutrition and non-nutrition calories
Prone	Delayed gastric emptying Increased regurgitation and vomiting Feeding interruptions	Lower GRV threshold 1.25-1.5 kcal/ml EN Post-pyloric feeding or PN
Respiratory failure	Restricted fluid input	Energy-dense formula Potential compromised protein intake

Table 1: Clinical features and medical management, nutritional implications and suggested nutrition management strategies for patients with COVID-19 in intensive care.
EN: Enteral Nutrition; ICU: Intensive Care Unit; GI; Gastrointestinal; GRV: Gastric Residual Volumes; PN: Parenteral Nutrition

required) (Poston et al. 2020; ANZICS 2020). In patients admitted to ICU, rates of mechanical ventilation have varied internationally from 47% in China (Wang et al. 2020), 69% in the UK (ICNARC 2020), 71% in the US (Arentz et al. 2020), and 88% in Italy (Grasselli et al. 2020b), with a median duration of 7 (IQR 4,11) days (ICNARC 2020). Additionally, in patients who develop ARDS or those with ongoing hypoxaemia, despite optimising ventilation strategies, high levels of sedation are common and the use of neuromuscular blocking agents (NMBAs) is recommended to facilitate protective lung ventilation (Poston et al. 2020). The use of deep sedation and NMBA may have significant effects on gastrointestinal (GI) function (Deane et al. 2019) and muscle wasting (Puthucheary et al. 2012).

In addition, patients are responding well to management strategies such as periodic prone ventilation (12-16 hours) (Murthy et al. 2020; Poston et al. 2020; ANZICS 2020) with around 27-50% of patients receiving this therapy (Grasselli et al. 2020b) in an attempt to promote equitable air distribution through the lungs and improve oxygenation (Scholten et al. 2017). One of the nutritional consequences of proning is the increased prevalence of delayed gastric emptying and risk of vomiting (Reignier et al. 2004). Therefore, nutritional strategies are required to appropriately manage delayed gastric emptying due to risks to both the patient and staff (airborne virus).

COVID-19, similar to ARDS, is associated with acute renal failure (possibly due to dehydration associated with ongoing pyrexia, shock or multi-organ failure) with ~20% receiving renal support (ICNARC 2020). Conservative fluid management practices are recommended as a means of reducing extravascular lung water (Murthy et al. 2020; Zhou et al. 2020; Poston et al. 2020; ANZICS 2020). As part of this strategy, enteral formula volume restriction may be required but sometimes compromises the quality of nutrition provision and may exacerbate dehydration and hypernatraemia.

Nutrition-impact symptoms and oral intake

COVID-19 presents a number of unique physiological symptoms likely to impact oral intake including a loss of taste and smell, and GI symptoms in around 10% of cases such as diarrhoea, nausea, and vomiting (Guan et al. 2020; Wang et al. 2020). Further, 62% of general ICU survi-

Recommendation	British Dietetics Association	Australia/New Zealand	European Society of Parenteral and Enteral Nutrition	American Society of Parenteral and Enteral Nutrition
Nutrition screening				
Nutrition screening	No recommendation	-High nutrition risk criteria stated	-Use MUST or NRS 2002	No recommendation
Nutrition prescription				
Calorie prescription	-As per current local practice	-No IC -Algorithm first 5 d (approximately 20-25kcal/kg) -25-30 kcal/kg/d after 5 d	-IC if safely available -Hypocaloric (<70% of EE) with increments to 80-100% after day 3	-No IC -Hypocaloric feeding progressive to 15-20 kcal/kg/day (~70-80% caloric requirements)
Protein prescription	-As per current local practice	-≥1.2g/kg/d	-1.3 g/kg/d delivered progressively to target by day 3-5 -Actual weight or adjusted body weight in obesity	-1.2-2.0 g/kg/d
Formula	-Consider protein supplements if unable to meet targets -Volume restricted/low electrolyte EN if fluid restricted -Consider 1.3/1.5 kcal/ml feeds if prone	-1.25-1.5 kcal/ml -Avoid 2 kcal/ml EN	No recommendation	-Standard high protein (> 20% protein) polymeric isosmotic enteral formula -Fibre can be considered once stable
Body weight used in equations	-Use actual body weight or ideal weight if unavailable	-Use actual weight or adjusted weight if overweight/obese	No recommendation	-Actual body weight
Nutrition delivery				
Timing	No recommendation	-Commence within 24h -Goal rate within 5 d	-'Early phase' feeding- not further specified -Goal rate within 3-5 d	-Commence within 24-48 h of ICU admission -Goal rate within first week
Route of feeding	-Gastric -Post-pyloric if poor tolerance -PN if post-pyloric not available	-Gastric -Post-pyloric or PN if not tolerating	-Gastric -Post-pyloric if not tolerating or at high aspiration risk -PN if not tolerating for 1 week	-Gastric -PN if gastric contraindicated

Gastrointestinal management	-GRV monitoring as per usual practice, or GRV cut-off <300ml, monitor 4 hourly if prone -Early/prophylactic prokinetics in patients with high GRVs	-GRV cut-off <300ml, monitor 8 hourly. Cease measures if GRVs <300ml for >48h in patients who are not prone	No recommendation	-No GRV monitoring -Prokinetics -Post-pyloric feeding if all other measures not successful
Proning	-Gastric feeding -Early/prophylactic prokinetics in patients with high GRVs -Consider post-pyloric feeding if poor tolerance 48-72hrs	-Gastric feeding -GRV cut-off -Consider post-pyloric feeding if poor tolerance -Pause EN and aspirate stomach prior to re-positioning	-Gastric feeding	-Gastric feeding -Elevated head of the bed to at least 10 to 25 degrees
Additional considerations				
Nutrition assessment and monitoring	-Close monitoring recommended	-Within 24-72h in high risk patients -3-5 d in lower risk patients	No recommendation	No recommendation
Population specific recommendations	-Non-invasive ventilation	-Obesity -Non-ventilated patients -Post-ICU	-Non-intubated patients -Post-extubation -Dysphagia -Post-ICU	-ECMO
Dietetic practices/resourcing	-Remote reviews -Upskill non-ICU dietitians -Stock levels of EN formula, pumps & ancillaries -Review communication pathways	-Remote reviews -Consider team structure -Train on PPE -Utilise Allied Health Assistants -Review food service systems -Stock levels of EN formula, pumps & ancillaries	No recommendation	-Bundling clinical care -Remote reviews -Stock levels of EN formula, pumps & ancillaries

Table 2: Comparison between different guidelines and recommendations for nutritional management of patients with COVID-19
ECMO: Extracorporeal Membrane Oxygenation; EE: Energy Expenditure; EN: Enteral Nutrition; GRV: Gastric Residual Volume; IC: Indirect Calorimetry; ICU: Intensive Care Unit; PN: Parenteral Nutrition; PPE: Personal Protective Equipment

vors experience dysphagia (Zuercher et al. 2019). These symptoms have particular implications for patients that are attempting to eat orally. These are coupled with nutrition-impacting symptoms typical of a respiratory illness, including extreme fatigue, dyspnoea, dry mouth and loss of appetite (Wang et al. 2020; Huang et al. 2020). Additional operational barriers to oral intake may impact menu selection, limitations with meal delivery, and feeding assistance, including fewer nursing staff, restrictions on family visitations, the need to conduct dietetic consultations remotely and less frequent reviews due to staffing levels, and restrictions on food service management systems.

Post-ICU nutrition

While mortality rates have been higher than in non-COVID-19 respiratory illness, approximately 50% of COVID-19 ICU patients are expected to survive (Wu and McGoogan 2020). Patients admitted with ARDS lose an average of 18% bodyweight by hospital discharge, with reduced functional outcomes and poor quality of life that persist long after ICU discharge (Herridge et al. 2003). A potential contributing factor is a reduction in intake during the post-ICU period; previous data suggests nutritional deficits after ICU discharge are greater than in ICU, particularly via the oral route (Chapple et al. 2016; Ridley et al. 2019; Merriweather et al. 2014). In addition, in periods of high ICU admission numbers and competition for ICU beds, early discharge to the ward is inevitable, and the potential reduction in physical and nutritional interventions due to resource shortages, may worsen long-term recovery of patients with COVID-19.

Resourcing

A further complicating aspect of a global pandemic is the large number of patients that will be affected, and hence admitted to intensive care. In addition, the potential spread of COVID-19 to healthcare workers leads to a reduction is trained clinicians. Given critical care nutrition is a specialist skillset requiring an in-depth understanding of nutrition support within the context of medical care, up-skilling of non-ICU trained dietitians should occur early, with prioritisation of patient complexity to clinician expertise. For nutrition support the influx of ICU patients combined with limited healthcare resources means the clinician roles, scope of practice, and ways of working will need to be carefully reviewed. Consideration should be given to the use of an algorithm-based feeding protocol early in the ICU admission, prioritised care to high nutrition risk patients, and utilisation of Allied Health Assistants where possible.

Clinical Nutrition Guidelines for COVID-19

A number of nutrition recommendations and guidelines for use in patients with COVID-19 have recently been made available. These recommendations are summarised below and in **Table 2**, highlighting important differences and similarities between the recommendations.

Nutrition prescription

Calorie targets

Indirect calorimetry (IC) is recommended as the gold standard to determine metabolic needs in critical illness (McClave et al. 2016; Singer et al. 2019). However, conducting IC requires disconnection of the ventilator circuit thereby potentially exposing staff to the airborne virus if attempted in a patient with COVID-19. For that reason, the majority of COVID-19 nutrition guidelines recommend against the use of IC (Chapple et al. 2020; Martindale et al. 2020; Bear and Terblanche 2020) or only where it can be conducted safely (Barazzoni et al. 2020).

In the absence of IC, caloric targets are similar to those recommended for critically ill patients, aiming for 20-25 kcal/kg/day (Barazzoni et al. 2020; Chapple et al. 2020; Martindale et al. 2020). The Australian/New Zealand guidelines also suggest up to 30 kcal/kg/day for those that are severely unwell or those with an anticipated length of MV >7 days (Barazzoni et al. 2020), and the American guidelines suggest initially providing less for those at risk of re-feeding (Martindale et al. 2020).

> **patients who are admitted to the ICU with COVID-19 are at high nutritional risk, due to their presenting condition, the intensive care management strategies required to treat the disease and the likely course of the treatment**

Protein targets

Protein recommendations are similar between the guidelines, aiming for at least 1.2 g/kg bodyweight/day should be provided as per international recommendations for the general ICU population (Singer et al. 2019; McClave et al. 2016), keeping in mind that less than this is often provided in routine care.

Nutrition delivery

Route

For critically ill adults, nasogastric tube (NGT) feeding is considered best practice which is consistent across all COVID-19 recommendations. Consideration to safety concerns of placement of NGTs in patients with COVID-19 and expose of staff to virus-containing gastric secretions is documented in two of the guidelines (Chapple et al. 2020; Martindale et al. 2020). In these, parenteral nutrition (PN) is recommended if a feeding tube cannot be safety inserted. For patients that are unable to meet calorie and protein targets over 5-7 days, alternative feeding methods, such as post-pyloric feeding or PN are recommended in all guidelines (Barazzoni et al. 2020; Bear and Terblanche 2020; Chapple et al. 2020; Martindale et al. 2020).

Delivery

In keeping with a slow introduction of nutrition in the acute early phase of illness, hypocaloric nutrition (~70% of requirements) is recommended for the first 3-7 days, with commencement within 24-48 hours. This is supported by international recommendations and large randomised controlled trials that suggest early hypocaloric enteral nutrition has no associated harms when compared to full nutrition provision in the first 5-7 days (TARGET Investigators et al. 2018; Singer et al. 2019; National Heart, Lung and Blood Institute et al. 2012).

Enteral formula

Three of the four nutrition guidelines provide recommendations on the type of EN formula to be prescribed, recommending energy-density (1.25-1.5 kcal/ml) for volume control (Bear and Terblanche 2020; Chapple et al. 2020) or a standard high protein polymeric formula (Martindale et al. 2020). The use of a concentrated enteral formula (i.e. 2 kcal/ml) is not recommended due to the increased osmolality and higher fat content likely exacerbating delayed gastric emptying (Kar et al. 2016; Chapple et al. 2020; Bear and Terblanche 2020).

GI tolerance

Current critical care nutrition guidelines provide different recommendations regarding monitoring of gastric residual volumes (GRVs) in critically ill patients (Singer et al. 2019; McClave et al. 2016), which may reflect differences in recommendations in COVID-19 nutrition guidelines. The American guidelines recommend not monitoring GRVs (Martindale et al. 2020), keeping in line with their recommendations for general ICU patients (McClave et al. 2016), and the European guidelines do not contain a specific recommendation on GRVs (Barazzoni et al. 2020). Viral content of gastric contents is not known and therefore GRV conduct may pose a risk if appropriate precautions are not used. Both the British and Australian/New Zealand guidelines; therefore, recommend a lower GRV threshold of <300ml to reduce the risk of vomiting (Bear and Terblanche 2020; Chapple et al. 2020), with less frequent monitoring recommended in the Australian/New Zealand guidelines, using appropriate PPE for airborne precautions (Chapple et al. 2020). Post-pyloric tube placement should also consider these risk/benefits.

Prone

Across all four COVID-19 nutrition guidelines, gastric feeding is recommended as the starting route for prone patients. If GI intolerance is observed, then early prokinetics or post-pyloric feeding is recommended, weighing up the risks/benefits (Chapple et al. 2020; Martindale et al. 2020; Bear and Terblanche 2020).

Oral intake

There is a growing appreciation of the nutrition risk in critically ill patients who are not receiving MV and eating orally, with 3 of the 4 COVID-19 nutrition guidelines including recommendations following extubation or for non-intubated patients (Barazzoni et al. 2020; Bear and Terblanche 2020; Chapple et al. 2020). For those able to eat, the recommendations suggest early intervention or close monitoring providing oral nutrition supplement prescription as soon as oral intake is commenced are recommended, with a lower threshold for escalation to EN (Bear and Terblanche 2020; Chapple et al. 2020) or supplemental PN (Barazzoni et al. 2020). For those patients who have a nasogastric in place, it is recommended that this is maintained where possible as it is recognised that oral intake is likely to be poor following extubation (Chapple et al. 2020).

Conclusion

Patients who are admitted to the ICU with COVID-19 are at high nutritional risk, due to their presenting condition, the intensive care management strategies required to treat the disease and the likely course of the treatment. Alteration in metabolism and gastrointestinal function, coupled with nutritional deficits during critical illness and following, are all likely to contribute to a decline in nutrition status and poorer functional ability.

Optimal nutrition therapy may help to minimise deficits and manage complications such as poor glycaemic control and delayed gastric emptying, with the aim of optimising recovery. The four nutrition guidelines for the management of patients with COVID-19 recommend providing early enteral nutrition support via the gastric route, use of algorithms or hypocaloric nutrition in the first 5-7 days, protein delivery of at least 1.2 g/kg/day, and consideration given to pandemic nutrition resourcing and planning. ■

Key Points

- Alterations in metabolism (including increased energy demands), catabolism, and insulin resistance, as well as alterations in normal gastrointestinal function are all features of COVID-19.
- The medical management of critically ill patients with COVID-19 may have nutrition implications (including deep sedation, early mechanical ventilation, conservative fluid management and the prone position).
- Contingency planning to prepare staff resources, services and stock is critical.
- Four nutrition guidelines for the management of patients with COVID-19 exist, with all recommending early enteral nutrition via the gastric route.

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