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Disease-Specific Nutrition

PULMONARY FAILURE

- Optimal pulmonary function is essential to the maintenance of adequate nutritional status.
- Through the process of gas exchange, the lungs and supporting respiratory structures provide **oxygen to vital tissues** for nutrient metabolism.
- The respiratory system also plays a major role for the regulation of **acid–base balance**.

- Pulmonary injury or insufficiency can lead to **malnutrition** and **dependence on mechanical ventilation** of the critically ill patient.
- Acute respiratory distress syndrome (**ARDS**), characterized by severe progressive hypoxemia and mechanical ventilation, is a frequent result of trauma, sepsis, or surgery in the critical care setting.
- The patient with chronic obstructive pulmonary disease (**COPD**) may also undergo periods of acute exacerbation requiring intensive care.

Malnutrition and Metabolic Abnormalities of Pulmonary Disease

- Malnutrition with COPD is the result of an imbalance between energy intake and utilization.
- Hyperinflation of the lung with an associated decrease in abdominal volume can lead to anorexia, early satiety, and tube feed intolerance.

- An **increase in energy consumption** from COPD has been attributed to an **increase in the work of breathing, tobacco use and medication (theophylline.)**
- Loss of lean body mass may occur as a result of **disuse atrophy, tissue hypoxia from arterial hypoxemia, anabolic hormonal insufficiency or systemic inflammation** as a result of recurrent infections and an imbalance of inflammatory cytokines.
- Currently interleukin **(IL)-1 β** is felt to play a more important role.

- **Respiratory muscles** display reduced efficiency and endurance during nutrition deprivation due to loss of muscle mass and depletion of energy reserves.
- **Impaired respiratory muscle function** may result in decreased ventilatory drive and inefficient gas exchange with hypercapnia and hypoxemia.
- **Phosphate deficiency** diminishes diaphragmatic muscle function and adversely affects the hemoglobin–oxygen dissociation curve by limiting the production of adenosine triphosphate and 2,3-diphosphoglycerate.

- **Hypoalbuminemia**, associated with critical illness and malnutrition, leads to an expansion of extracellular fluid and increased interstitial lung fluid or **pulmonary edema**.
- **Malnutrition** also adversely influences the production of **secretory IgA**, alveolar macrophage recruitment and function and clearance of bacteria from the upper respiratory tract placing patients at risk for **nosocomial pneumonia**.

Energy and Protein Requirements During Pulmonary Disease

- Substrate utilization is the ratio of oxygen consumed to carbon dioxide produced for a given macronutrients and is referred to as the **respiratory quotient** (R/Q).
- The oxidation of **fat**, **protein**, and **carbohydrate** produces an R/Q of **0.7**, **0.8**, and **1.0**, respectively.

- Ideally, the R/Q of a given patient should **approximate 0.85** to reflect metabolism of mixed substrates.
- When carbohydrate or total calorie provisions exceed energy requirements, **R/Q levels rise above 1.0** to suggest fat synthesis.
- **An R/Q of less than 0.7** is indicative of **inadequate nutritional support** with breakdown body fat and protein stores from adipose and lean tissue.

- Underfeeding energy may increase risk of infection, prolong ventilator dependence, delay wound healing, and increase overall hospital morbidity and mortality.
- Overfeeding energy needs is associated with several metabolic, hepatic, and respiratory complications, including increased carbon dioxide production with inability to wean from mechanical ventilation.
- 25 to 30 kcal/kg/d should be used to determine energy needs.

- The provision of IV carbohydrate in excess of 5 mg per kg per minute to severely stressed patients increases carbon dioxide production ($V \cdot CO_2$) and may delay weaning from mechanical ventilation.
- The intersociety clinical guidelines for critical care suggest withholding or limiting soybean oil IVFE during the first week following initiation of PN to a maximum of 100 g per week (often divided into 2 doses per week if there is concern for essential fatty acid deficiency).

- **Rapid infusion of IVFE** may adversely affect
 - I. Gas exchange by decreased rate of clearance,
 - II. Deposition of lipid particles within the reticuloendothelial system,
 - III. subsequent reduction of pulmonary diffusion capacity.

- This effect is most often seen among patients with existing pulmonary dysfunction and with rates of lipid administration **more than 0.11 g/kg/hr**

- Protein requirements of critically ill patients with pulmonary failure are elevated in accordance with the hyper catabolism of stressed states.
- Guideline recommendations suggest that protein intake range from 1.2 to 2.0 g/kg/d of actual body weight.
- Unfortunately, an increase in ventilatory drive and minute ventilation may be seen with protein infusion.

Nutritional Assessment During Pulmonary Disease

- **Malnutrition**, which is typically defined for COPD patients as a **BMI of less than 20 kg per m²**, is an important co-morbidity with an incidence of approximately **20% to 40%**.
- Patients with a **BMI < 20 kg per m²** have a significantly **lower FEV(1)** when compared to patients who were overweight or obese.

- The impact of nutritional intervention has been demonstrated in two meta-analyses of long-term trials of ambulatory malnourished patients with COPD.
- These reports have demonstrated that when given for **two or more weeks**, oral and enteral supplements lead to significant gain of weight, lean body mass, fat mass, respiratory muscle strength, physical endurance, and **quality of life**.

- In regard to defining nutritional status in the ICU, Faisy et al. compared changes of **bioelectrical impedance analysis** (BIA) with various anthropometric and biologic parameters among patients with COPD and acute respiratory failure.
- **Low serum albumin** levels were also significantly associated with **increased mortality** among patients in this study.

- Others have found that weight loss and **low percentage of ideal body weight** can significantly predict the need for mechanical ventilation among hospitalized COPD patients.
- **Weight changes**, **serum albumin levels**, and **BIA**, when available, are thus valuable tools in assessment of nutritional status and prediction of outcomes for patients with severe respiratory insufficiency.

- It has been suggested that all patients admitted to the ICU undergo nutritional assessment utilizing a scoring system that examines both nutritional status and disease severity.
- **The Nutrition Risk Screening (NRS) 2002 and NUTRIC score** fulfill both of these criteria and have been clinically validated.

NUTRIC Score¹

The NUTRIC Score is designed to quantify the risk of critically ill patients developing adverse events that may be modified by aggressive nutrition therapy. The score, of 1-10, is based on 6 variables that are explained below in Table 1. The scoring system is shown in Tables 2 and 3.

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.²

¹ Heyland DK, Dhaliwal R, Jiang X, Day AG. Identifying critically ill patients who benefit the most from nutrition therapy: the development and initial validation of a novel risk assessment tool. *Critical Care*. 2011;15(6):R268.

²Rahman A, Hasan RM, Agarwala R, Martin C, Day AG, Heyland DK. Identifying critically-ill patients who will benefit most from nutritional therapy: Further validation of the "modified NUTRIC" nutritional risk assessment tool. *Clin Nutr*. 2015. [Epub ahead of print]

Thank you