REVIEW ARTICLE

Nutritional Status & Effect of Nutrition in COPD

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Introduction :

Nutrition is an important consideration for the patient with respiratory insufficiency. The incidence of malnutrition is high in both patients with chronic respiratory disease and those hospitalized with respiratory failure[1-4].

Overview :

* Malnutrition occurs commonly in patients with chronic illness, including those with respiratory failure and chronic obstructive pulmonary disease.
* Weight loss occurs in 25% to 65% of patients as a result of (i) inadequate caloric intake due to anorexia, shortness of breath or gastrointestinal distress, and/or (ii) increased caloric requirements due to the the excess effort of breathing.
* Patients often have depressed biochemical measurements of nutritional status.
* When caloric intake is decreased the body cannibalizes muscles, including the respiratory muscles to meet energy needs.
* As a consequence of malnutrition, the energy content and strength of respiratory muscles decreases.
* The degree of nutritional depletion is correlated with the severity of chronic lung disease.
* Inpatients with chronic pulmonary disease, depressed nutritional status is associated with respiratory failure and heart failure (cor -pulmonalae).
* Semistarvation depresses hypoxic ventilatory response.
* Malnutrition lowers resistance to infection which is a common complication in pulmonary disease.

The goal of nutrition support is to provide required nutients without further compromising respiratory function

Rationale of Nutrition Support :

Malnutrition is recognised as a major problem in hospitalised patients as well as in outpatients with chronic diseases of long duration. Increasing evidences suggests that patients with COPD and respiratory failure suffer from malnutrition. Symptoms of respiratory disease may limit caloric and nutrient intake, resulting in deterioration of nutritional status over time. Poor nutritional status in turn negatively affects pulmonary function.

Patients with COPD which usually is a mixtue of emphysema and chronic bronchitis1, develop various degrees of respiratory muscle fatigue, hypoventilation, hypercapnia, and oxygen depletion (hypoxemia).

Weight loss of 10% or more preceded heart failure in patients with COPD and hypercapnia[5]. Nutritional repletion in patients with COPD results in improved respiratory function and quality of life. In a study by Irwin and Openbrier[6], the effectiveness of aggressive supplementation via

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home tube feeding was evaluated in four undernourished patients with COPD. Following 4 weeks of intervention, all four patients gained weight and raised inspiratory and expiratory pressures.

Goldstein et al[7] reported significant improvements in quadriceps strength, hamstring strength, and endurance in six malnourished patients with COPD following nutritional repletion via tube feeding for a 2-week period.

Effects of Impaired Nutritional Status on Respiratory Function :

Poor nutritional status compounds respiratory insufficiency by acting detrimentally on respiratory muscle function, hypoxic ventilatory response, resistance to infection, and lung structure.

Respiratory Muscle Function :

As a result of reduced nutrient intake, body energy stores are depleted. The respiratory muscles (diaphragmatic, intercostal, and accessory), like other skeletal muscles, are cannibalised to meet energy needs[8].

Hypoxic Ventilatroy Response :

Nutrition can affect central nervous system control of respiration. Unlike in unaffected persons for whom the drive to breath is an increase in $PaCO_2$, the main ventilatory drive in patients with COPD and respiratory failure is hypoxia. Therefore, maintenance of hypoxic drive in these patients is important[9].

Undernutrition significanty decreased metabolic rate and hypoxic ventilatory response. Hypercapnic ventilatory response also decreased, but not significantly. These changes were reversible on refeeding.

Resistance to Infection :

The relationship between nutrition and the immune system is well recognised. Poor nutritional status results in decreased resistance to infection. Maintenance of the immune system is especially important for patients with COPD, since infection in the tracheobronchial tree is a common cause of respiratory failure in these patients[10,11].

Lung Structure :

As a result of starvation, production of pulmonary phospholipid and surfactant is reduced, and compliance of the lung decreases. Malnutrition may result in decreased replication of pulmonary epithelium, and laryngeal ulceration may occur with prolonged intubation[8,12,13].

The high prevalence of malnutrition among patients with advanced COPD and its correlation with anatomic and functional abnormalities, as well as mortality, suggest that nutritional care should be a part of therapy. There is increasing evidence that nutrition intervention can reverse the biochemical, anatomic, and functional abnormalities that have been described.

Respiratory Quotient and Gas Exchange :

Protein, fat carbohydrate are metabolic fuels that are converted into energy (heat) in the body. In the process of converting the major nutrients to energy, oxygen is consumed and carbon dioxide is produced. The equation of oxidation of a carbohydrate, e.g., glucose, is the following[14].

$$1 \text{ glucose} + 6\ O_2 \rightarrow 6\ CO_2 + 6H_2O$$

The equation for oxidation of a fat, e.g., Palmitate is as follows[15].

$$1 \text{ palmitate} + 23\ O_2 \rightarrow 16\ CO_2 + 16\ H_2O$$

Protein is oxidised according to the following general equation15.

$$1 \text{ amino acid} + 5.1 O_2 \rightarrow 4.1\ CO_2 + 0.7 \text{ urea} + 2.8\ H_2O$$

For a given amount of oxygen consumed, more carbon dioxide is produced from metabolism of carbohydrate than from fat or protein. Metabolism of fat yields the lowest RQ; that is, the least carbon dioxide is produced for the amount of oxygen consumed. The volume of gases exchanged from the metabolism of 1 g or 1 Cal of each major nutrient is listed in Table. The RQ of a typical mixed diet is 0.85.

Gas Exchange during Metabolism of Major Nutrients

	Oxygen Consumption (L)		Carbon Dioxide Produced (L)		
	Per g	Per Cal	Per g	Per Cal	RQ
Carbohydrate	0.81	0.20	0.81	0.20	1.0
Fat	1.96	0.22	1.39	0.15	0.7
Protein	0.94	0.24	0.75	1.19	0.8

Administration of a diet with an increased proportion of fat calories can decrease carbon dioxide production and RQ, thus diminishing ventilatory requirements. This end result is desirable both for the patient with COPD, for whom hypercapnia may lead to respiratory failure, and for the patient with respiratory failure, who must be weaned from mechanical ventilation.

Recent enteral studies also confirm the benefits of high-fat feeding regimens. Carbon dioxide production, RQ, forced vital capacity (FVC), and forced expiratory volume in 1 second (FEV_1) were evaluated in ambulatory COPD patients with carbon dioxide retention. The patients were fed low moderate-, and high-carbohydrate diets. Patients fed a low farbohydrate, high-fat (55% of total calories) diet had a significantly decreased production of carbon dioxide and a lower RQ. At the end of the study, FEV_1 and FVC improved 22% over baseline[16].

In both hypermetabolic and nutritionally depleted patients, the result of aggressive nutrition support with a high-carbohydrate regimen is an increase in carbon dioxide production, which may be detrimental to the patient with pulmonary disease. High-carbohydrate loads can precipitate respoiratory failure. The administration of high-carbohydrate regimens to patients requiring mechanical ventilation can impair the ability to wean[17,18].

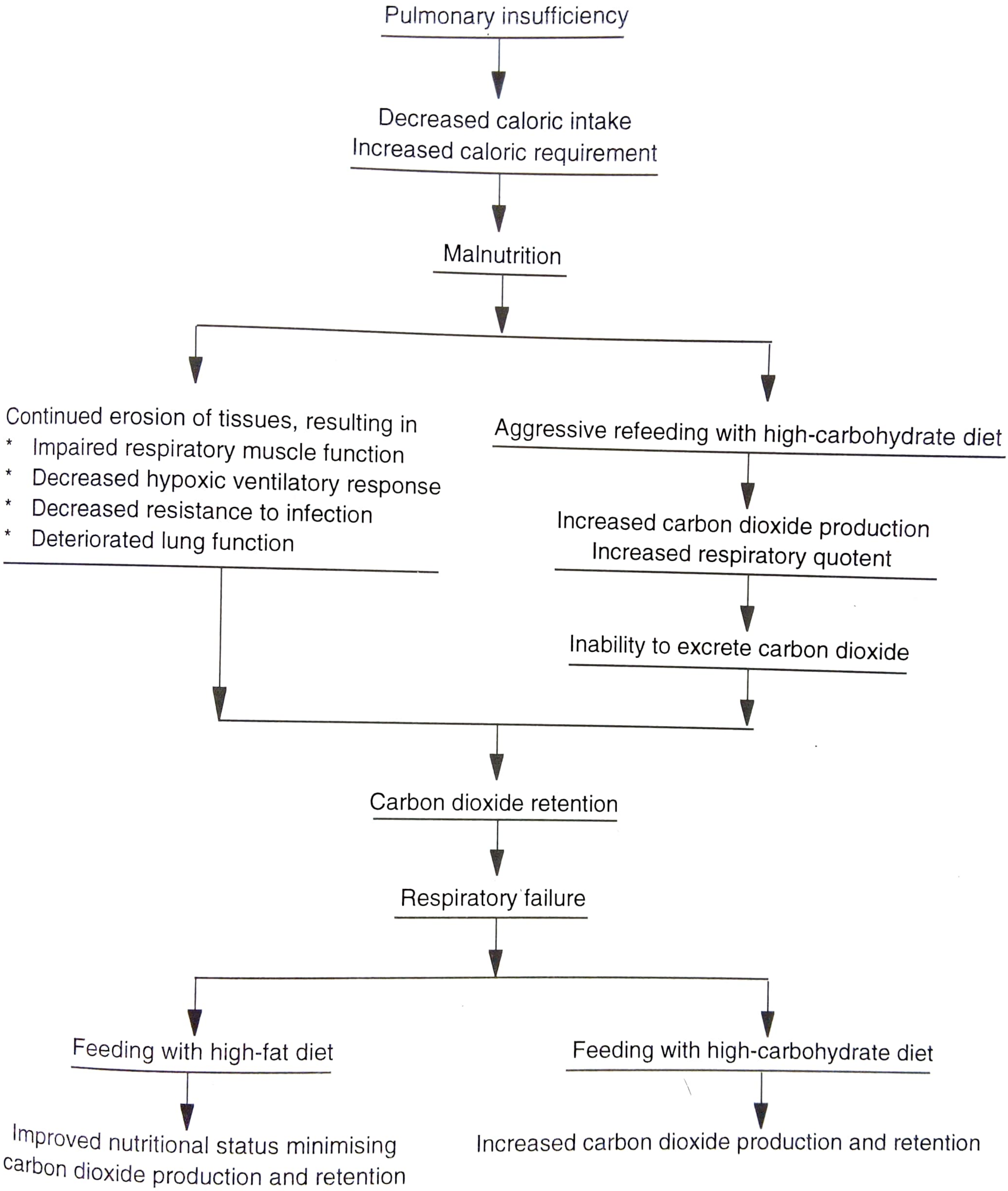
Summary :

Malnutrition is common in patients with chronic pulmonary disease. Inadequate nutrient intakes and increased caloric requirements due to the work of breathing cause depleted nutritional status. Without nutrition support, nutritional status continues to decline, with detrimental effects on respiratory muscles, ventilatory response, resistance to infection, and lung structure.

High-carbohydrate diets increase carbon dioxide production, which can precipitate or prolong respiratory failure in patients whose pulmonary dysfunction prevents them from excreting the excess carbon dioxide. Administration of a high-carbohydrate diet in poorly nourished, ventilator-dependent patients interferes with the weaning process. The administration of carbohydrate in excess of caloric requirements leads to lipogenesis and further increases ventilatory requirements.

Intrarelationship between nutrition and respiratory status in patients with pulmonary insufficiency. Influence of high-carbohydrate and high-fat diets is shown below

Interrelationship between nutrition and respiratory status in patients with pulmonary insufficiency. Influence of high-carbohydrate and high-fat diets is shown below


Pulmonary insufficiency
Decreased caloric intake
Increased caloric requirement
Malnutrition
Continued erosion of tissues, resulting in
* Impaired respiratory muscle function
* Decreased hypoxic ventilatory response
* Decreased resistance to infection
* Deteriorated lung function
Aggressive refeeding with high-carbohydrate diet
Increased carbon dioxide production
Increased respiratory quotent
Inability to excrete carbon dioxide
Carbon dioxide retention
Respiratory failure
Feeding with high-fat diet
Improved nutritional status minimising carbon dioxide production and retention
Feeding with high-carbohydrate diet
Increased carbon dioxide production and retention

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