NUTRITION IN MECHANICALLY VENTILATED PATIENTS

Essay

Submitted for partial fulfillment of master degree in Intensive Care Medicine

Presented by

Tawfik Tarek El Menshawy

M.B.B.ch.

Supervised by

Prof. Dr.

AHMED OMAR AL NIDANI

Professor of Anesthesia and Intensive Care
Faculty of Medicine
Ain Shams University

Dr.

DALIA ABDEL HAMID NASR

Asst. Professor of Anesthesia and Intensive Care
Faculty of Medicine
Ain Shams University

Dr.

WALID AHMED MANSOUR

Lecturer of Anesthesia and Intensive Care
Faculty of Medicine
Ain Shams University

FACULTY OF MEDICINE
AIN SHAMS UNIVERSITY

2011

تغذية المرضي تحت جهاز التنفس الصناعي

رسالة

توطئة للحصول على درجة الماجستير
فى الرعاية المركزة

مقدمة من

الطبيب / توفيق طارق المنشاوي

بكالوريوس الطب والجراحة

تحت إشراف

الاستاذ الدكتور

أحمد عمر النيداني

أستاذ التخدير والرعاية المركزة
كلية الطب
جامعة عين شمس

الدكتورة

داليا عبد الحميد نصر

أستاذ مساعد التخدير والرعاية المركزة
كلية الطب
جامعة عين شمس

الدكتور

وليد أحمد منصور

مدرس التخدير والرعاية المركزة
كلية الطب
جامعة عين شمس

كلية الطب
جامعة عين شمس
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SUMMARY

The goal of nutrient intake in the malnourished patient is to correct the malnourished state. However, the malnutrition that accompanies critical illness is different from the malnutrition that accompanies starvation. Whereas the malnutrition from starvation is due to deficient body stores of essential nutrients, the malnutrition that accompanies serious illnesses is due to abnormal nutrient processing. As such, the intake of nutrients will not correct the malnutrition that is associated with serious illnesses until the underlying disease is controlled and the metabolic abnormalities abate. Therefore, the most important factor in correcting the malnutrition in critically ill patients is successful treatment of the primary disease process, and not the intake of nutrients.

Many aspects of the immune system are frequently abnormal in patients with generalized malnutrition. Decreased numbers of circulating T cells, decreased numbers of total circulating lymphocytes, and an impaired delayed cutaneous hypersensitivity response to skin test antigens in patients with protein depletion or protein-calorie malnutrition indicate concomitant impairment of cell-mediated immunity.

Parenteral nutrition can be used to supply all the essential nutrients without the use of the intestinal tract. In most cases, parenteral nutrition is reserved for patients who are unable to meet their nutritional requirements through enteral routes as infusing nutrients directly into the bloodstream is the least preferred method of providing nutritional therapy. However, for patients with no other option for nutrition support, parenteral nutrition is a lifesaving therapy.

Complete bowel rest is accompanied by progressive atrophy and disruption of the intestinal mucosa. This effect becomes evident after just a few days and is not prevented by parenteral nutrition. So that depletion of

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AA	:	Aminoacid
APN	:	Advanced practice nurse
ARDS	:	Acute respiratory distress syndrome
BCAA	:	Branched chain aminoacids
BEE	:	Basal energy expenditure
BG	:	Blood glucose
BMI	:	Body mass index
BMR	:	Basal metabolic rate
BPH	:	Benign prostatic hypertrophy
BUN	:	Blood urea nitrogen
C	:	Centigrade
Ca	:	Calcium
CL	:	Chloride
CNS	:	Central nervous system
CPN	:	Central parenteral nutrition
CVC	:	Central venous catheter
DHA	:	Docosahexaenoic Acid
EE	:	Energy expenditure
EEA	:	Energy expenditure of activity
EFA	:	Essential fatty acids
EN	:	Enteral nutrition
EPA	:	Eicosapentaenoic
F	:	Fahrenheit
FAO	:	Food and agriculture organization
FDA	:	Food and drug administration
Fe	:	Iron
Fr	:	French and one French unit = 0.33mm
GI	:	Gastrointestinal
GRAS	:	Generally recognized as safe
GRV	:	Gastric residual volume
HBC	:	Hypercatabolism
HIV	:	Human immunodeficiency virus
HN	:	High nitrogen
HOB	:	Head of bed
I/O	:	Input/output
Ib	:	450gram of weight
IBW	:	Ideal body weight
ICU	:	Intensive care unit
IV	:	Intravenous
IVFE	:	Intravenous fat emulsions
Kcal	:	Kilocalories
KUB	:	Kidney urinarybladder x-ray
LCT	:	Long chain triglycerides
LDL	:	Low density lipoprotein
LFTs	:	Liver function tests
LOS	:	Length of stay
MAOIs	:	Monoamino oxidase inhibitors

MCT	:	Medium chain triglycerides
Meds	:	Medications
Mg	:	Magnesium
Na	:	Sodium
NGT	:	Nasogastric tube
NS	:	Normal saline
OGT	:	Orogastric tube
Oz	:	Ounce = 30ml
P	:	Phosphorus
PCO_2	:	Partial arterial CO_2 tension
PEG	:	Percutaneous endoscopic gastrostomy
PEJ	:	Percutaneous endoscopic jejunostomy
PN	:	Parenteral nutrition
PO_2	:	Partial arterial O_2 tension
PO_4	:	Phosphate
PPIS	:	Proton pump inhibitors
PPN	:	Peripheral parenteral nutrition
Prn	:	As needed
RD	:	Registered dietitian
RDA	:	Recommended daily allowances for vitamins and essential trace elements
REE	:	Resting energy expenditure
RF	:	Renal failure
RMR	:	Resting metabolic rate
RN	:	Registered nurse
RQ	:	Respiratory quotient
RV	:	Residual volume
SAO_2	:	Arterial O_2 Saturation
SBFT	:	Small bowel feeding tube
SC	:	Subcutaneous
SDA	:	Specific dynamic action
SVO_2	:	Mixed venous o2 saturation
Tbs	:	Tablespoon = 15ml
TEA	:	Thermal effect of activity
TEE	:	Total energy expenditure
TEF	:	Thermal effect of food
TF	:	Tube feeding
TNA	:	Total nutritient admixture
TPN	:	Total parenteral nutrition
Tsp	:	Teaspoon = 4ml
VCO_2	:	Total body co2 production
Vent	:	Ventilator
VO_2	:	Total body o2 consumption
WHO	:	World health organization
Zn	:	Zinc
ω	:	Omega

INTRODUCTION

The nutritional management of critically ill patients has changed dramatically over the past 10 years. The rationale for nutrition support comes from the knowledge that critically ill patients are prone to develop malnutrition, which is known to be associated with serious complications such as sepsis and pneumonia, leading to a poor outcome and even death. Although guidelines continue to be in evolution, there are sufficient data on clinically proven principles and methods of nutrition support to permit practical and useful recommendations for the specific problems and questions confronted by the intensivist. ***(Giner et al., 1996).***

It is not known how long a critically ill patient can tolerate lack of nutrient intake without adverse consequences, but because critical depletion of lean tissue can occur after 14 days of starvation in severely catabolic patients, it is recommended that nutrition support be instituted in patients who are not expected to resume oral feeding for 7 to 10 days. ***(Klein et al., 1997).***

The need for nutritional support is determined by the balance between endogenous energy reserves of the body and the severity of stress. The best clinical markers of stress are fever, leukocytosis, hypoalbuminemia, and a negative nitrogen balance. ***(Cerra et al., 1997).***

The fundamental goal of nutritional support is to provide individual patients with their daily nutritional requirements. So we must have to know how to determine the nutrient and energy needs of each patient in the ICU. ***(Bistrian And McCowen , 2006).***

The three organic (carbon - based) fuels used by the human body are carbohydrates, proteins, and lipids. The energy yield from the combustion of these fuels is measured as heat production in Kilocalories (Kcal) per gram of substrate. The energy yield from the combustion of each of the organic fuels is shown in the following table:

Table (1): The Oxidative Metabolism of Organic Fuels

Fuel	VO_2 (l/g)	VCO_2 (l/g)	RQ	Energy yield (Kcal/g)
Lipids	2.00	1.40	0.70	9.1
Protein	0.96	0.78	0.80	4.0
Glucose	0.74	0.74	1.00	3.7

RQ = Respiratory quotient = VCo_2/Vo_2 ***(Bistrian And McCowen , 2006).***

The summed metabolism of all three organic substrates determines the total–body O_2 consumption (Vo_2), Co_2 production (VCo_2), and energy expenditure (EE) for any given period. The 24-hour EE then determines the daily calorie requirements that must be provided by nutrition support. ***(Bistrian And McCowen , 2006).***

AIM OF THE WORK

To develop a plan of Care to promote nutritional support for the mechanically ventilated ICU patients .

METABOLIC SUBSTRATE REQUIREMENTS

Carbohydrates:

Carbohydrates supply approximately 70% of the non-protein calories. Because the human body has limited carbohydrate stores, daily intake of carbohydrates is necessary to ensure proper functioning of the central nervous system, which relies heavily on glucose as its principle fuel source. ***(Rodriguez et al., 1985).***

However, excessive intake of carbohydrates can prove detrimental for the following reasons:-

1- Carbohydrates stimulate the release of insulin, and insulin inhibits the mobilization of free fatty acids from adipose tissue. Because adipose tissue fat is the major source of endogenous calories, excessive carbohydrate intake impairs the ability of the body to rely on endogenous fat stores during periods of inadequate nutrition.

Table (2): Endogenous fuel stores in adults

Fuel source	Amount (kg)	Energy yield (kcal)
Muscle protein	6.0	24,000
Adipose tissue fat	15.0	141,000
Total glycogen	0.09	900

2- The oxidative metabolism of glucose produces an abundance of Co_2 relative to the oxygen consumed, as indicated by the respiratory quotients listed in table(1). Furthermore, ingestion of excessive carbohydrates leads to de novo lipogenesis, which has a respiratory quotient of 0.8. Therefore, the ingestion of excessive carbohydrates can be accompanied by an exaggerated production of Co_2, and this could promote hypercapnia in patients with compromised lung function. In fact, excessive calories from any nutrient source can be accompanied by excessive Co_2 production. ***(Talpers et al., 1992).***

Lipids:

Dietary lipids have the highest energy yield of the three organic fuels, and lipid stores in adipose tissues represent the major endogenous fuel source in healthy adults. Most nutritional regimens use endogenous lipids to provide approximately 30% of the daily energy needs. ***(Jones And Kubow , 2006).***

- ***Linoleic acid:***

Dietary lipids are triglycerides, which are composed of a glycerol molecule linked to three fatty acids. The only dietary fatty acid that is considered essential (i.e., must be provided in the diet) is linoleic acid. A deficient intake of this essential fatty acid produces a clinical disorder characterized by a scaly dermopathy, cardiac dysfunction, and increased susceptibility to infections. This disorder is prevented by providing 0.5 % of the dietary fatty acids as linoleic acid. Safflower oil is used as the source of linoleic acid in most nutritional support regimens. ***(Jones And Kubow , 2006).***

Protein requirements:

Protein intake can be estimated by using the following generalized predictions for normal and hyper-catabolic patients:

Normal metabolism 0.8 - 1.0g / kg
Hyper-catabolism 1.2 - 1.6g / kg ***(Matthews , 2006).***

- ***Nitrogen balance and caloric intake:***

The first step in achieving a positive nitrogen balance is to provide enough non-protein calories to spare proteins from being degraded to provide energy. When the daily protein intake is constant, the nitrogen balance becomes positive only when the intake of non-protein calories is sufficient to meet the daily energy needs (i.e., the REE). If the non-protein calorie intake is insufficient, some of the protein provided in the diet will be broken down to provide calories, which will produce a negative nitrogen balance. Therefore when the daily intake of non-protein calories is insufficient, increasing the protein intake becomes an inefficient method of achieving a positive nitrogen balance. ***(Matthews , 2006).***

Vitamin requirements:

Twelve vitamins are considered an essential part of the daily diet. The recommended daily dose of individual vitamins in enteral and parenteral nutritional regimens is shown in table 3. It is important to emphasize that the daily vitamin requirements may be much higher than indicated in this table in seriously ill, hyper-metabolic patients. ***(Headley , 2003).***

Table (3): Recommended daily requirements for vitamins

Vitamin	Enteral dose	Parenteral dose
Vitamin A	1000 µg	3300 IU
Vitamin B12	3 µg	5 µg
Vitamin C	60 mg	100 mg
Vitamin D	5 µg	200 IU
Vitamin E	10 mg	10 IU
Vitamin K	100 µg	10 mg
Thiamine (B1)	2 mg	3 mg
Riboflavin (B2)	2 mg	4 mg
Pyridoxine (B6)	2 mg	4 mg
Pantothenic acid	6 mg	15 mg
Biotin	150 µg	60 µg
Folate	400 µg	400 µg

(Dark And Pingleton , 1993).

The following comments on thiamine and the antioxidant vitamins are deserved:

- ***Thiamine:***

Thiamine (vitamin B1) is a component of thiamine pyrophosphate, an essential cofactor in carbohydrate metabolism. Thiamine deficiency is likely to be common in patients in the ICU for the following reasons:

First, The normal body content of thiamine is only approximately 30 mg. So assuming a daily thiamine requirement of 3mg in patients in the ICU, lack of thiamine intake could result in depletion of endogenous thiamine stores after just 10 days.

Second, The use of thiamine is increased beyond expected levels in hyper-catabolic conditions. And may also be increased in patients receiving nutritional support with glucose-rich formulas.

Third, Urinary thiamine excretion is increased by furosemide, which is a commonly used diuretic in the ICU. Finally, magnesium is necessary for the conversion of thiamine into thiamine pyrophosphate, so magnesium depletion (which is common in patients in the ICU) causes a "functional" form of thiamine deficiency. ***(Butterworth , 2006).***

➯ ***Antioxidant vitamins:***

Two vitamins serve as important endogenous antioxidants: vitamin C and vitamin E. Vitamin E is the major lipid soluble antioxidant in the body, vitamin C is water-soluble and serves as one of the major antioxidants in the extra-cellular fluid. Considering that oxidant-induced cell injury may play an important role in multi-organ failure, it is wise to maintain adequate body stores of the antioxidant vitamins in critically ill patients. The increased rates of biological oxidation that are common in critical illness are likely to increase the daily requirements for vitamin C and vitamin E far above those listed in table (3). ***(Butterworth , 2006).***

Essential trace elements:

A trace element is a substance that is present in the body in amounts less than 50 microgram per gram of body tissue. Seven trace elements are considered essential in humans, and these are chromium, copper, iodine, iron, manganese, selenium and zinc. The daily trace element requirements in hyper-metabolic patients in the ICU may be far greater than normal. ***(Fleming , 1989).***

Table (4): Daily requirements for essential trace elements

Trace element	Enteral dose	Parenteral dose
Chromium	200 µg	15 µg
Copper	3 mg	1.5 mg
Iodine	150 µg	150 µg
Iron	10 mg	2.5 mg
Manganese	5 mg	100 µg
Selenium	200 µg	70 µg
Zinc	15 mg	4 mg

(Dark And Pingleton , 1993).

The following trace elements are mentioned because of their relevance to oxidation-induced cell injury.

- ***Iron***

One reason why the body may be so concerned with binding iron is the ability of free iron to promote oxidation-induced cell injury. Iron in the reduced state (Fe^{++}) promotes the formation of hydroxyl radicals, and hydroxyl radicals are considered the most reactive oxidants known in biochemistry. ***(Herbert et al., 1994).***

- ***Selenium***

Selenium is an endogenous antioxidant by virtue of its role as a co-factor for glutathione peroxidase, one of the important endogenous antioxidant enzymes. Selenium use is increased in acute illness, and plasma selenium levels can fall to subnormal levels within 1 weak after the onset of acute illness. So selenium deficiency is common in patients in the ICU. Such condition will promote oxidant cell injury. ***(Ishida et al., 2003).***

Effects of drugs on nutrients:

The following table shows the side effects of some drugs:

Table (5): Side effects of some drugs.

Drug	Effect
Anti-infective agents	
Amikacin, gentamicin, tobramycin	Hypokalemia, hypomagnesemia, hypocalcemia
Aminosalicylic acid	Decreased vitamin B12 and fat absorption
Amphotericin B	Hypokalemia, hypomagnesemia
Capreomycin	Hypokalemia, hypomagnesemia, hypocalcemia
Cycloserine	Decreased serum folate
Isoniazid	Pyridoxine deficiency
Neomycin	Decreased absorption of carotene, iron, vitamin B12, and cholesterol
Rifampin	Decreased serum 25-hydroxycholecalciferol level
Sulfasalazine	Folate deficiency
Tetracycline	Decreased absorption of Ca, Mg, Fe, Zn
Anticoagulants	
Warfarin	Decreased vitamin K-dependant coagulation factors
Cardiovascular drugs	
Colestipol	Decreased absorption of fat-soluble vitamins and folic acid
Hydralazine	Pyridoxine deficiency
Sodium nitoprusside	Decreased total serum vitamin B12
Thiazides, ethacrynic acid	Increased urinary loss of Na, K, Mg, Zn, P
Triameterene, spironolactone	Increased urinary loss of K, Ca, Mg, Zn
CNS drugs	
Alcohol	Increased urinary loss of Mg, Zn, Ca
Aspirin	Decreased serum folate
MAOIs	
Isocarboxazid	Decreased leukocyte and platelet ascorbic acid levels
Pargyline	Increased iron loss
Phenelzine	Increased sensitivity to tyramine-containing foods; possible development of hypertensive crisis
Tranylcypromine	Pyridoxine deficiency
Electrolyte affecting drugs	
Potassium chloride, slow-release	Decreased vitamin B12 absorption