Nutrition Study Guide

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Learning Objectives

At the completion of this activity, the student should be able to:

- Describe the biochemical changes that occur following trauma, sepsis, or burns and compare with normal physiology.
- Given clinical information on a patient who has sustained major trauma or burn injuries, compare and contrast the metabolic differences between injury and starvation.
- Compare and contrast nutritional requirements for critically ill patients with non-injured patients.
- Apply the basic methods of assessing a patient's nutrition status to a simulated or real patient.
- Describe the different routes of nutrition, the risks associated with them, and when is most appropriate to use them.
- Write basic nutrition orders, including orders for simple total parenteral nutrition.
- Discuss the consequences of poor nutrition on patient survival and outcomes.

Introduction

Nutrition is a broad subject with many dimensions. For the purposes of this course, recommendations of patient nutrition will be limited to the critical care setting. Critically ill patients are in a hypermetabolic and thus catabolic state due to the increased requirements on the body (e.g. production of inflammatory mediators, wound healing, increased stress hormones, etc). As such, there has been increasing recognition of the importance of adequate nutrition for critically ill patients. The Society for Critical Care Medicine (SCCM) and the American Society for Parenteral and Enteral Nutrition (ASPEN), stated in a joint recommendation, that "the goals of nutritional support include preservation of immune function, avoidance of metabolic complications, and preservation of lean body mass."[1] Although not commonly thought of, nutritional deficiencies and derangements can result in impaired immune function, difficulty weaning from the ventilator (resulting in prolonged mechanical ventilation), and increased infections, prolonged hospitalization, and increased mortality. A careful understanding of the pathophysiology associated with trauma and critical illness is crucial for understanding the nutritional needs in the ICU setting. Also important is the understanding that in critical illness patients have energy requirements of at least 30-70% above normal, and even as much as 150%. This increased energy requirement can last for months (and there is some speculation that it can last years in burn patients).

Physiologic Changes in Stress and Trauma

Healthy patients with ideal body mass require about 20-25kcal/kg/day to maintain their metabolic needs. Half of these calories should come from carbohydrates, about 30% from lipids, and 20% from proteins. Proteins amount can be estimated at 1g/kg/day with essential amino acids comprising 20% of that load. Healthy patients' primary fuel source is carbohydrates. In the absence of carbohydrate intake (e.g. starvation), the healthy person uses glycogen stores in the liver as a source of glucose to supply to the brain. However, these stores are depleted after about 24 hours. In early starvation, the body uses fat stores for fuel, and some hepatic gluconeogenesis from protein breakdown to supply glucose to the brain and other obligate glucose users (peripheral nerves, adrenal medulla, RBC, and WBC). In late starvation however the body is attempting to save muscle mass, so the nitrogen excretion decreases and there is increased ketone production to provide fuel for the brain. In starvation, patients will have decreased resting energy expenditure (REE) and decreased urinary nitrogen excretion.

In trauma and burn patients however this process is slightly different. This is critical to know because the nutritional replacement that we provide for these patients needs to reflect what their body is using and needs. In trauma/burn patients the body does not conserve muscle the way that it does in periods of starvation. They have increased metabolic demand and are in a catabolic state, and therefore will not conserve protein. These patients use fat *and* protein as their primary fuel source. The inflammatory process also adds to the increased energy demands due to increased muscle proteolysis, gluconeogenesis, hepatic protein synthesis, and protein synthesis. We also see increased activity of cortisol, ACTH, Epinephrine, and glucagon production; as well as increased proinflammatory cytokines such as IL-1, IL-6, and TN. All of this combined results in an **increased** REE that can frequently be 100-150% of normal (as opposed to starvation which results in **decreased** REE). In addition, fever raises the patient's metabolic rate by 10% for each degree Celsius above 38 degrees. All in all, these demands can add 20-40% more to patients' daily caloric requirement.

The metabolic changes are critical to understanding the replacement of nutrition for patients in the ICU. In critical illness the body breaks down muscle not only for gluconeogenesis, but also for thermogenesis, immune function, tissue repair, and to synthesize acute phase reactants. Considering the body's robust response it is not surprising that patients with critical illness have rapid muscle loss (predominantly skeletal muscle). To adjust for the increased loss of protein, it is recommended that critically ill patients receive amino acids at a rate of at least 1.5-2.0g/kg/day. In addition to the changes in protein use and metabolism, patients with critical illness also process carbohydrates differently than the normal person or even the starvation state. In critical illness, the body's peripheral tissues develop resistance to insulin resulting in hyperglycemia due to the increased gluconeogenesis necessary to supply the brain and other glucose dependent organs. Believe it or not, metabolism of protein is a major source of glucose in these patients, therefore providing additional carbohydrates does not suppress the gluconeogenesis (as you would expect in healthy patients), but only exacerbates the hyperglycemia. For this reason, the recommendation is to limit carbohydrates to 50-60% of the daily calories. Basically, in critical illness the body uses protein excessively and normal regulatory systems don't apply (e.g. giving carbs doesn't suppress the gluconeogenesis). Therefore, to supply appropriate nutrition to these patients requires increased amino acids and decreased carbohydrates.

Nutritional Requirements	Healthy Adult Male	Critically Ill Patient
Daily Caloric Need	Approx. 20-25 calories/kg/day	
Protein Calories	20% (1g /kg/day)	30-40% (1.5-2.0g/kg/day)
Fat	30%	
Carbohydrates	50%	50-60% daily calories

Special Circumstances: Burns

Metabolic regulation in burn patients is influenced by the degree of body surface area burned. Burn patients have even higher rates of catabolism and can have lean body mass loss of up to 40g/day of nitrogen. Therefore enteral nutrition is an important component to caring for burn patients. Unlike trauma patients and other critically ill patients where it is acceptable to wait up to 7 days to initiate feeds, burn patients should have enteral nutrition initiated within 12-48 hours. Discussion of the resuscitation and specifics of determining caloric needs for burn patients is outside the scope of this session but there are multiple formulas that can be used for this including the Curreri and Galveston formulas.

Assessing Nutritional Status

There are multiple ways to assess a patient's nutritional status, and ideally this should be done more than once. It is important to remember that patients were not necessarily "healthy" from a nutrition status even before they became ill. Therefore an initial assessment is important. Clinically nutrition can be assessed based on a patient's weight (if they weighed 100kg when they were admitted and now they weigh 80kg this is a problem). In addition, for cancer patients, an understanding of their weight loss in the months prior to admission is important as well. In addition, an assessment of their clinical history and physical exam is crucial (are the cachectic appearing, do they have end stage pancreatic cancer, etc.). On top of this, an assessment of bowel function is critical (you're not going to give PO feeds to someone with cancer all over their intestines who throws up everything they eat), as well as their injury type and severity (e.g. does this person have 90% total body surface area burns?).

There are also several labs that are useful in assessing nutrition. These labs are:

- **Albumin**: (Normal = 3.5-5.5 g/dl)
  - Half-life of 18 days.
  - Not a good measure of their acute nutrition status, but is a better marker of their overall nutrition status.

    - Admission albumin <2.5 has been correlated with an increased mortality.
- **Prealbumin**: (Normal = 17-40mg/dl)
    - Half-life of 2 days.
    - Good marker of short-term nutritional status.
    - Can be falsely elevated by corticosteroids and renal failure.
- **Transferrin**: (Normal = 170-370 mg/dl)
    - Half-life of 10 days.
    - Used as a predictor of morbidity and mortality.
    - <100mg/dl = indicative of severe serum protein loss.
    - 100-150mg/dl = indicates moderate depletion.
    - 150-200mg/dl = mild nutritional malnutrition.
    - May not reflect actual nutritional depletion during stress due to preferential protein synthesis by the liver.
- **Retinol- Binding Protein** (Normal = 3-6mg/dl)
    - Half-life of 12 hours.
    - Good short term marker of nutrition.
    - Also affected by renal failure (and therefore not as accurate in these patients).

Best **acute** indicators of nutritional status are the retinol binding protein, prealbumin, and transferrin.

However these lab tests should be combined with additional assessments such as the urinary nitrogen excretion and indirect calorimetry.

So how do we assess what the patient's nutritional requirements are?

- **Predictive Equations (eg. Harris Benedict Equation)**
    - Basically these equations use factors to calculate the patient's Basal energy expenditure (BEE) which is the amount of energy expended by the body in a resting state under basal conditions. To account for the stress and trauma, this is then multiplied by a factor (typically 1.3-1.5).
    - For overweight patients to calculate their caloric needs you can use the formula: weight = [(actual weight - IBW) x 0.25] + IBW.
    - Burn patients' calories can be estimated by the following equation: 25kcal/kg/day + (30kcal/day x %burned). Their protein content can then be calculated by 1-1.5g/kg/day + (3g x %burn).

- **Indirect Calorimetry (Respiratory Quotient – RQ)**
    - Most accurate assessment of a patient's energy expenditure
    - uses a metabolic cart to measure oxygen consumption and carbon dioxide production.

- RQ>1 = lipogenesis (overfeeding). Should decrease carbs and caloric intake.
- RQ<0.7 = ketosis and fat oxidation (i.e. starvation). Need to increase carbohydrates and caloric intake.
- In general Pure fat utilization will result in a RQ = 0.7, whereas protein utilization will equal 0.8, and carbohydrate utilization will equal 1.0.
- Typically your goal will be a RQ = 0.85

- **Weight Determination**
  - Daily weights.

- **Nitrogen Balance**
  - Used to assess the adequacy of protein provision.
  - In critically ill patients with extensive proteolysis, it can be possible to see Urinary urea nitrogen exceeding 15 - 20g/day.
  - Goal is POSITIVE nitrogen balance of 2 - 4 g/day.
  - Requires timed 24 hour urine collection.
  - Also not accurate in renal failure.

Critical Care Nutrition: Routes of Nutrition Administration

When considering routes of administering nutrition, the most important concept is determining the functional status of the GI tract. In a patient who is breathing spontaneously, conscious, and has an intact GI tract, the best way to feed the patient is to give them a diet of solid food and liquids by mouth. A patient in the hospital does not necessarily need extravagant measures in order to be fed properly. For those patients needing nutritional support, it is important to remember some indications:

- Patient will be without adequate nutrition for 5 - 7 days.
- Expected illness course of longer than 10 days.
- Evidence of malnourishment.
  - Loss of 5lbs (2.3kg) or loss of 5% of ideal body weight in 1 month.
  - Weight loss 15% or more of ideal body weight.
  - BMI < 18.5.

Under these conditions, the next step is to determine the best route for feeding them, determine their caloric needs, and begin feeding the patient.

Enteral Nutrition

By definition, enteral nutrition is nutrition (calories, proteins, electrolytes, vitamins, etc) via an **intestinal route**. Enteral feeds are those administered via a tube into the patient's stomach, duodenum, or the jejunum – though the stomach is the most common location. The most common route of administration is through a nasogastric tube (NGT), but can also be through an orogastric tube (OGT), or dobhoff tube (DHT), or gastric tube (e.g. PEG) as well as feeding jejunostomy (J-tube). NGT and OGT can be placed either into the stomach or post pyloric. Which route is best is patient dependent. Whether to place the tube in the stomach or post-pyloric is in large part determined by the patient, if there is concerned for delayed gastric emptying, then post pyloric or jejeunal feeds are typically preferred.

Nasogastric tubes are tubes that extend from the nose into the stomach or beyond. They come in a variety of sizes and are relatively safe, however there are drawbacks to each method. Nasogastric tubes, although relatively easy to place are commonly dislodged, and prolonged placement can result in nasal and esophageal erosion and sinusitis. In addition, placement must always be confirmed as there is always the chance that the tube is in the airway instead of the esophagus. NGT can serve both to feed, as well as to remove fluids from the stomach. Dobhoff tubes however are dedicated feeding tubes. These are typically weighted at the end and therefore are somewhat easier to pass post-pyloric. These too carry the risk of winding up in the lungs.

Despite all of this, if enteral feeds are possible they are preferred due to the improved immunologic function and overall better outcomes of enterally fed patients. The intestines are a major immune organ, and disuse results in atrophy and decreased immunologic function – resulting in increased infections. Even low dose tube feeds (10cc/hr) have shown to improve overall function and morbidity and mortality compared to patients on TPN. Enteral feeds are not without complications however, the most common of which are incorrect placement of the feeding tube, as well as aspiration. Therefore it is crucial that patients on enteral feeds are upright or kept at > 30 degrees inclined in bed. In addition, if there are concerns about dysmotility (delayed gastric emptying, etc) contributing to high residuals and aspiration, promotility agents such as erythromycin and reglan can be used.

Parenteral Nutrition

Parenteral feeds bypass the intestines and are administered through direct access to the bloodstream. There are two forms of PN, peripheral parenteral nutrition (PPN) and Total Parenteral Nutrition (TPN). TPN is more common and PPN is rarely used. PPN is parenteral nutrition that is administered for no more than a few days and is given via a peripheral IV. Parenteral nutrition cannot be delivered via the peripheral veins for more than a few days because the high osmotic load is caustic to the veins. Therefore, if parenteral nutrition will be utilized for longer than a few days, central venous access of some form (PICC line, central venous catheter, tunneled central venous catheter) must be obtained.

Securing access

As mentioned, parenteral nutrition that will be administered for longer than a few days requires central venous access. Placement of either a tunneled or non-tunneled central venous catheter into one of the large central veins around the neck (Internal jugular, subclavian veins) or a peripherally inserted central catheter (PICC) into one of the arm veins (basilic, cephalic, brachial, then advanced centrally to the SVC-atrial junction) provides the best route for parenteral nutrition. The femoral vein can also be used, but is more prone to infection.

Complications
Although life-saving in some circumstances (for example patients with short gut), TPN is not without complications. These complications are broken down into catheter related complications and metabolic complications. Catheter related complications include catheter obstruction (and need for replacement), venous thromboembolism at the catheter site, pneumothorax (during placement), and of course catheter related infection. The metabolic complications from TPN include overfeeding (protein, carbohydrates, and fats) and refeeding syndrome. Administration of excess protein in the TPN is associated with azotemia and elevated BUN. This is most commonly seen in patients who have preexisting liver dysfunction or kidney dysfunction. Excess carbohydrates can result in many complications, including liver disease (hepatic steatosis and cholestasis), as well as excessive carbon dioxide production which can lead to issues with weaning from the ventilator. The most common complication from excess carbohydrate administration is hyperglycemia, and it is not uncommon to start an insulin drip with TPN and/or put insulin in the TPN itself. Excess administration of lipids in TPN results in hypertriglyceridemia, immune suppression, and hepatic steatosis. Careful monitoring of the patient's glucose and kidney function are necessary to prevent further complications.

Monitoring Nutrition Status

Following initiation of nutrition, its effectiveness should be closely monitored.

- Daily weights.
- Weekly prealbumin and transferrin (shorter half-lives compared to albumin).
- Baseline 24-hour urinary urea nitrogen measurement with routine 24-hour urine urea nitrogen measurement to calculate nitrogen balance and make adjustments to keep patients in positive nitrogen balance.
- Daily electrolyte monitoring (especially potassium, phosphorous, magnesium, and ionized calcium).
- Baseline and weekly monitoring of triglyceride concentrations and liver function tests.
- Glucose monitoring.
- Clinical examination of patient's wounds or incisions for evidence of healthy wound healing.

Critical Care Nutrition: Nutrients

Enteral feeds are generally given in pre-mixed formulas and are given in boluses when feeding the stomach, or as continuous feeds into the jejunum. These formulas include carbohydrates, proteins, vitamins, and fats. Typical formulas are 1 kcal/mL.

18-25kcal/kg/day in a patient with normal body weight is a good starting goal for enteral supplementation. Immunoprotective factors such as glucosamine are generally not added to enteral feeds. Fiber is a common additive to decrease the chance of diarrhea, a common complication.

TPN feeds have slightly different considerations. Dextrose is used to deliver soluble carbohydrates to the patient. All essential amino acids are given to the patient except for Arginine and Glutamine. Once thought to be immunoprotective agents, arginine and glutamine metabolism can increase the concentration of ammonia and lead to encephalopathy. Vitamins, minerals, and lipids are also added to the formula.

Conclusion

In the face of critical illness and severe trauma it is easy to forget about the importance of nutrition and a patient's nutrition status. However, nutrition is a critical part of the patient's ability to heal and recover. The goal of nutritional support is to heal the patient more quickly and provide the energy that the body requires to do so. When possible enteral nutrition should be initiated as early as feasible, but that is not the end of the road; the efficacy of the nutrition delivered should be monitored and adjusted accordingly in order to give the patient the best chance for a good outcome.

References:

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