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Nutrition in Traumatic Brain Injuries

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NUTRITION IN TRAUMATIC BRAIN INJURIES

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Abstract

Nutrition intervention and support is a critical part of caring for traumatic brain injury (TBI) patients. TBI patients have high energy and protein needs, as well as increased needs for some vitamins and minerals. There are a number of ways to assess energy and protein needs for TBI patients including indirect calorimetry, the Harrris-Benedict Equations and the Glasgow Coma Scale Equation. Most TBI patients are either non-responsive (comatose) or develop some form of dysphagia and, therefore, are unable to consume adequate amounts of nutrition via the oral route. Nutrition support through enteral or parenteral routes may improve the medical outcome of TBI patients when oral intake is either not possible or inadequate. Adequate nutrition, avoiding under nutrition and over nutrition, as well as proper timing are critical in effective nutrition support. Proper evaluation of feeding methods and nutrition requirements, in addition to timely initiation of nutrition support are essential in treatment of TBI patents. TBI patents who receive appropriate nutrition intervention tend to have improved outcomes and shorter lengths of hospital stay.

Introduction

Traumatic brain injuries (TBI) are a common injury in the United States. Typical causes include cerebralvascular accidents and accidents including motor vehicle and firearm accidents. Most of these patients require Trauma and Intensive Care Unit services followed by rehabilitation. For the most effective care, treatment should be multidisciplinary including many different disciplines including primary care, nursing, respiratory, physical therapy, social work, and nutrition support dietitians. The services provided to the patient by each discipline are critical for an optimal patient outcome. The following is a review of nutritional treatment in TBI, as well as the positive implications of proper nutrition care.

Increased Energy Needs

TBI patients have much higher energy needs than healthy individuals. Donaldson et al. (1) explains that this is due to a hypermetabolic state. This hypermetabolic state can be caused by many different factors including injured tissue, infections, perfusion deficits and dead tissue (1).

The body reacts to injury in two phases known as the ebb and flow phases. The ebb phase is a short term, initial response. It consists of hyperglycemia and lower energy expenditure (2). This usually only lasts 48-72 hours after the initial insult occurs. Following the ebb phase, the body then enters what is called the flow phase. During this phase the body releases many hormones such as cortisol, epinephrine, norepinephrine, insulin and glucagon. The increase in these hormones puts the body into a hypermetabolic, hypercatabolic state (2). This results in the body having a negative nitrogen balance. This same process applies to almost all TBI and critical care patients.

Donaldson et al.(1) reports that these patients expend up to 169% of their basal energy needs. This tends to be true even in patents with paralysis, who would appear to have very low energy needs due to their lack of movement.

Calculating Energy Needs

Energy needs for TBI patients can be hard to estimate. The degree of injury differs greatly from patient to patient as well as during the course of healing process. As a result, hypermetabolism and, in turn, energy and nutrient needs vary between patients as well as within a patient's recovery time (1). The fact that patients' needs are always different leads to the challenge of calculating and meeting individual patients' energy and nutrient needs. There are three commonly used methods of calculating patients' energy needs all of which have their own benefits and drawbacks. They are indirect calorimetry, the Harris-Benedict equation, and the Glasgow Comma Scale equation.

Indirect Calorimetry

The most effective method of evaluating basal energy expenditure is via indirect calorimetry. This is conducted by the use of a machine which analyzes the ratio of O2 breathed in and CO2 that a patient breaths out (1). This measurement is easily performed at bedside and gives the most individualized estimation of energy expenditure. This is useful due to the variation in hypermetabolic response from patient to patient; however, this method is not always practical due to the expense of the equipment and the challenges in conducting the test on a ventilator dependent patient (1).

Harris-Benedict equations

The Harris-Benedict equations are another tool used to estimate energy expenditure. These equations, one for males and females, were developed by Harris and

Benedict in1919 (3). The equations have proven to be accurate and useful over time for noninjured patients. The equations are used to estimate basal energy expenditure for patients. Basal energy expenditure is estimated using the factors of age, height, weight and sex. After basal energy requirements are calculated, an activity and injury factor can be applied in order to calculate total energy needs. Typically an injury factor of 1.4 is used for non-paralyzed TBI patients and 1.0 is used for paralyzed TBI patients. An activity factor of approximately 1.0 is also used for both paralyzed and non-paralyzed TBI patients (1). Donaldson et al. (1) also points out the fact that nutritional requirements vary and must be reevaluated and adjusted often. Although this equation is easy to use, widely known and a fairly accurate calculation of basal energy expenditure, it has been found to be inaccurate for patients with trauma, such as a TBI. Pepe et al. (4) noted that predictions of energy expenditure using the Harris- Benedict Equation were found to be accurate only 50% of the time. The following figure is an example of the calculation for basal energy expenditure by the Harris-Benedict Equation as listed by Pepe et al. (4) (note: an appropriate injury and activity factor must be applied to the results of the following equations to estimate overall energy expenditure):

<u>Harris-Benedict Equations: BEE</u>

Males: $66 + (13.7 \times W) + (5 \times H) - (6.8 \times A)$
Females: $665 + (9.6 \times W) + (1.7 \times H) - (4.7 \times A)$

W = weight in kilograms
H = height in centimeters
A = age in years
BEE = basal energy expenditure

Glasgow Coma Scale equation

The Glasgow Coma Scale (GCS) equation was developed specifically for TBI patients and calculates energy expenditure based on the severity of the injury. GCS takes into account such things as eye opening, verbal response, and motor response (5). Each patient is given a score based on their functional abilities in these areas. The sum of the scores from each individual area gives an overall rating of patient status in relationship to head injury. A score of <12 is indicative of a severe head injury. A score of <8 suggests need for intubation and ventilation. A score of <6 suggests a need for intracranial pressure monitoring (5).

After the GCS score is determined, this number can be used in the GCS equation to calculate the percentage of resting metabolic expenditure for patients. The equation, as listed by Pepe et al. (4) is as follows:

Glasgow Coma Scale Equation: RME

For GCS<7:
%RME = 152 - 14(GSC) + 0.4(HR) + 7(DSI)

For GCS>7
%RME = 90 - 3(GSC) + 0.9(HR)

GSC=Glasgow Coma Scale score
HR=heart rate
DSI=days since injury

Protein Needs

Along with increased overall energy needs, TBI patients have much higher protein needs. Esper (6) found that TBI patients need 15-20% of total calories from protein or 1.5 to 2.0 grams of protein per kilogram of body weight. Estimation of nitrogen loss plays an important role in determining protein needs. TBI patients can lose 10 to 40 grams of protein per day. A positive nitrogen balance is usually not obtained for at least two to three weeks after injury (6). Immobility of TBI patients can further increase nitrogen loss. Reversing nitrogen loss can be aided by increased protein intake; however, increasing overall calories alone will not result in a positive nitrogen balance (7). The type of protein given to TBI patients can also affect patient outcomes. Esper (6) suggests that higher amounts of branched chained amino acids (BCAA's) may promote positive nitrogen balance better than other types of amino acids since they are reduced with gluconeogenesis. However, more research is needed in this area.

Micronutrient Needs

Adequate micronutrient requirements need to be addressed within the nutritional management of TBI patients. Nutritionally complete enteral nutrition formulas, given in sufficient amounts, provide approximately 100% of the Daily Value for most micronutrients. Enteral Nutrition (EN) patients who do not receive adequate amounts of formula are usually given a daily multivitamin to meets their daily needs (7). Patients on total parenteral nutrition (TPN) are also given a solution of vitamins and minerals with their TPN solution. Twelve to thirteen vitamins are included in TPN solutions and are usually stable for up to 24 hours. Adult formulas usually meet 100% of the Daily Value for each vitamin and mineral when sufficient volume is administered. Trace minerals can be added to TPN solutions separately or as a standard multiple-trace mineral solution (7). Electrolytes can be added, but are often complicated to include in TPN solution due to the fact that they often are not compatible with other compounds in the solution. They are often given in different salt forms in order to avoid reactions with other compounds in the TPN solution

There are some specific micronutrients which higher levels of supplementation may benefit TBI patients including zinc, magnesium and anti-oxidants. Zinc aids in utilization of fats, carbohydrates and protein by facilitating enzymes involved in these processes. TBI patients have increased urinary zinc excretion leading to low serum zinc levels. Zinc supplementation in TBI patients have been correlated with a reduced mortality rate (7). Magnesium supplementation is also beneficial in TBI patients. The A.S.P.E.N. Nutrition Support Manual (7) reports that "magnesium supplementation given 1 hour post head injury has been reported to decrease brain edema and improve neurologic scores 48 hours post head injury."

Stress in TBI patients results in high amounts of oxidative stress. Increased oxidative stress has been shown to lead to multiple organ damage in TBI patients (8). As a result, these patients require a higher level of antioxidants in their diet. Nathens et al. (8) found that treating patients in the ICU with 1000 milligrams of vitamin C via IV drip, as well as 1000 IU of vitamin E by mouth every eight hours showed significant improvement in patient outcomes. Improvements included decrease in organ failure, duration of ventilator use and ICU stay.

Challenges in Meeting Nutrient needs

Once requirements have been calculated, the next challenge is insuring the patient receives the nutrition he/she requires. Many TBI patients are not able to meet their needs through oral intake because they are in a coma and are unable to respond and are, therefore, unable to eat. Of those TBI patients who are responsive, many have other complications that limit their function and make it difficult for them to eat. This can include paralysis, loss of fine motor function, and dysphagia.

Dysphagia and Aspiration

Mackay et al. (9) reported dysphagia was experienced by 25-42% of patients with TBI and that the average time from injury to oral feeding for TBI patients with dysphagia was 13 weeks (9). Nine different abnormalities in swallowing were reported that led to decreased or absent oral intake. The most frequent was loss of bolus control and reduced lingual movement and control (9). For those with dysphagia, oral feeding is unsafe because patients with difficulties swallowing are at high risk of aspiration. Of patients with swallowing difficulties, 41% experienced aspiration. Aspiration leads to severe respiratory complications such as pneumonia. The study also found that patients who aspirated were on ventilators twice as long as patients who did not aspirate. This study demonstrates the importance of reducing the risk of aspiration by insuring patients have appropriate diet orders in relation to the extent of their dysphagia.

Nutrition Support

The combination of increased nutrition needs and decreased ability for oral intake often make nutrition support necessary in the treatment of TBI patients. There are many debates and ongoing research regarding nutrition support and the safest and most effective method for the individual patient with TBI. Historically nutrition management usually consisted of parenteral or intravenous nutrition because of the high rates of intolerance to gastric feedings. However, the current practice in most hospitals is enteral, or gastrointestinal, nutrition. A study by Barzotta et al. (10) was one of the earlier studies to argue the value of enteral nutrition in the treatment of patients with TBI. This study examined the use of a surgically placed feeding tube that fed into the jejunum and the use of TPN. This study compared the two types of feeding in the areas of nutritional adequacy, total complications of treatment and total cost of treatment. The results showed that enteral feeding was more desirable because it was lower overall in cost, patient's experienced less hyperglycemia and diarrhea, and there were fewer disruptions in feedings due to less or decreased tube blockages and/or dislodgement (10). Although enteral feedings are the preferred route and TPN should be limited, parenteral nutrition (PN) does have a role in treatment of critically ill patients. Datta et al. (11) suggests that supplementing enteral feeds with PN can effectively improve nitrogen balance and have beneficial effects for critically ill patients. Datta et al. (11) reviewed three case studies in which patients' enteral feeds were supplemented with PN. All three patients had a continual decrease in serum albumin, total protein and peripheral edema with enteral feeds. Upon supplementation with parenteral feeds, all three parameters showed a significant increase. This indicates that there are situations in which enteral feeds may not be sufficient to treat critically ill patients and short term use of PN can be appropriate.

Safety of Nutrition Support

The wide spread use of enteral feeding for patients suffering from TBI brings up concerns regarding the safety of feeding. A study conducted by Klodell et al. (12) was conducted to study the risk of aspiration in TBI patients who are fed enterally. Patients who have suffered a TBI have delayed gastric emptying and poor esophageal sphincter tone, both of which put them at higher risk for aspiration (12). This study found that enteral nutrition was safe and effective. Enteral feedings did not seem to cause an accelerated rate of aspiration and complications that come with it. Enteral feedings were also able to meet the nutritional needs of TBI patients. Klodell et al. (12) also compared the advantages of PEG tubes versus nasogastric tubes. Nasogastric tubes were easily placed and less expensive, however this type of tube is easily dislodged and is not suitable for long term use (12). In contrast, PEG tubes were designed for long term use and were much more difficult to be dislodged. Although this type of tube had many benefits, it is much more expensive and requires a minor surgical procedure to place and is therefore not suitable for use with some patients (12). The decision as to which type of feeding tube used is dependent upon the length of time the patient will be receiving enteral feedings.

Feeding: Under or Over?

After the most appropriate method of feeding has been identified for TBI patients, appropriate amounts of nutrition should be administered. Caloric requirements should be estimated following one of the methods mentioned earlier. Donaldson et al. (1) noted the importance of supplying TBI patients with adequate calories and nutrition. There is an association between multiple organ failure in TBI patients and insufficient calories over time. Long-term under nutrition is related to decreased immunity and resistance to infection as well as decreased wound healing. Underfeeding eventually leads to organ failure because these tissues are deprived of essential proteins and are no longer able to function (1). Dentes (13) also reports the problems associated with underfeeding including the fact that malnourished TBI patients had more complications than TBI patients that were well nourished. Malnourished patients had higher incidences of pressure sores, infections, and ossification as well as slower rates of rehabilitation and recovery (13).

The previous studies emphasize the importance of insuring patients receive adequate nutrition over time; however there are negative consequences to overfeeding patients as well. Donaldson et al. (1) noted that too many calories can lead to many complications such as hyperglycemia, elevated blood urea nitrogen levels, hepatic dysfunction, and increased cholesterol and triglycerides. Overfeeding can also lead to decreased ability for patients to wean from a ventilator due to the increased amounts of CO_2 produced as a result of excess glucose calories (1).

The current practice today is short-term permissive underfeeding. Dr. Robert Martindale summarized the current practice at the 2006 Utah Dietetic Association annual meeting (14). Feeding should be initialized with in the first 24 hours of admittance. Feeding should only meet 33-66% of patients needs for the first 3-5 days (14). After Day six and beyond, feeding should be slowly increased to a goal rate to meet 100% of patients estimated needs. Martindale suggests that this process has been shown to decrease ICU stay, and improve recovery time in many different critically ill patients, including TBI patients.

The key to giving patients the appropriate amount of nutrition is a balance to avoid under and over feeding patients and the complications that come with each.

TBI patients should be encouraged to advance to an oral diet as early as possible when it is safe for the patient. Formisano et al. (15) found a statistically significant link between early transition to oral feedings and decreased recovery time in TBI patients. The first initiation of oral feedings can be an accurate prognostic indicator for these patients.

Summary

Nutrition intervention is a critical part of TBI treatment and requires early and ongoing nutrition support. Proper evaluation of feeding methods, nutrition requirements as well as timely initiation of nutrition support are all essential in treatment of TBI patents. TBI patents who receive appropriate nutrition intervention tend to have improved outcomes and shorter lengths of hospital stay.

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