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ORIGINAL RESEARCH

Enteral Nutrition for Patients With Traumatic Brain Injury in the Rehabilitation Setting: Associations With Patient Preinjury and Injury Characteristics and Outcomes

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Abstract

Objective: To determine the association of enteral nutrition (EN) with patient preinjury and injury characteristics and outcomes for patients receiving inpatient rehabilitation after traumatic brain injury (TBI).

Design: Prospective observational study.

Setting: Nine rehabilitation centers.

Participants: Patients (N = 1701) admitted for first full inpatient rehabilitation after TBI.

Interventions: Not applicable.

Main Outcome Measures: FIM at rehabilitation discharge, length of stay, weight loss, and various infections.

Results: There were many significant differences in preinjury and injury characteristics between patients who received EN and patients who did not. After matching patients with a propensity score of >40% for the likely use of EN, patients receiving EN with either a standard or a high-protein formula (>20% of calories coming from protein) for >25% of their rehabilitation stay had higher FIM motor and cognitive scores at rehabilitation discharge and less weight loss than did patients with similar characteristics not receiving EN.

Conclusions: For patients receiving inpatient rehabilitation after TBI and matched on a propensity score of >40% for the likely use of EN, clinicians should strongly consider, when possible, EN for ≥25% of the rehabilitation stay and especially with a formula that contains at least 20% protein rather than a standard formula.

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The provision of adequate nutritional support for patients with moderate-to-severe traumatic brain injury (TBI) has been a clinical challenge for decades.[1-3] Patients' primary and secondary injuries create unique metabolic derangements that pose issues such as optimal timing and route of nutrition, appropriate fluid and electrolyte balance, drug administration, and dysphagia. In addition, it may be difficult to maintain tubes and lines in a confused or agitated patient, particularly in a rehabilitation setting.

Individuals with TBI have a much higher resting metabolic expenditure (RME) than do patients without TBI.[4] In fact, with severe TBI, RME has been found to range up to 240% of RME in patients without TBI; they are similar in metabolic response to patients with burns over 20% to 40% of their body surface area.[4] The consequences of hypermetabolism, hypercatabolism, and altered immune function in patients with acute TBI are excessive

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protein breakdown, which can lead to malnutrition.[5] However, patients with TBI requiring hospitalization often do not, or cannot, consume enough nutrition to support their increased requirements for recovery and rehabilitation.[5]

Enteral nutrition (EN) administered as early as possible has been established as the preferential route of nutritional support for this population versus total parenteral nutrition (TPN); some centers use a combination of EN and TPN in the early stages of injury if the patient does not tolerate adequate amounts of EN alone.[6] Chourdakis et al[7] recently reported that early EN may affect hormonal response to TBI and suggests that this may reduce catabolic and inflammatory processes induced by TBI. There appears to be a consensus on early initiation of EN, but less definitive are recommendations on advancement timing and formula components (eg, whether to use specialty formulas such as those containing immune-enhancing properties).[8-12] The Institute of Medicine recommended inclusion of nutrient additives (eg, n-3 fatty acids, creatine, choline, and zinc) as potentially beneficial for recovery after TBI.[3,5] Patients with TBI, similar to other trauma patients, likely require 2.0 to 2.5g of protein/kg at a minimum, especially during the early period after injury.[6,13] Evaluation of the duration of a higher protein requirement has not been reported in the literature, but it likely correlates with metabolic status. If increased metabolic rates extend into the rehabilitation setting, then increased protein needs may also be present.

Swallowing disorders and decreased behavioral/cognitive skills are frequently present in patients with severe brain injury and significantly affect oral intake.[14] Persons who swallow abnormally take much longer to start eating and to achieve total oral feeding, and they require nonoral supplementation 3 to 4 times longer than those who swallow normally.[14] Patients with severe TBI may also have intolerance to EN, which hampers survival and rehabilitation.[15] Haddad and Arabi[16] discuss proactive use of prokinetic agents, such as erythromycin and metoclopramide, as well as postpyloric feeding as ways to overcome problems of gastric distention and intolerance experienced by patients with TBI.

Most reports[11,13,17,18] regarding nutrition in patients with TBI address the route (TPN vs EN) and/or timing (early vs late) of initiation of nutritional support related to hospital admission and have addressed outcomes such as mortality or length of stay (LOS) in the acute care setting. We could not find any published reports that address the role of nutritional support during rehabilitation of patients with TBI. A practice-based evidence (PBE) study in stroke rehabilitation found that the use of EN support for $\geq$25% of the rehabilitation stay for patients with severe stroke was a significant factor in predicting higher discharge FIM total and motor scores, controlling for patient and other treatment differences.[19,20] It is not known if these findings are applicable to the population with TBI receiving rehabilitation. This article describes nutritional support methods used for patients in a TBI-PBE study during rehabilitation[21] and examines associations of patient preinjury and injury characteristics with use and duration of EN support, as well as associations of EN with outcomes, controlling for patient differences.

List of abbreviations:

CSI	**Comprehensive Severity Index**
EN	**enteral nutrition**
LOS	**length of stay**
PBE	**practice-based evidence**
RME	**resting metabolic expenditure**
TBI	**traumatic brain injury**
TPN	**total parenteral nutrition**

Methods

This comparative effectiveness PBE study examined the differential effects of a wide array of specific treatments administered in 10 acute inpatient rehabilitation facilities serving patients with TBI in a brain injury specialty unit who were enrolled from October 2008 to September 2011. The 10 participating centers constituted a convenience sample of adults with TBI on the basis of their willingness to participate in the research. The institutional review board at each center approved the study; each patient or his/her proxy gave informed consent.

Participants

Inclusion criteria were as follows[21]: (1) Sustained a TBI, defined as damage to brain tissue caused by external force and evidenced by loss of consciousness, posttraumatic amnesia, skull fracture, or objective neurological findings. Diagnoses included *International Classification of Diseases, 9th Revision, Clinical Modification* codes consistent with the Centers for Disease Control and Prevention Guidelines for Surveillance of Central Nervous System Injury; (2) received inpatient care in a designated brain injury rehabilitation unit of one of the participating rehabilitation facilities; and (3) were 14 years or older and treated in an adult rehabilitation unit.

Patient variables

Patient characteristics, including demographic characteristics and injury characteristics, were recorded on the basis of clinicians' suggestions as well as previous research indicating their importance in populations with TBI. In addition to patient data available on admission, we collected information on patients' status during their rehabilitation stay, including the presence of aphasia and dysphagia. Table 1 lists the characteristics of study patients.

Functional dependence

We used admission FIM, an assessment of independent functioning consisting of 18 items in 2 domains: motor (13 items) and cognitive (5 items). Each FIM item was rated on a 7-category scale, ranging from 1 (total assistance required) to 7 (complete independence). To eliminate distortion in quantifying the status of patients whose capability is at the extremes of the instrument's range, FIM motor and cognitive scores were recoded separately using tables published by Heinemann et al,[22] which were based on Rasch analysis of FIM data of a large sample with brain injury.

Injury severity and comorbidity

The primary medical severity measure used was the Comprehensive Severity Index (CSI), which defines severity as the physiological and psychosocial complexity presented owing to the extent and interactions of a patient's disease(s).[21] The CSI is age- and disease-specific and is independent of treatments. It provides an objective, consistent method to operationalize patient severity of illness on the basis of >2100 individual signs, symptoms, and physical findings and >5600 disease-specific criteria sets related to all of a patient's disease(s). More details about the CSI appear elsewhere.[21] The CSI modification used here allowed separating severity of brain injury (called brain