Nutrition, Trauma, and the Brain

The perspective of a neurosurgeon

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Clinical Professor of Neurological Surgery
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DAY 1

KEEP THE BLOOD PRESSURE UP
- monitor arterial BP and CVP
- Cerebral Perfusion Pressure 50-70

KEEP BRAIN PRESSURE DOWN:
- evacuate hematomas
- monitor ICP- drain CSF
- mannitol
- decompressive craniectomy
Current clinical goals

- Meet 100-140% of energy requirement asap
- Use TPN or gastric route
- Consider transpyloric route or medications for persistent gastric residuals

Current problems

- Not measuring energy requirement
- Majority of patients do not get full caloric needs met in first week - integral part of any solution

NOT FEEDING ENOUGH AND DONT KNOW HOW MUCH TO FEED
What is BTF?

- A non-profit, established in 1986
- Our mission is to improve outcomes of traumatic brain injury (TBI) patients through:
  - Evidence based Guidelines development
  - AANS, CNS Neurotrauma section partners
  - Medical education (TBI-trac.edu)
  - Clinical research (TBI-trac)
  - Quality improvement programs (TBI-trac)
  - Mild TBI (concussion) research
• Center for Disease Control; Journal of Trauma (Dec 2007)
  • Patients are twice as likely to survive if BTF guidelines are followed
  • Proportion of patients with “good” outcomes rose from 35% to 66%
  • Proportion of patients with “poor” outcomes fell from 34% to 19%
  • Potential savings- $3.8 Billion
Guidelines for the management of severe TBI - 3rd edition

Early indicators of prognosis in severe TBI

Guidelines for the Pre-hospital Management of severe TBI - 2nd edition

Guidelines for the surgical management of TBI

Guidelines for the field management of combat-related head trauma

Guidelines for the acute management of severe TBI in infants, children and adolescents

www.braintrauma.org
TBI GUIDELINES

Third Edition

What’s new?

- Blood pressure and oxygenation
- Prophylactic Hypothermia New
- Indications for Intracranial Pressure Monitoring
- Intracranial Pressure Monitoring Technology
- Intracranial Pressure Thresholds
- Cerebral Perfusion Thresholds
- Brain Oxygen Monitoring and Thresholds New
- Infection Prophylaxis New
- DVT Prophylaxis New
- Hyperosmolar Therapy 1/2 New
- Anesthetics Analgesics and Sedatives 1/2 New
- Nutrition
- Antiseizure Prophylaxis
- Hyperventilation
- Steroids

AANS
CNS
Joint Section NTCC

Brain Trauma Foundation
visit us online at www.braintrauma.org
TBI GUIDELINES

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XII. Nutrition

I. RECOMMENDATIONS

A. Level I

There are insufficient data to support a Level I recommendation for this topic.

B. Level II

Patients should be fed to attain full caloric replacement by day 7 post-injury.

II. OVERVIEW

IV. SCIENTIFIC FOUNDATION

Metabolism and Energy Expenditure and Caloric Intake

Researchers found that, in TBI patients, paralysis with pancuronium bromide or barbiturate coma decreased metabolic expenditure from a mean of 160% of that expected to 100–120%. This finding suggests that a major part of the increased metabolic expenditure is related to muscle tone. Even with paralysis, energy expenditure remained elevated by 20–30% in some patients. In the first 2 weeks after injury, energy expenditure seems to rise regardless of neurological course.
II. OVERVIEW

There are still few studies specifically addressing the impact of nutrition on traumatic brain injury (TBI) outcome. The effects of TBI on metabolism and nitrogen wasting have been studied most thoroughly. Prior to the 1980s, there were occasional case reports of hypermetabolism in TBI. The general attitude toward nutritional replacement was based on the assumption that, due to coma, metabolic requirements were reduced. However, over the last 25 years, numerous studies have documented hypermetabolism and nitrogen wasting in TBI patients.

Data measuring metabolic expenditure in rested comatose patients with isolated TBI yielded a mean increase of approximately 140% of the expected metabolic expenditure with variations from 120% to 250% of that expected. These findings were consistent whether corticosteroids were used or not. Since the 2000 guidelines, two Class II studies have been conducted.

Rapp et al., 1983

Thirty-eight TBI patients were randomly assigned to receive total parenteral nutrition (TPN) or standard enteral nutrition (SEN). Mean intake for the TPN group was 1750 calories and 10.2 g/day of N for the first 18 days. The TPN group got full nutritional replacement within 7 days of injury. The SEN group achieved 1600 calories replacement by 14 days after injury. For the SEN group mean intake in the same period was 685 calories and 4.0 g/day of N.

The favorable effect of early parenteral feeding on survival in head-injured patients

Robert P. Rapp, Pharm.D., Byron Young, M.D., Diana Twyman, M.S., Brack A. Bivins, M.D., Dennis Haack, Ph.D., Phillip A. Tebbs, M.D., and James R. Bean, M.D.

J. Neurosurg. / Volume 58 / June, 1983

II

There were 8 deaths in the enteral nutrition group and none in the parenteral nutrition group in the first 18 days ($p < 0.001$). Early feeding reduced mortality from TBI.
TBI GUIDELINES

RCT of TBI patients receiving mechanical ventilation comparing accelerated enteral feeding versus standard feeding.

Taylor et al 1999

There was a trend toward better GOS at 3 months in the accelerated feeding cohort, but no difference at 6 months. Accelerated feeding met goals faster in first week and there were less infections.

Prospective, randomized, controlled trial to determine the effect of early enhanced enteral nutrition on clinical outcome in mechanically ventilated patients suffering head injury.

Taylor, Stephen; PhD, SRD; Fettes, Sheila; BSc, SRD; Jewkes, Claire; MBBS, FRCA; Nelson, Richard; MA, FRCS


Figure 1. Median percentage of patients' estimated energy (E) and nitrogen (N) requirements met by enteral nutrition.

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Control (%)</th>
<th>Intervention (%)</th>
<th>p Value</th>
<th>Risk Ratio</th>
<th>95% CI</th>
<th>NNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good outcome at</td>
<td>39</td>
<td>61</td>
<td>0.08</td>
<td>1.6</td>
<td>0.99–2.5</td>
<td>5</td>
</tr>
<tr>
<td>3 months</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 months</td>
<td>61</td>
<td>68</td>
<td>0.64</td>
<td>1.12</td>
<td>0.8–1.5</td>
<td>14</td>
</tr>
<tr>
<td>Infections (&gt;0)</td>
<td>85</td>
<td>61</td>
<td>0.02</td>
<td>0.71</td>
<td>0.5–0.94</td>
<td>14</td>
</tr>
<tr>
<td>Complications (&gt;1)</td>
<td>61</td>
<td>37</td>
<td>0.046</td>
<td>0.55</td>
<td>0.3–0.95</td>
<td>4</td>
</tr>
</tbody>
</table>

CI, confidence interval; NNT, number needed to treat.
BTF TBI QI Program Participants

**NATIONAL (AWI)**
- Mission Hospital: Mission Viejo, CA
- Sharp Memorial: San Diego, CA
- Scripps- Mercy Hospital: San Diego, CA
- Santa Rosa Medical Center: CA
- Long Beach Memorial: Long Beach, CA
- LeHigh Valley Hospital: Allentown, PA
- York Hospital: York, PA
- Hahnemann: Philadelphia, PA
- Lancaster General Hospital: PA
- Miami Valley Hospital: Dayton, OH
- Grant Hospital: Columbus, OH
- Christiana Medical Center, Newark DE
- Bronson Medical Center: Kalamazoo, MI
- Borgess Medical Center: Kalamazoo, MI
- Spectrum Health: Grand Rapids MI
- Queen’s Hospital: Honolulu, HI
- St. Mary Corwin: Pueblo, CO
- St Anthony’s: Denver, CO
- St. Alphonsus: Boise, ID
- University of Kansas Hospital: KS
- Wilford Hall Medical Center: Lackland, TX

**NEW YORK STATE**
- Albany Medical Center: Albany, NY
- Bellevue Hospital Center: New York, NY
- Brookdale Hospital: Brooklyn, NY
- Elmhurst City Hospital: Elmhurst, NY
- Erie County Medical Center: Buffalo, NY
- Good Samaritan Hospital: West Islip, NY
- Jacobi Medical Center: Bronx, NY
- Jamaica Hospital: Jamaica, NY
- Kings County Hospital: Brooklyn, NY
- Lincoln Hospital: Bronx, NY
- New York Hospital: Queens, NY
- New York Presbyterian Hospital: NY, NY
- Northshore U. Hospital: Manhasset, NY
- St. Barnabas Hospital: Bronx, NY
- Strong Memorial: Rochester, NY
- University Hospital: Stonybrook, NY
- University Hospital: Syracuse, NY
- Westchester Medical Center: Valhalla, NY
- Winthrop University Hospital: Mineola, NY
Compliance with Nutrition Guideline by Center (2009)
Effect of early nutrition on deaths due to severe traumatic brain injury

ROGER HÄRTL, M.D.,¹ LINDA M. GERBER, PH.D.,² QUANHONG NI, M.S.,² AND JAMSHID GHAJAR, M.D., PH.D.¹³

Departments of ¹Neurological Surgery and ²Public Health, Weill Cornell Medical College; and ³Brain Trauma Foundation, New York, New York

Object. Traumatic brain injury (TBI) remains a serious public health crisis requiring continuous improvement in pre-hospital and in-hospital care. This condition results in a hypermetabolic state that increases systemic and cerebral energy requirements, but achieving adequate nutrition to meet this demand has not been a priority in reducing death due to TBI. The effect of timing and quantity of nutrition on death within the first 2 weeks of injury was analyzed in a large prospective database of adult patients with severe TBI in New York State.

Methods. The study is based on 797 patients with severe TBI (Glasgow Coma Scale [GCS] score < 9) treated at 22 trauma centers enrolled in a New York State quality improvement program between 2000 and 2006. The in-hospital section of the prospectively collected database includes information on age, initial GCS score, weight and height, results of CT scanning, and daily parameters such as pupillary status, arterial hypotension, GCS score, and number of calories fed per day.

Results. Patients who were not fed within 5 and 7 days after TBI had a 2- and 4-fold increased likelihood of death, respectively. The amount of nutrition in the first 5 days was related to death; every 10-kcal/kg decrease in caloric intake was associated with a 30–40% increase in mortality rates. This held up even after controlling for factors known to affect mortality, including arterial hypotension, age, pupillary status, initial GCS score, and CT scan findings.

Conclusions. Nutrition is a significant predictor of death due to TBI. Together with prevention of arterial hypotension, hypoxia, and intracranial hypertension it is one of the few therapeutic interventions that can directly affect TBI outcome. (DOI: 10.3171/JNS/2008/109/7/0050)

3-1. What is the effect of timing and quantity of nutritional support on early mortality? Is there a relationship between these parameters and severity of injury?
Effect of early nutrition on deaths due to severe traumatic brain injury

ROGER HÄRTL, M.D.,1 LINDA M. GERBER, PH.D.,2 QUANHONG NI, M.S.,2 AND JAMSHID GHAJAR, M.D., PH.D.1,3

Departments of 1Neurological Surgery and 2Public Health, Weill Cornell Medical College; and 3Brain Trauma Foundation, New York, New York

3-4. Is there any research on the effect of nutrition after the acute phase of injury?
3-5. Are there any unique problems with nutrition support with severe brain injury (i.e. volume constraints or concerns about nutritional impacts on intracerebral pressure)?
Background: Early and adequate nutrition after severe traumatic brain injury (TBI) improves outcome. Achieving adequate nutritional intake in this patient population is difficult and nutritional therapy in many ICUs is suboptimal. Despite best intentions our Level 1 Trauma Center was consistently well below the goal of 25 Kcal/kg/day. A Quality Improvement (QI) initiative was undertaken. Methods: Kcal/kg per patient per day is collected by nurse registrars into an online database (TBI-tracs™) as part of a quality initiative through the Brain Trauma Foundation. Quarterly data review demonstrated that the mean Kcal/Kg/day was well below goal. The QI team reviewed patient records, developed protocols, obtained physician consensus, monitored compliance and revised the nutrition protocol as needed. The current protocol calls for enteral feeding over 20 hours of the day, with a 4 hour time period built in for 'catch up'. Results: The percent of patients receiving nutrition by Day 2 increased from 29% in 2007 to 50% in 2010. Average Kcal/kg on hospital day 5 increased from a mean of 14.4 in 2007 to 28.8 in 2010 (p=0.006). The percent of patients that received at least 25 Kcal/kg on Day 5 increased from 19.4% in 2007 to 75% in 2010 (p=0.018). The percentage of patients that achieved 25 Kcal/kg/day on any day within the first 5 days post injury increased from 25.8% in 2007 to 91.7% in 2010 (p=0.001) Conclusions: Achieving adequate nutritional intake in severe TBI patients presents unique challenges. Successful implementation of a protocol to improve nutrition is slow and requires creativity and teamwork. Despite these obstacles success in increasing nutritional intake can be achieved.
Nutrition therapy in the critical care setting: What is “best achievable” practice? An international multicenter observational study*

Naomi E. Cahill, RD, MSc; Rupinder Dhaliwal, RD; Andrew G. Day, MSc; Xuran Jiang, MSc; Daren K. Heyland, MD, FRCPC

**Objective:** To describe current nutrition practices in intensive care units and determine “best achievable” practice relative to evidence-based Critical Care Nutrition Clinical Practice Guidelines.

**Design:** An international, prospective, observational, cohort study conducted January to June 2007.

**Setting:** One hundred fifty-eight adult intensive care units from 20 countries.

**Patients:** Two-thousand nine-hundred forty-six consecutively enrolled mechanically ventilated adult patients (mean, 18.6 per site) who stayed in the intensive care unit for at least 72 hrs.

**Interventions:** Data on nutrition practices were collected from intensive care unit admission to intensive care unit discharge or a maximum of 12 days.

**Measurements and Main Results:** Relative to recommendations of the Clinical Practice Guidelines, we report average, best, and worst site performance on key nutrition practices. Adherence to Clinical Practice Guideline recommendations was high for some recommendations: use of enteral nutrition in preference to parenteral nutrition, glycemic control, lack of utilization of arginine-enriched enteral formulas, delivery of hypocaloric parenteral nutrition, and the presence of a feeding protocol. However, significant practice gaps were identified for other recommendations. Average time to start of enteral nutrition was 46.5 hrs (site average range, 8.2–149.1 hrs). The average use of motility agents and small bowel feeding in patients who had high gastric residual volumes was 58.7% (site average range, 0%–100%) and 14.7% (site average range, 0%–100%), respectively. There was poor adherence to recommendations for the use of enteral formulas enriched with fish oils, glutamine supplementation, timing of supplemental parenteral nutrition, and avoidance of soybean oil-based parenteral lipids. Average nutritional adequacy was 59% (site average range, 20.5%–94.4%) for energy and 60.3% (site average range, 18.6%–152.5%) for protein.

**Conclusions:** Despite high adherence to some recommendations, large gaps exist between many recommendations and actual practice in intensive care units, and consequently nutrition therapy is suboptimal. We have identified “best achievable” practice that can serve as targets for future quality improvement initiatives. (Crit Care Med 2010; 38:395–401)

**Key Words:** nutrition support; enteral nutrition; parenteral nutrition; intensive care unit; critical illness; clinical practice guidelines
Abstract
Primary objective: To examine the evidence on the metabolic state and nutritional treatment of patients with moderate-to-severe traumatic brain injury (TBI).

Research design: A systematic review of the literature.

Methods and procedures: From 1547 citations, 232 articles were identified and retrieved for text screening. Thirty-six studies fulfilled the criteria and 30 were accepted for data extraction.

Main outcomes and results: Variations in measurement methods and definitions of metabolic abnormalities hampered comparison of studies. However, consistent data demonstrated increased metabolic rate (96–160% of the predicted values), of hypercatabolism (3 to 16 g N per day) and of upper gastrointestinal intolerance in the majority of the patients during the first 2 weeks after injury. Data also indicated a tendency towards less morbidity and mortality in early fed patients.

Conclusions: The impact of timing, content and ways of administration of nutritional support on neurological outcome after TBI remains to be demonstrated.

3-1. Is there any research on special nutritional formulations (foods/nutrients/diets) for critical care TBI patients?
Disparate response to metoclopramide therapy for gastric feeding intolerance in trauma patients with and without traumatic brain injury.
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Abstract
PURPOSE: To evaluate the efficacy of transpyloric feeding (TPF) compared with gastric feeding (GF) with regard to the incidence of ventilator-associated pneumonia in severe traumatic brain injury patients (TBI).

DESIGN AND SETTING: Prospective, open-label, randomized study in an intensive care unit of a university hospital.

PATIENTS: One hundred and four adult patients admitted for TBI between April 2007 and December 2008. Patients were included within the first 24 h after ICU admission and were followed until discharge or 30 days after admission.

INTERVENTION: Patients were randomized to TPF or GF groups. They received the same diet, with 25 kcal kg(-1) day(-1) of calculated energy requirements and a nitrogen intake of 0.2 g N kg(-1) day(-1). Primary outcome was the incidence of early and ventilatory-associated pneumonia. Secondary outcomes were enteral nutrition-related gastrointestinal complications (GIC), days on mechanical ventilation, length of ICU stay and hospital stay, and sequential organ failure assessment score (SOFA).

RESULTS: The TPF group had a lower incidence of pneumonia, OR 0.3 (95% CI 0.1-0.7, P = 0.01). There were no significant differences in other nosocomial infections. The TPF group received higher amounts of diet compared to the GF group (92 vs. 84%, P < 0.01) and had lesser incidence of increased gastric residuals, OR 0.2 (95% CI 0.04-0.6, P = 0.003).

CONCLUSIONS: Enteral nutrition delivered through the transpyloric route reduces the incidence of overall and late pneumonia and improves nutritional efficacy in severe TBI patients.

Prokinetic use
Metoclopramide increases peristalsis of the jejunum and duodenum, increases tone and amplitude of gastric contractions, and relaxes the pyloric sphincter and duodenal bulb.
Current clinical goals

- Meet 100-140% of energy requirement asap
- Use TPN or gastric route
- Consider transpyloric route or medications for persistent gastric residuals

Current problems

- Not measuring energy requirement
- Majority of patients do not get full caloric needs met in first week - this should be addressed:
  - Delay in initiation, gastric residuals and transport for testing and procedures delays full nutrition

NOT FEEDING ENOUGH AND DONT KNOW HOW MUCH TO FEED