

# ERABI

EVIDENCE-BASED REVIEW  
of moderate to severe  
ACQUIRED BRAIN INJURY

## 5. Dysphagia, Aspiration, and Nutritional Interventions for Patients with Acquired Brain Injury

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Figure 1. The phases of swallowing

**Abbreviations**

ABI	Acquired Brain Injury
BCAA	Branched-Chain Amino Acids
BSE	Bedside Swallowing Evaluation
CTAR	Chin Tuck Against Resistance
EEF	Early Enteral Feeding
EN	Enteral Nutrition
FOIS	Functional Oral Intake Scale
FOTT	Facial-Oral Tract Therapy
FEES	Fiberoptic Endoscopic Examination of Swallowing
FIM	Functional Independence Measure
GCS	Glasgow Coma Scale
GH	Growth Hormone
ICP	Intracranial Pressure
ICU	Intensive Care Unit
IEN	Immune Enhancing Nutrition
IGF-1	Insulin-like Growth Factor-1
LOS	Length of Stay
MBS	Modified Barium Swallow
MEBD	Modified Evans Blue Dye
NPO	Nothing by Mouth
PEG	Percutaneous Endoscopic Gastronomy
PMV	Passy-Muir (Positive Closure) Speaking Valves
PN	Parenteral Nutrition
RCT	Randomized Controlled Trial
REE	Resting Energy Expenditure
SLP	Speech-Language Pathologist
TBI	Traumatic Brain Injury
TPN	Total Parenteral Nutrition
VFSS	Videofluoroscopic Swallow Study

VMBS Videofluoroscopic Modified Barium Swallowing

WST Water-Swallowing Tests

### Key Points

Oral hygiene alone results in a significant decrease in dental plaque.

There are no differences in efficacy between the use of a manual or electric toothbrush on ICP or CPP

Maintaining good oral health during hospitalization has been shown to reduce the risk of nosocomial infections and pneumonia post ABI.

Enteral nutrition may not reduce weight loss in individuals post ABI.

For those with ABI and being provided with enteral nutrition, energy expenditure levels may be beyond those predicted by equations.

Parenteral nutrition with a continuous infusion of insulin may lower blood glucose levels in ABI populations.

A combination of both enteral and parenteral nutrition has been shown to provide an increase in protein levels post ABI.

Further research is needed to clarify the effect of both feeding routes on nitrogen balance and albumin levels post ABI.

The evidence is conflicting regarding the effect of enhanced enteral nutrition on infection rates, ventilator dependency, and hospital length of stay in patients post ABI.

Early enteral nutrition may be more beneficial than standard or late enteral nutrition for several patient outcomes post ABI.

Early parenteral nutrition support of ABI patients may improve immunologic function.

There may be an increased risk of developing pneumonia for ventilated stroke and head injury patients fed by a nasogastric versus a gastrostomy tube.

The use of metoclopramide to aid in gastric emptying may not be effective post TBI.

Zinc supplementation in the immediate post-injury period has been shown to be beneficial in terms of neurologic recovery and visceral protein concentrations, but not mortality rates, in ABI patients.

Growth hormone may enhance nutritional repletion, but it is unclear as to whether or not it improves nitrogen balance in patients post ABI.

High-protein nitrogen feedings may restore nitrogen losses post ABI.



**Branched-chain amino acid supplementation in patients with ABI may improve disability scores.**

## 5. Dysphagia, Aspiration, and Nutritional Interventions for Patients with Acquired Brain Injury

### 5.1 Introduction

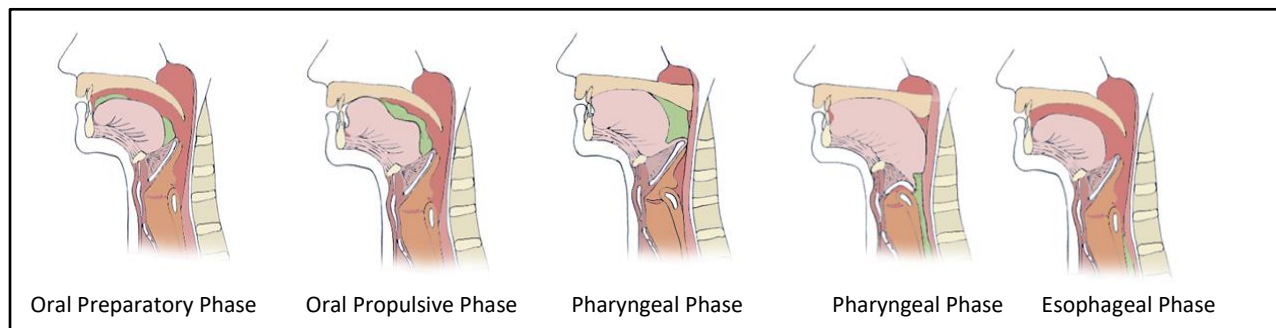
After an acquired brain injury (ABI) a wide range of swallowing disorders may occur. ABI associated with focal and diffuse cortical and brainstem damage may impair swallowing ability and lead to the development of dysphagia and aspiration (Morgan & Ward, 2001). Dysphagia is defined as difficulty or discomfort with swallowing. Aspiration is defined as the entry of material into the airway below the level of the true vocal cords. The two terms are not synonymous as many patients with dysphagia do not aspirate; although, they are closely associated (Morgan & Ward, 2001). Reported rates of aspiration post ABI vary in the literature; trends illustrate a decrease in the incidence of aspiration over time, particularly beyond 3-month follow-up (Morgan & Ward, 2001). This module will discuss dysphagia, aspiration, as well as nutritional interventions for individuals post ABI. ABI-specific literature related to dysphagia, aspiration, and nutrition is limited; for this reason, many studies from the stroke literature have been included as supplementary information. The generalizability of interventions from the stroke literature to individuals with ABI has limitations and should be approached with caution due to differing etiologies in these clinical populations.

Swallowing is implicated in both dysphagia and aspiration. Swallowing has four sequential coordinated phases which are summarized in Table 5.1 and illustrated in Figure 1.

**Table 5.1 The Four Phases of Normal Swallowing (Platt, 2001)**

Phase	Characteristics
Oral Preparatory	Food in the oral cavity is manipulated, masticated, and mixed with saliva in preparation for swallowing. The back of the tongue controls the position of the food, preventing it from entering prematurely into the pharynx.
Oral (Propulsive)	The tongue transfers the bolus of food from anterior to posterior aspects of the oral cavity and to the pharynx, triggering the pharyngeal swallow.
Pharyngeal	Complex and coordinated movements of the tongue, pharyngeal musculature and structures propel the bolus into the esophagus, while protecting the airway.
Esophageal	Coordinated contractions of the muscles of the esophagus move the bolus through the esophagus towards the stomach.

**Figure 1: The phases of swallowing**



## 5.2 Dysphagia Post ABI

Dysphagia post ABI has been attributed to pharyngeal muscular dysfunction and lack of coordination secondary to central nervous system loss of control. The reported incidence of dysphagia among individuals with brain injury varies considerably, due in part to differences in the timing and method of assessment and the initial level of severity. Although the incidence of dysphagia can be high following ABI, swallowing function frequently improves in this population over time.

Rates of dysphagia are variable, with the literature ranging between 26% and 70% (Cherney & Halper, 1996; Cherney, 1989; Field & Weiss, 1989; Halper et al., 1999; Mackay et al., 1999; Schurr et al., 1999; Winstein, 1983). Many of these rates are determined at admission; however, Winstein (1983) reported that at the time of discharge, 84% of those patients admitted with swallowing problems were eating orally. At follow-up, in the outpatient clinic, this number increased to 94%. The most common swallowing problems among patients with ABI included prolonged oral transit (87.5%), delayed swallow reflex (87.5%), valleculae pooling (62.5%), and pyriform sinus pooling (62.5%) (Field & Weiss, 1989). In a study by Mackay et al. (1999) other swallowing abnormalities included loss of bolus control (79%), reduced lingual control (79%), decreased tongue base retraction (61%), delayed trigger of swallowing reflex (48%), reduced laryngeal closure (45%), reduced laryngeal elevation (36%), unilateral pharyngeal paralysis (24%), absent swallow reflex (6%), and cricopharyngeal dysfunction (3%). For these studies, the most common factor impacting swallowing problems was cognitive functioning (Mackay et al., 1999; Winstein, 1983).

### 5.2.1 Risk Factors for Dysphagia Post ABI

Typically the more severe the brain injury, the more severe the swallowing problem (Logemann, 2013); however, the relationship between injury severity/characteristics and the nature of the swallowing disorder needs to be further studied. Within the literature, many have attempted to identify the factors that may affect the presence and severity of dysphagia post ABI (Cherney & Halper, 1996; Halper et al., 1999; Mackay et al., 1999; Morgan & Mackay, 1999). For example, injuries that result from translaryngeal intubation or tracheostomy may contribute to prolonged swallowing dysfunction in ABI patients (Morgan & Mackay, 1999), but their etiology is secondary compared to primary dysphagia.

**Table 5.2 Risk Factors for Dysphagia Post ABI**

- |   |
|---|
| <ul style="list-style-type: none"> <li>• Extent of brain injury</li> <li>• Duration of coma (Lazarus &amp; Logemann, 1987)</li> <li>• Lower Glasgow Coma Score on admission (GCS 3-5) (Mackay et al., 1999)</li> <li>• Severity of CT Scan findings (Mackay et al., 1999)</li> <li>• Duration of mechanical ventilation (Mackay et al., 1999)</li> <li>• Tracheostomy</li> <li>• Translaryngeal (endotracheal) intubation</li> <li>• Severe cognitive and cognition disorders</li> <li>• Physical damage to oral, pharyngeal, laryngeal, and esophageal structures</li> <li>• Oral and pharyngeal sensory difficulties</li> </ul> |
|---|

## 5.3 Aspiration Post ABI

When assessing the patient for signs of aspiration a videofluoroscopic swallow study (VFSS) or, as it was later called, a modified barium swallow (MBS) may be undertaken. Each of these tests require the patient to swallow liquids or solids of various consistencies (from thin to thick, or thick to thin) and the path taken by the bolus during the swallow is observed. This procedure allows for observation of any structural or functional anomalies as well as determining whether aspiration occurs..

Rates of aspiration within the literature are variable, ranging from 25% to 71% depending on the sample surveyed (Mackay et al., 1999; O'Neil-Pirozzi et al., 2003b; Schurr et al., 1999). Terre and Mearin (2009) followed 26 patients with traumatic brain injury (TBI) who aspirated; 35% were silent aspirators (no cough/throat clear response to aspiration), for one year. With silent aspiration there are no overt signs that an individual has aspirated, and the individual themselves may not be aware that either solids or liquids have entered their airway or lungs (Terre & Mearin, 2009). At 3, 6, and 12 months, the number of patients who aspirated continuously declined, such that aspiration was present in only 6 of the 26 patients by the end of the first year (Terre & Mearin, 2009). For the majority of patients, the most significant changes were seen at the 3-month evaluation. Relating to assessment, O'Neil-Pirozzi et al. (2003b) studied 12 patients with tracheostomy who also had severely disordered consciousness and found that an MBS was successfully completed with all of them; consequently, these more severely impaired patients with TBI remain potential MBS candidates. In terms of potential treatment for aspiration, a study by Steele et al. (2013) found that patients had improvements on measures of tongue pressure and penetration aspiration after the completion of a 24-session tongue-pressure resistance training program. Increased tongue strength may therefore be seen as beneficial in improving swallowing and isometric tasks. Studies examining interventions for aspiration do exist in evidence-based literature, though no studies met our inclusion criteria. For those who do develop difficulty with swallowing post injury it is reassuring to note that the majority make good gains within the first year.

### 5.3.1 Risk Factors for Aspiration Post ABI

Aspiration should be suspected when the patient with an ABI has any of the following: a complaint of trouble swallowing, an abnormal chest x-ray, congested vocal quality, or a delay in voluntary initiation of the swallow reflex and coughing during or after swallowing (Horner & Massey, 1988). While all patients with ABI have the potential to aspirate, there are risk factors that place some patients at higher risk (Table 5.3). Initial severity of the brain injury appears to be the strongest predictor of dysphagia-related aspiration; therefore, the risk of dysphagia-related aspiration is proportional to the initial severity of head injury. Further, patients with severe ABI, neurogenic dysphagia and a tracheostomy are at a particularly high-risk of aspiration (Morgan & Mackay, 1999). The negative effects can be minimized by ensuring the use of appropriately sized tracheostomy tubes and by avoiding over-inflation of any cuff (Tolep et al., 1996).

**Table 5.3 Risk Factors for Aspiration Post ABI**

<ul style="list-style-type: none"> <li>• Lower Glasgow Coma Score (3-5) (Morgan &amp; Mackay, 1999)</li> <li>• Presence of a tracheostomy</li> <li>• Poor cognitive functioning</li> <li>• Hypoactive gag reflex</li> <li>• Prolonged period of mechanical ventilation (Morgan &amp; Mackay, 1999)</li> <li>• Reduced pharyngeal sensation</li> <li>• Brainstem involvement</li> <li>• Difficulty swallowing oral secretions</li> </ul>	<ul style="list-style-type: none"> <li>• Coughing/throat clearing or wet/gurgly voice quality after swallowing water</li> <li>• Choking more than once while drinking 50 ml of water</li> <li>• Weak voice and cough</li> <li>• Wet-hoarse voice quality</li> <li>• Recurrent lower respiratory infections</li> <li>• Low-grade fever or leukocytosis</li> <li>• Auscultatory evidence of lower lobe congestion</li> <li>• Immunocompromised state</li> </ul>
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### 5.3.2 Silent Aspiration

Silent aspiration is defined as *“penetration of food below the level of the true vocal cords, without cough or any outward sign of difficulty”* (Linden & Siebens, 1983). The incidence of silent aspiration among individuals with ABI has not been well documented; aspiration cannot always be diagnosed by a bedside examination, as patients may aspirate without outward signs. Detailed clinical swallowing assessments have been shown to underdiagnose or miss cases of aspiration (Horner & Massey, 1988; Splaingard et

al., 1988). Silent aspiration may be missed in the absence of a modified barium swallow study. Silent aspiration should be suspected in patients with ABI who have recurrent lower respiratory infections, chronic congestion, low-grade fever, or leukocytosis (Muller-Lissner et al., 1982). Clinical markers of silent aspiration may include a weak voice or cough, or a wet-hoarse vocal quality after swallowing. Patients who silently aspirates are considered to be at increased risk of developing more serious complications such as pneumonia, which is discussed in more detail in the next section.

Lazarus and Logemann (1987) identified aspiration in 38% of their ABI sample and found that many of these patients, despite aspirating, did not produce a reflexive cough and required prompting to clear aspirated material. In another study, approximately 33% of the subjects silently aspirated and issues with aspiration seemed to resolve within the 12 month duration of the study (Terre & Mearin, 2009).

### 5.3.3 Pneumonia and Aspiration Post ABI

Aspiration of small amounts of saliva occurs during sleep in almost half of healthy subjects (Finegold, 1991; Huxley et al., 1978). The presence of aspiration alone is not sufficient to cause pneumonia. Aspiration pneumonia is thought to occur when the lung's natural defenses are overwhelmed when excessive and/or toxic gastric contents are aspirated, leading to a localized infection or a chemical pneumonitis. Patients with reduced levels of consciousness, a tracheostomy, gastric reflux or emesis, nasogastric tubes (due to mechanical interference with the cardiac sphincter), or a compromised immune system are at increased risk for the development of aspiration pneumonia (Finegold, 1991). In individuals with severe TBI, Langmore et al. (1998) identified the following factors as predictors of pneumonia: dependence in self-feeding and oral-care, the amount of tooth decay, the need for tube feeding, greater than one medical diagnosis, smoking, and the total number of medications. In a study by Vejdani and Khosravi (2013), significantly fewer patients with head injury experienced nosocomial pneumonia when they received flexible bronchoscopy and bronchoalveolar lavage in combination with routine methods compared to routine clearance procedures alone (14% versus 34%,  $p=0.03$ ), demonstrating that it is possible to treat aspiration.

The clinical criteria used to define aspiration pneumonia varies between studies, impacting the reported incidence. Due to the absence of ABI specific studies, the criteria used within the stroke literature has been provided in Table 5.4.

**Table 5.4 Criteria for Defining Aspiration Pneumonia in Stroke**

Author/ Year Country	Criteria
<a href="#">Dziewas et al.</a> (2008) Germany No Score	Pneumonia was diagnosed on the basis of 3 of the following indicators: temp $>38^{\circ}\text{C}$ , productive cough with purulent sputum, abnormal respiratory exam including tachypnea, ( $>22$ breaths/min), tachycardia, inspiratory crackles, bronchial breathing, abnormal chest x-ray, arterial hypoxemia ( $\text{PO}_2 < 9.3$ kPa) and a positive gram stain.
<a href="#">Carnaby et al.</a> (2006) USA; <a href="#">Dziewas et al.</a> (2004) Germany	Three of the following indicators: temp $>38^{\circ}\text{C}$ , productive cough with purulent sputum, abnormal respiratory exam including tachypnea, ( $>22$ breaths/min), tachycardia, inspiratory crackles, bronchial breathing, abnormal chest x-ray, arterial hypoxemia ( $\text{PO}_2 < 9.3$ kPa) and positive chest radiography.
<a href="#">Teasell et al.</a> (1996) Canada	Radiological evidence of consolidation, and at least one other clinical feature including granulocytosis, temp $>38^{\circ}\text{C}$ and/or shortness of breath.
<a href="#">Smithard et al.</a> (1996) UK	Presence of at least two of the following: tachypnea ( $>22/\text{min}$ ), tachycardia, aspiratory crackles, bronchial breathing or antibiotic usage.
<a href="#">Kidd et al.</a> (1995) UK	Production of sputum in conjunction with the development of crackles on auscultation, with or without the presence of fever or leucocytosis.

Author/ Year Country	Criteria
<a href="#">Dziewas et al.</a> (2008) Germany No Score	Pneumonia was diagnosed on the basis of 3 of the following indicators: temp >38°C, productive cough with purulent sputum, abnormal respiratory exam including tachypnea, (>22 breaths/min), tachycardia, inspiratory crackles, bronchial breathing, abnormal chest x-ray, arterial hypoxemia (PO <sub>2</sub> <9.3 kPa) and a positive gram stain.
<a href="#">DePippo et al.</a> (1994); <a href="#">Holas et al.</a> (1994) USA	A positive chest x-ray or the presence of at least three of the following: temp >100 °F, drop in PO <sub>2</sub> >10 torr, presence of WBC in sputum and/or positive sputum culture for pathogen.
<a href="#">Johnson et al.</a> (1993) USA	Segmental consolidation or infiltrate on chest x-ray or clinical diagnosis which included an episode of respiratory difficulty with segmental moist rales on auscultation and two other symptoms including temp >100 °F, WBC >10,000 or hypoxia.

Within the TBI population, there are significant gaps in the literature in this area, thus we rely on data from stroke populations to infer an understanding of the relationship between dysphagia, aspiration and aspiration pneumonia. In stroke, an association between pneumonia and dysphagia/aspiration has been reasonably well-established, in that the presence of dysphagia and aspiration has been associated with an increased risk of pneumonia (Dziewas et al., 2004).

Hansen et al. (2008) explored the risk factors associated with pneumonia in patients with severe TBI. The study found that pneumonia was more common among individuals with low levels of consciousness and for those with a feeding or tracheotomy tube, similar to patterns seen in stroke. Glasgow Coma Scale (GCS) scores and Rancho Los Amigos scale scores were also associated with elevated risk of pneumonia, with individuals who had lower GCS scores, as well as individuals with lower Rancho Los Amigo Scale scores, being at high risk. These two scales, along with the Functional Oral Intake Scale (FOIS) and Functional Independence Measure (FIM) scores were found to be predictive of return to an unrestricted diet (Hansen et al., 2008). Further, Hui et al. (2013) found that patients were more likely to develop pneumonia if they were older, on ventilation for a longer period of time, suffered blunt trauma, and/or had suffered a severe TBI.

#### 5.4 Assessment of Dysphagia and Aspiration Post ABI Using Stroke Models of Care

Following a head injury, a thorough assessment of swallowing is often required. Assessments may include a bedside clinical evaluation and/or a radiological procedure such as the MBS/VFSS or a fiberoptic endoscopic examination of swallowing (FEES) most often completed by a Speech-Language Pathologist. Assessments should be completed throughout admission to a rehabilitation program. Established deficits or any risk factors for swallowing difficulties must be taken into account when making dietary decisions. Once again, there are limited studies discussing assessment of dysphagia post ABI so stroke models of care will be highlighted instead.

To be clinically useful, screening tests need to be valid, reliable, easy to use, non-invasive, quick to administer (15-20 min), and pose little risk to the patient. Although many screening tools have been developed it is unclear how many of them are used in institutions beyond those where they were initially developed. Many institutions use informal processes, or simply restrict all food and drink intake until an assessment has been completed by a Speech-Language Pathologist (SLP).

Although ERABI focuses primarily on interventional studies, information pertaining to assessment tools used in dysphagia practice have been included within this section to increase its clinical relevance. Although many of these tools are used in practice with ABI populations, none have been studied extensively within this population.

### 5.4.1 The Bedside Clinical Examination

Several forms of clinical or bedside swallowing evaluations (BSE) have been described for the purposes of screening and/or assessment. Some of these methods target specific functions or tasks, while others evaluate swallowing ability using a more comprehensive approach (Table 5.5). The clinical BSE typically involves general observations, an oral motor examination, a review of receptive and expressive language and ability to understand directions, and a review of current medications (Halper et al., 1999). The protocol may or may not include a water-swallowing test (WST), and in some cases various consistencies of food and liquids. While the BSE is non-invasive and easy to perform, this method has been shown to poorly predict the presence of silent aspiration. Moreover, aspiration cannot be distinguished from laryngeal penetration using a bedside evaluation, resulting in the over diagnosis of observed aspiration and, in some cases, needless dietary restrictions (Smith et al., 2000).

The BSE is typically completed by a SLP or a professional trained in dysphagia. This examination is generally completed once the patient's history has been reviewed by the clinician (Logemann, 1989). Clinicians are expected to make several observations: status of lip closure; oral versus nasal breathing; level of secretions; patient's awareness of secretions; patient's awareness of clinician's approach; and the nature of content of initial verbalization by the patient (Logemann, 1989).

**Table 5.5 Aspects Included in Various Bedside Screening/Assessment Tools for Dysphagia**

Author/Year	Components of Selected Dysphagia Screening/Assessment Tools	
<a href="#">Westergren et al.</a> , (2001) (Screening for eating difficulties)	<ul style="list-style-type: none"> <li>• Ingestion: sitting position, manipulation of food on plate, transport of food to mouth</li> </ul>	<ul style="list-style-type: none"> <li>• Deglutition: opening or closing of mouth, manipulating food in the mouth</li> </ul>
<a href="#">Perry</a> (2001) (Screening)	<ul style="list-style-type: none"> <li>• Conscious level</li> <li>• Trunk control while seated</li> <li>• Volitional cough present</li> <li>• Control of saliva</li> </ul>	<ul style="list-style-type: none"> <li>• Tongue control</li> <li>• Ease of breathing</li> <li>• Voice quality</li> <li>• Includes water-swallowing test</li> </ul>
<a href="#">Mann et al.</a> , (2000) (Assessment)	<ul style="list-style-type: none"> <li>• General examination: Consciousness, cooperation, language function, verbal/oral praxis, articulation</li> <li>• Oral preparation: Control of saliva, lip seal, tongue movement/strength, oral preparation, assessment of respiration</li> </ul>	<ul style="list-style-type: none"> <li>• Oral phase: Gag reflex, palatal movement, oral transit time, bolus clearance, water swallowing test</li> <li>• Pharyngeal phase: Pharyngeal control/pooling, laryngeal elevation, reflex/voluntary cough, voice quality</li> </ul>
<a href="#">Daniels et al.</a> (1997) (Screening)	<ul style="list-style-type: none"> <li>• Assessment of mandible, lips, tongue, velum</li> <li>• Gag Reflex</li> <li>• Cough or voice change with swallow</li> <li>• Facial numbness/tingling</li> </ul>	<ul style="list-style-type: none"> <li>• Dysphonia</li> <li>• Dysarthria</li> <li>• Volitional cough</li> <li>• Includes water-swallowing test</li> </ul>
<a href="#">Smithard et al.</a> , (1996) (Screening)	<ul style="list-style-type: none"> <li>• Conscious level</li> <li>• Head and trunk control</li> <li>• Breathing pattern</li> <li>• Lip closure</li> <li>• Palate movement</li> </ul>	<ul style="list-style-type: none"> <li>• Laryngeal function</li> <li>• Gag</li> <li>• Voluntary cough</li> <li>• Includes water-swallow test</li> </ul>
<a href="#">DePippo et al.</a> , (1992) (The Burke Dysphagia Screening test)	<ul style="list-style-type: none"> <li>• Bilateral/brainstem stroke</li> <li>• History of pneumonia</li> <li>• Cough with feeding/3 oz. water</li> </ul>	<ul style="list-style-type: none"> <li>• Failure to finish ½ of meals</li> <li>• Prolonged time required for feeding</li> <li>• Presently fed non-orally</li> </ul>

### 5.4.2 Water Swallowing Test

The WST originally required a patient to swallow 3oz (90ml) of water; however, smaller amounts have also been used. Although the WST has not been studied in ABI individuals, it warrants inclusion given its



persistent use by health providers (especially non-SLPs) at the bedside. This sensitivity and specificity of this test has been studied extensively within the stroke population.

Stroke populations are used to illustrate the benefit of these screening tools, as research and supporting evidence specific to the TBI population is lacking. The results of a systematic review by Martino et al. (2000) evaluating the accuracy of 49 individual clinical screening tests for oropharyngeal dysphagia suggested that there was only sufficient evidence to support the value of two tests: abnormal pharyngeal sensation and the 50 mL WST. Both of these tests assessed only for the presence or absence of aspiration. Their associated likelihood ratios were 5.7 (95% CI 2.5-12.9) and 2.5 (95% CI 1.7-3.7), respectively. Evidence suggests that the number of aspirations observed increases as the amount of liquid increases (Osawa et al., 2013). 2013), although interestingly an increase in liquid volume did not increase the specificity of the VFSS. Daniels et al. (2012) reviewed the sensitivity, specificity, and positive likelihood ratio of items on 17 screening tools designed to detect aspiration. Items with high sensitivity (>80%) included weak palatal movement, cough on a 50 mL and repeated 5 mL WST, dysarthria, abnormal volitional cough, abnormal voice, and abnormal pharyngeal sensation. Only 1 item (impaired pharyngeal response) was associated with a likelihood ratio greater than 10, the clinically relevant threshold. According to Nishiwaki et al. (2005), cough/voice change in the WST was the only variable that was significantly associated with aspiration on videofluoroscopic modified barium swallow (VMBS) examination, with a sensitivity of 72% and a specificity of 67%.

#### 5.4.3 Videofluoroscopic Modified Barium Swallow Studies

When aspiration is suspected, the VMBS study is considered by some to be the “gold standard” in confirming the diagnosis (Splaingard et al., 1988). A VMBS study examines the oral and pharyngeal phases of swallowing; however, the patient must have sufficient cognitive and physical skills to undergo testing (Bach et al., 1989). The subject is placed in the sitting position in a chair designed to simulate the ideal/optimal mealtime posture. Radio-opaque materials of various consistencies are tested: barium impregnated thin and thick liquids, pudding, bread, and cookies are routinely used. Various aspects of oral, laryngeal, and pharyngeal involvement are noted during the radiographic examination (Table 5.6). In some, but not all cases, it may be appropriate to follow the VMBS study with a chest x-ray to document any barium, which may have been aspirated into the tracheobronchial tree. If a VMBS study is indicated and the result is positive, a second VMBS study may be appropriate in 1 to 3 months, if swallowing concerns persist.

Those patients who aspirate over 10% of the test bolus or who have severe oral and/or pharyngeal motility problems on VMBS testing are considered at high risk for pneumonia (Logemann, 1983; Milazzo et al., 1989). In many cases, it is difficult to practically assess whether 10% or more of the test bolus has been aspirated, particularly since images are seen two dimensionally. Nevertheless, the degree of aspiration seen on VMBS study is a critical determinant of patient management. Predicting whether a patient will develop pneumonia post aspiration is, to some extent, dependent on other factors such as the immune state or general health of the patient with ABI.

The VMBS assessment not only establishes the presence and extent of aspiration but may also reveal the mechanism of the swallowing disorder. Aspiration most often results from a functional disturbance in the pharyngeal phase of swallowing related to reduced laryngeal closure or pharyngeal paresis. A VMBS study is recommended in those cases where the patient is experiencing obvious problems maintaining adequate hydration/nutrition, where concern is expressed regarding frequent choking while



eating, or in the case of recurrent respiratory infections. Other factors such as cognition, depression, underlying lung disease, and being immunocompromised must also be considered.

**Table 5.6 Radiological Evaluation during VMBS (Bach et al., 1989)**

<b>Oral Phase</b>	Lips	Closure
	Tongue	Anterior and posterior motion with consonants; motion and coordination during transport, and manipulation of the bolus
	Soft Palate	Evaluation and retraction with consonants
	Jaw	Motion
	Oral	Pocketing
<b>Pharyngeal Phase</b>	Swallow	Delay, absence
	Peristalsis or pharyngeal stripping	Residue in valleculae, pyriform sinuses, nasopharyngeal regurgitation
<b>Laryngeal Phase</b>	Elevation of larynx	
	Penetration into laryngeal vestibule	
	Aspiration	
	Cough	Presence, delay, effectiveness/productiveness
	Vocal cord function	
<b>Post Exam Chest X-Ray</b>	Chronic Stages	
	Presence of barium in valleculae, pyriform sinuses, tracheobronchial tree, lungs	

#### 5.4.4 Fiberoptic Endoscopic Evaluation of Swallowing

Although VMBS (or MBS) studies are considered by some to be the gold standard for detection of aspiration, other clinical assessment techniques are currently used as they are designed to be less invasive, more cost effective, more easily accessed or easier to administer.

Flexible endoscopic evaluation of swallowing (FEES), is recognized as an objective tool for the assessment of swallowing function and aspiration. FEES is a procedure that allows direct viewing of swallowing function by passing a very thin flexible fiberoptic tube through the nose to obtain a view directly down the throat during swallowing. FEES allows for the full evaluation of the swallow function as food passes from the mouth into the throat. The evaluation identifies functional abnormalities and helps to determine the safest position and food texture for the patient in order to maximize nutritional status and eliminate the risk of aspiration and unsafe swallowing.

In addition to assessing the motor components of swallowing, FEES can also include a sensory testing assessment when an air pulse is delivered to the mucosa innervated by the superior laryngeal nerve. This form of assessment is known as flexible endoscopic examination of swallowing with sensory testing.

As a result of the multiple benefits of FEES (reliability, safety, ease of administration, low cost, and lack of exposure to radiation), this tool has gained much support for the detection of dysphagia, particularly in acute stroke (Bax et al., 2014). FEES in combination with a cough reflex test and clinical swallowing evaluation may focus the criteria for the induction of candidates for FEES to make this service more efficient and productive. The selection of patients for referral to instrumental assessment may be improved by the use of these assessments in conjunction since they provide stronger evidence for the presence of dysphagia and subsequent complications among those who fail the cough reflex test (Bax et al., 2014). Furthermore, conflicting evidence from other studies suggests that an increase in the length of hospital stay is associated with increased rates of pneumonia (Finlayson et al., 2011; Wilson & Howe, 2012). However, significant results suggesting the opposite are true in the study by Bax et al. (2014). The authors explain that this relationship may be due to the provision of FEES leading to a higher referral rate to swallowing rehabilitation and a subsequent increase in length of stay. In support of this

conclusion, there was an increase in the proportion of patients leaving the hospital on normal diets. Overall, the use of FEES, especially in combination with cough reflex testing, seems to ultimately benefit patient health outcomes.

A good quality randomized controlled trial (RCT) assessed the use of Facial-Oral Tract Therapy (FOTT) versus FEES as a standard assessment indicating the opportunity for initiation of oral feeding (Kjaersgaard et al., 2014). After excluding patients who developed pneumonia outside of the primary study criteria, there was no difference in the incidence of this respiratory infection between the two groups (3/62 FOTT patients; 4 of 57 FEES patients). These results were supported in a study by Barquist et al. (2001) who found that the risk of pneumonia was not significantly different between 70 patients screened with either FEES or clinical assessment within 48 hours of endotracheal intubation. It seems that FEES, when combined, may be beneficial to some clinical non-instrumental assessments such as FOTT in reducing the risk of aspiration pneumonia after starting oral feeding.

Aviv (2000) compared the incidence of pneumonia over a one-year period between patients screened by MBS or FEES for dysphagia and aspiration with sensory testing and treated based on their respective outcomes. Among the stroke patients, the incidence of pneumonia for those assessed by FEES with sensory testing was significantly lower compared to those assessed with MBS. The authors speculated that one of the reasons for the lower incidence might be due to the sensory testing component of the FEES examination, absent from the MBS evaluation, which was used to more effectively guide management.

Rather than attempt to compare the accuracy of swallowing abnormalities assessed between VMBS and FEES evaluations, Leder and Espinosa (2002) compared the ability of six clinical identifiers of aspiration (dysphonia, dysarthria, abnormal gag reflex, abnormal volitional cough, cough after swallow, and voice change after swallow) with FEES assessment to determine the accuracy of predicting aspiration risk following stroke. Their results suggest that the ability of the test to correctly identify patients not at risk of aspiration was poor using clinical criteria (low specificity). However, two studies conclude that FEES is the gold standard to assess the accuracy of either the WST and/or pulse oximetry to detect aspiration within the stroke population (Chong et al., 2003; Lim et al., 2001).

#### 5.4.5 Pulse Oximetry

Pulse oximetry has also been suggested as an additional method of detecting aspiration, based on the principle that aspiration of food into the airway leads to bronchospasm or airway obstruction, which leads to a reduction in oxygen saturation. This technique is non-invasive, requires little patient cooperation and is easy to obtain; however, its accuracy in detecting aspiration is unproven and it remains uncertain whether oxygen desaturation can predict aspiration. Wang et al. (2005) reported no significant association between the reduction in oxygen saturation and aspiration, identified simultaneously by VMBS, among 60 patients with dysphagia due to stroke and nasopharyngeal cancer, while Collins and Bakheit (1997) reported that pulse oximetry could be used to detect a high proportion of stroke patients who aspirated on the VMBS study.

Although pulse oximetry is a quick and non-invasive method to detect aspiration following stroke, its association with oxygen desaturation has been inconclusive. Generally, its performance when measured against VMBS studies has been poor due to its low sensitivity and specificity (39%-87%) (Collins & Bakheit, 1997; Smith et al., 2000; Wang et al., 2005). Therefore, it is unclear whether it is a clinically viable tool for the detection of dysphagia and aspiration.

#### 5.4.6 Blue Dye Assessment for Swallowing

The blue dye assessment for swallowing has been used since the early 1970's with patients who have a tracheostomy; however, the accuracy of the test has been questioned since the 1980's (O'Neil-Pirozzi et al., 2003a). For patients with a tracheostomy, this assessment involves placing blue dye on the tongue or, in the case of the modified blue dye test, mixing it with water or semisolid food. If blue dye appears in or around the tracheostomy tube, or at defined intervals during suctioning, then the patient has possibly aspirated. This test tends to be relatively easy to administer, inexpensive and can be performed at a patient's bedside. Unfortunately, research has shown that the test may have a 50% false-negative error rate in the detection of aspirated material (Belafsky et al., 2003; Brady et al., 1999; Donzelli et al., 2001). There is conflicting evidence regarding both the sensitivity and specificity of the blue dye assessment in specific population groups as well. Belafsky et al. (2003), in a study of 30 patients with tracheostomies, concluded that the use of the modified Evans blue dye test (MEBD) is beneficial specifically in patient populations who have a tracheostomy tube (82% sensitivity) and in particular those who receive mechanical ventilation (100% sensitivity). O'Neil-Pirozzi et al. (2003b) found that the blue dye test was unable to correctly identify aspiration in 20% of the study's tracheostomy patients and 38% of tracheostomy patients who were not aspirating. Brady et al. (1999), in a study looking at the effectiveness of the MEBD test and the VMBS, found that the MEBD test was not able to detect "trace amounts" of aspiration in patients who had a tracheostomy. On the other hand, if patients aspirated more than "trace amounts", then the MEBD was able to detect it. Brady et al. (1999) recommended that the MEBD be followed by a VMBS to rule out the possibility of trace aspiration. Although this test is used in practice with individuals post ABI, no studies were found looking at its effectiveness within that specific population; therefore, individuals who are assessed for aspiration or dysphagia using the MEBD test should be followed up with a more established test with greater sensitivity and specificity.

#### 5.4.7 Other Methods of Assessing Dysphagia and Aspiration

In addition to conventional assessment methods, tracheal pH monitoring has been used experimentally to detect drops in pH, which may indicate aspiration. Clayton et al. (2006) reported that in 9 of 32 patients examined, there was a drop in tracheal pH following ingestion of acidic foods. Tracheal pH was monitored by the use of a sensor, which was inserted into the trachea by the cricothyroid membrane. All patients were studied following the ingestion of foods which had been considered to be safe on the basis of a VMBS examination.

Another assessment tool is voice analysis. Ryu et al. (2004) evaluated voice analysis as a means to clinically predict laryngeal penetration among 93 patients (46% of whom had suffered a stroke) using VMBS to confirm aspiration. Of five voice parameters tested (average fundamental frequency, relative average perturbation, shimmer percentage, noise-to-harmonic ratio, and voice turbulence index), relative average perturbation most accurately predicted aspiration.

Cervical auscultation, another tool to assess aspiration, is generally conducted using a stethoscope or some other listening device (Borr et al., 2007; Leslie et al., 2007; Youmans & Stierwalt, 2005). It is believed that this type of test can provide additional information on the pharyngeal swallow in all patients without any additional costs or by using any intrusive methods (Borr et al., 2007; Youmans & Stierwalt, 2005). Cervical auscultation was compared to the VMBS in patients being treated for dysphagia (Zenner et al., 1995). Although agreement was found between the two tests on the oral phase, pharyngeal phase, and diet management components, the VMBS did appear to be slightly more sensitive in identifying patients who had aspirated. In another study, Stroud et al. (2002) found that raters were able to identify patients who were aspirating quite easily but challenges arose when

evaluating patients who were not aspirating resulting in a significant number of false positives. Due to the limited evidence for cervical auscultation, caution should be taken when using this technique (Leslie et al., 2007).

### 5.5 Treatment of Dysphagia Post ABI

The careful management of dysphagia is essential for the successful rehabilitation of acute brain injury patients (Hoppers & Holm, 1999). For patients with dysphagia following head injury, based on the status of swallowing function at the time of admission, three distinct types of rehabilitation programs have been described: 1) non-feeding, 2) facilitation and feeding, and 3) progressive feeding (Winstein, 1983). The goal of dysphagia treatment is always to have an individual become independent in their feeding skills as individuals with dysphagia who are fed by someone else have a 20 times greater risk of pneumonia than those patients who are able to feed themselves (Langmore et al., 1998).

The non-feeding program was designed as a stimulation program for very low-level patients, in order to prepare them for later feeding and includes desensitization techniques (e.g., stroking, applying pressure, or stretching) to facilitate normal swallowing, sucking, and intraoral responses (Winstein, 1983). The facilitation and feeding program uses small amounts of puree consistency food to assist normal feeding patterns (Winstein, 1983). Finally, the progressive feeding program uses specialized techniques to help the patient develop swallowing endurance by systematically increasing the amount of oral intake. This progressive feeding program continues until the patient can consume a complete meal within thirty minutes without difficulties (Winstein, 1983).

For patients who are safe with some form of oral intake, therapeutic strategies utilized in dysphagia management can be divided into two categories: (a) compensatory treatment techniques and (b) therapy techniques (Logemann, 1999). Compensatory treatment techniques do not involve direct treatment of the swallowing disorder; rather they reduce or eliminate the symptoms of dysphagia and risk of aspiration by altering how swallowing occurs (Logemann, 1991, 1999). The types of compensatory strategies include: (a) postural adjustment of the head, neck, and body to modify the dimensions of the pharynx and improve the flow of the bolus; (b) sensory stimulation techniques used to improve sensory input either prior to or during the swallow; (c) food consistency and viscosity alterations; (d) modifying the volume and rate of food/fluid presentation; (e) use of intraoral prosthetics (Logemann, 1999). Conversely, therapy techniques are designed to alter the swallow physiology (Logemann, 1999). They include range-of-motion and bolus handling tasks to improve neuromuscular control without actually swallowing. They also include swallowing maneuvers that target specific aspects of the pharyngeal stage of the swallow. Medical and surgical management techniques are included in this category (Logemann, 1999), with these interventions typically only introduced once trials with more traditional behavioural treatment techniques have proven to be unsuccessful.

Several interventions have been investigated for the treatment of dysphagia. Included among these are vocal fold adduction exercises, range of motion exercises for the lips, tongue, and jaw, and chewing exercises (Logemann, 1993). Many of these exercises, although tested within stroke or other populations, have not been tested specifically within the ABI population. As there is a need for more clinical data supporting dysphagia treatments within an ABI population, this section will focus on research based on both ABI populations that did not meeting inclusion criteria, as well as stroke patient data and will discuss the literature supporting dysphagia management in a stroke population.

### 5.5.1 Stroke Best Practice Guidelines for Managing Dysphagia

The Canadian Stroke Best Practice Recommendations have outlined guidelines for the assessment and management of dysphagia post stroke. A well-coordinated care plan has many benefits, such as reducing the length of acute care hospital stay, minimizing the development of dysphagia complications, and more timely access to rehabilitation (Heart and Stoke Foundation of Ontario, 2002). Ultimately, dysphagia management has the following goals: (1) meet the nutrition and hydration requirements of the patient; (2) prevent aspiration-related complications; and (3) maintain and promote swallowing function as much as possible (Heart and Stoke Foundation of Ontario, 2002). Similar guidelines have not been developed yet for ABI; however, the general principles outlined in the stroke guidelines are applicable to this population. Screening protocols for stroke patients with a risk of dysphagia can be found below (Table 5.7). Additionally, low-risk feeding strategies are outlined in Table 5.8.

**Table 5.7 Best Practice Guidelines for the Assessment and Management of Dysphagia Post Stroke (2016).**

i.	Patients should be screened for swallowing deficits as soon as they are alert and ready for trialing oral intake (e.g. medications, food, liquid) using a valid screening tool by an appropriately trained professional [Evidence Level B]. <i>Refer to Appendix Table 3: Canadian Stroke Best Practices Swallow Screening and Assessment Tools for more information.</i>
ii.	Abnormal results from the initial or ongoing swallowing screens should prompt a referral to a professional experienced in dysphagia assessment, treatment and management, ideally a Speech-Language Pathologist, for more detailed bedside swallowing assessment and management of swallowing [Evidence Level B]. <ol style="list-style-type: none"> <li>If a Speech-Language Pathologist is not available, then referral should be made to an occupational therapist, dietitian, or other trained dysphagia clinician [Evidence Level C].</li> <li>An individualized management plan should be developed to address therapy for dysphagia, dietary needs, and specialized nutrition plans [Evidence Level B].</li> </ol>

**Table 5.8 Low Risk Feeding Strategies in Stroke Patients with Dysphagia**

<ul style="list-style-type: none"> <li>Ability of feeder to deal with emergencies, such as choking.</li> <li>Calm eating environment with a minimum of distractions.</li> <li>Patient properly position – upright, midline with neck slightly flexed.</li> <li>Proper oral care.</li> <li>Feed at eye-level.</li> <li>Metal teaspoons (no tablespoons or plastic).</li> <li>Feed slowly.</li> </ul>	<ul style="list-style-type: none"> <li>Drink from wide-mouth cup or a straw to reduce neck extension.</li> <li>Ensure swallowing is complete before offering additional items thorough meals.</li> <li>Properly position and monitor for swallowing problems for at least 30 minutes after each meal.</li> <li>Carefully monitor patient's oral intake.</li> </ul>
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### 5.5.2 Oral Motor Exercises

Exercises introduced with those who have developed a swallowing disorder include various oral motor exercises, such as range of motion exercises for the tongue and the pharyngeal structures (Logemann, 1998). These exercises are designed to improve strength, movement, awareness, and muscle coordination when swallowing (Kramer et al., 2007). To aid in the improvement of oral transit, exercises to assist in tongue elevation and lateralization may be implemented. Here the patient may be asked to perform very specific tongue exercises in an effort to improve speech and swallowing (Logemann, 1998). Individuals may also be asked to participate in tongue resistance exercises (pushing the tongue against a tongue blade or popsicle stick for 1 second) and bolus control exercises (to allow the patient to learn to control or manipulate items placed in the mouth) (Logemann, 1998).

#### 5.5.2.1 Range of Motion Exercises for the Pharyngeal Structures: Airway Entrance

When participating in range of motion exercises, the individual is asked to bear down while holding his or her breath from a seated position. This exercise is not recommended for those with uncontrolled

blood pressure (Logemann, 1998). It is recommended that this exercise be done 5 to 10 times each day for 5 minutes.

### **5.5.2.2 Vocal Fold Adduction Exercises**

Vocal fold adduction exercises aim to improve vocal quality and reduce the risk of aspiration. Individuals are asked to bear down, with one hand against a chair while producing a clear voice. This is done five times. The individual is then asked to repeat an “ah” sound five times. Again, it is recommended that these exercises be repeated three times in sequence, 5 to 10 times each day for five minutes. If there is no significant improvement in swallowing at the end of one week, individuals may be asked to pull up on the seat of a chair, while sitting in it, and prolong phonation (Logemann, 1998). This exercise is recommended for those individuals whose vocal folds fail to close completely (Kramer et al., 2007).

### **5.5.3 Strengthening Exercises**

Exercises which strengthen the muscles in the throat and neck may improve swallowing function. However, patients need to be able to physically complete the required motions without injury in order to use this treatment method (Kraaijenga et al., 2015).

#### **5.5.3.1 The Shaker Exercise**

For the Shaker exercise, patients are asked to lay flat on the floor or in bed and raise their heads high enough to see their toes. This position is held for one minute, and then the patient rests for one minute. The exercise is repeated three times. Following this sequence, the patient lifts their head, looks at their toes, and then lowers their head. This head up then down sequence is repeated 30 times. It is recommended that the Shaker exercise be completed three times per day for a period of six weeks. This exercise has been shown to have some success in improving hyolaryngeal movement (Logemann, 1998; Shaker et al., 2002; Shaker et al., 1997); however, it has not been studied specifically in the ABI population.

#### **5.5.3.2 Chin Tuck Against Resistance**

An alternative exercise to strengthen suprahyoid muscles is the chin tuck against resistance (CTAR) exercise. This involves two steps for participants: 1) squeezing a rubber ball by tucking the chin in for 10s (isometric) and 2) squeezing a rubber ball with the chin as hard as possible 10 consecutive times (isokinetic) (Yoon et al., 2014). A preliminary study using healthy subjects evaluating the potential use of the CTAR in populations with dysphasia concluded that this method resulted in greater maximum surface electromyography when compared to the Shaker exercise (Yoon et al., 2014). However, in order to determine the effectiveness of exercising suprahyoid muscles for dysphagia the authors stated that clinical trials are needed (Sze et al., 2016; Yoon et al., 2014).

### **5.5.4 Swallow Maneuvers**

During the acute stage of recovery, patients may experience more swallowing difficulties than they do during later rehabilitation. Failing to address and treat swallowing difficulties in the early stages may lead to compliance issues with the recommended diets, and possible setbacks secondary to aspiration pneumonia. Overall, this can hinder the patient’s ability to participate in formal rehabilitation. Post-ABI swallowing difficulties are often the result of eating too quickly, taking large bites, cognitive impairments, and decreased swallowing sensitivity (Logemann, 1998). Swallowing difficulties can be addressed through four maneuvers but they require the patient to follow directions, be alert, and be able to exert the physical effort it takes to perform the maneuvers correctly (Kramer et al., 2007).



#### 5.5.4.1 Supraglottic Swallow

This maneuver is meant to close the airway at the level of the true vocal folds before and during the swallow, as well as clear residue afterwards (Logemann, 1998; Logemann et al., 1997). Individuals are asked to hold their breath while swallowing and then to cough immediately after the swallow. This maneuver encourages closure of the true vocal cords in an effort to address reduced or delayed vocal fold closure or delayed pharyngeal swallow. The cough portion of this maneuver is meant to eject any objects or residue within the laryngeal vestibule.

#### 5.5.4.2 Super-supraglottic Swallow

This procedure targets closure of the entrance to the airway both before and during the swallow, increases pressure generation, and aims to clear residue afterward the swallow is complete (Logemann, 1998). During this maneuver the patient completes the following sequence: 1) take a deep breath; 2) hold the breath while bearing down hard; 3) swallow hard while holding this breath; 4) cough immediately after the swallow and clear throat; 5) swallow again (Logemann et al., 1997).

#### 5.5.4.3 Effortful Swallow

Effortful swallow is meant to increase posterior movement of the tongue base (Kramer et al., 2007). This technique involves asking the individual, as they swallow, to squeeze hard with all the muscles they use for swallowing (throat and neck muscles).

#### 5.5.4.4 Mendelsohn Maneuver

The objective of this maneuver is to address decreased laryngeal movement and discoordination of the swallow. Improvements in swallowing function are achieved through increasing the extent and duration of laryngeal elevation which increases the duration and width of the cricopharyngeal opening (Logemann, 1998). Typically, patients are asked to swallow, but as they do so, to hold their larynx (i.e. Adam's apple) elevated for two to three seconds prior to completing the swallow.

#### 5.5.5 Thermal-tactile Stimulation

Thermal stimulation or thermal-tactile stimulation was developed to stimulate the swallowing reflex in patients who have neurological impairment (Lazzara et al., 1986). The procedure for thermal-tactile stimulation involves having the patient open their mouth and applying a cold laryngeal mirror to the base of the faucial arches. The mirror, while being in contact with the arch, is rubbed up and down five times. For those patients who have sustained a trauma, contact will be made on the normal (non-injured) side of the mouth (Logemann, 1998). Pharyngeal swallow may not be triggered at the time of stimulation, but the purpose is to heighten the sensitivity for swallowing via the central nervous system. It is hoped that once a patient attempts to swallow, the pharyngeal swallow will be triggered more quickly (Logemann, 1998).

The use of a chilled laryngeal mirror applied to the anterior faucial pillars (three strokes per side) before swallowing was compared to 10 consecutive swallows of semi-solid boluses in 22 patients with dysphagia post stroke (Rosenbek et al., 1996). Following the stimulation, patients were asked to swallow a bolus. Results indicated that the duration of stage transition and total swallow duration was reduced following thermal stimulation (Rosenbek et al., 1996). This method requires further research before conclusions on its efficacy in post-ABI populations may be made.

### 5.5.6 Postural Techniques

Physically moving the patient in order to change the position of the head, neck, and/or body may assist in changing the direction of the bolus flow, thereby improving pharyngeal clearance and/or reducing the risk of aspiration. Five postures that have been shown to have some success in assisting individuals improve their swallowing function (Table 5.9) (Logemann, 2008).

For individuals who have significant cognitive deficits post injury, having the patient engage in any one of these techniques may be challenging. It has been suggested that patients with oral and pharyngeal deficits consistently do the following: remain upright for 30 minutes post meal to reduce the risk of aspiration, take controlled bites/sips, alternate solids and liquids, take multiple swallows, and clear or remove food that has pocketed in the mouth (Kramer et al., 2007).

**Table 5.9 Five Postures to Improve Swallowing Function (Logemann, 2008)**

1. Chin Down Posture	<ul style="list-style-type: none"> <li>• Helpful for those who have tongue base retraction issues;</li> <li>• Mechanism of change widens the valleculae, allowing the valleculae to contain the bolus in event of pharyngeal delay.</li> </ul>
2. Chin Up Posture	<ul style="list-style-type: none"> <li>• Helpful for those who have oral tongue propulsion problems;</li> <li>• Aids in gaining adequate lingual pressure to drive the food or liquid out of the mouth and into the pharynx.</li> </ul>
3. Head Turn (left or right)	<ul style="list-style-type: none"> <li>• Involves rotating the head to the side that is damaged;</li> <li>• Bolus is then directed through the “normal” safe side.</li> </ul>
4. Head Tilt (left or right)	<ul style="list-style-type: none"> <li>• Head is tilted toward the stronger side, to promote the flow of food and liquid through that side.</li> </ul>
5. Lying Down	<ul style="list-style-type: none"> <li>• Effective in those with posterior pharyngeal wall contraction or reduced laryngeal elevation with resulting residue and subsequent aspiration after swallowing.</li> <li>• Residual or pooling of food or liquid in the pharynx is less able to enter the airway as gravity pulls the bolus towards the posterior pharyngeal wall and is more easily moved through to the esophagus (Drake et al., 1997; Rasley et al., 1993).</li> </ul>

### 5.5.7 Diet Modification

Modification in consistency and viscosity of foods and liquids is common practice in the management and treatment of dysphagia. Unfortunately, standardization of these diets as well as the language used to describe them has been challenged. Although an attempt has been made to standardize dysphagic diets (McCallum, 2003), there continues to be significant variation in their use in clinical practice, and in how these diets are labelled. The following tables illustrate two examples of diets for dysphagia (Table 5.10; Table 5.11).

#### International Dysphagia Diet Standardization Initiative (IDDSI)

In 2013 an IDDSI committee was formed from a volunteer group of individuals in nutrition & dietetics, medicine, speech pathology, occupational therapy, nursing, patient safety, engineering, food science & technology. The goal was to develop standardization in terminology used in describing dysphagia diets for individuals across age, care settings and cultures, internationally. The work by this committee resulted in the creation of what is now known as the International Dysphagia Diet Framework (Initiative, 2018).

Research efforts by Steele et al. 2018 to evaluate the International Dysphagia Diet Standardisation Initiative Functional Diet Scale showed strong consensual validity, criterion validity, and interrater reliability (Steele et al., 2018). In their study, 176 respondents from 29 countries completed a web based survey related to 16 clinical cases. They found poorest consensus with the cases “involving liquid-only diets, transition from nonoral feeding, or trial diet advances in therapy”. Perhaps more telling was the



finding that “most (>70%) respondents indicated enthusiasm for implementing the International Dysphagia Diet Standardisation Initiative Functional Diet Scale” in general (Steele et al., 2018). This certainly speaks to great need for standardization of language and descriptors in providing best practices in therapeutic diet interventions.

It should be noted that restrictions to diet and specific consistencies of food should be the last strategy examined (Logemann, 1997). Restrictions to diets and consistencies, especially thin fluids, can be very challenging for individuals (Logemann, 1997). Often patients may begin with a very restrictive diet (liquids of various consistencies – purees) and move to less restrictive diets (diced to regular foods) at a pace that has been deemed safe for that individual (Kramer et al., 2007). Asking the patient to limit the amount of food they attempt to swallow (taking smaller bites) will also help reduce difficulties with swallowing.

**Table 5.10 A Description of Four Levels of Diets**

<b>Level 1</b>	Soft textured foods – may be pureed or mashed foods. Pudding may also be given.
<b>Level 2</b>	Minced and Moist – foods are soft, minced. This may include cooked cereals, yogurts, curds.
<b>Level 3</b>	Smooth pureed – foods may include soft bananas, ground meats and fish, cream soups, ice-cream etc.
<b>Level 4</b>	Foods are finely chopped.

**Table 5.11 Diet Levels as Defined by a Canadian Hospital (Parkwood Institute-SJHC)**

<b>Dysphagia Diet Fluids</b>	
<b>Thin Fluids</b>	All fluids that are thin at room temperature: water/ice chips/juices/ tea/liquid nutritional supplements/ regular or strained soups/ice cream/jello.
<b>Nectar Thick Fluids</b>	Thin fluids that are thickened to the consistency of nectar and are sipped from a cup: nectar thick juices, milk, water, soup.
<b>Honey Thick Fluids</b>	Thin fluids that are thickened to the consistency of liquid honey but can be sipped from a cup: honey thick juices, milk, water, soup.
<b>Honey Thick/Thin Fluids</b>	Honey thickened fluids with the addition of thin fluids as determined in consultation with the patients/ resident/SDM and the SLP/RD.
<b>Honey Thick Clear Fluids</b>	Only honey thickened CLEAR fluids are allowed (no textures): honey thick apple/orange/cranberry juice and honey thick water.
<b>Honey Thick Full Fluids</b>	Only honey thickened FULL fluids are allowed (no textures): honey thick juices/water/mild/soup/hot cereals/custard/pudding/smooth yogurt.
<b>Pudding Thick Fluids</b>	Thin Fluids that are thickened to the consistency of pudding and are eaten with a spoon: pudding thick juices/mild/water/soup/custards, high energy puddings/smooth yogurt.
<b>Pudding Thick/Thin Fluids</b>	Pudding thickened fluids with the addition of thin fluids as determined in consultation with the patient/resident/SDM/and the SLP/RD.
<b>Pudding Thick Clear Fluids</b>	Only pudding thickened CLEAR fluids are allowed (no textures): pudding thick/apple/cranberry juices and pudding thick water.
<b>Pudding Thick Full Fluids</b>	Only pudding thickened FULL fluids are allowed (no textures): pudding thick juices/water/mild/soups: hot cereals, custard, pudding, smooth yogurt.
<b>Dysphagia Diet Textures</b>	
<b>Regular</b>	All items are served unmodified.
<b>Ready</b>	Same as regular but roast meats are diced.
<b>Diced Meat/Modified Vegetable</b>	Most meats are diced/soft proteins are allowed whole (meatloaf); also allowed: bananas, watermelon, strawberries etc); not allowed: raw vegetables, brussel sprouts, large pieces of cauliflower, whole corn.
<b>Minced meat/Modified Vegetable</b>	Most meats are minced, soft protein items are allowed, nothing on a bun, no brussel sprouts, florets of cauliflower or broccoli, no stir fry (mince before serving); allowed: mashed potatoes, macaroni salads, bananas, sliced strawberries and seedless watermelon.
<b>Minced</b>	Minced meats, vegetables, mashed potatoes, potato puffs, scalloped potatoes, cheese, peanut butter sandwiches, fresh bananas, minced strawberries, seedless watermelon.

<b>Minced/Pureed</b>	Minced meat and vegetables, mashed potatoes (not rice), soft casseroles, scrambled eggs, pureed fruits, strained soups, oatmeal or cream of wheat.
<b>Pureed Entrée/Modified Bread</b>	Same as above; can add crustless bread toast, moist cakes.
<b>Pureed with oatmeal</b>	Oatmeal, foods with a pudding type consistency, all entree must be pureed.
<b>Pureed</b>	All foods with a pudding type consistency, all entrees to be pureed, bread with diet syrup. No bananas, cottage cheese, oatmeal, old cereal, peanut butter.

Dysphagia Diet Guidelines, Parkwood Institute, St. Joseph's Health Care London, London, Ontario

### 5.5.8 Passy-Muir Speaking Valve (PMV)

Passy-Muir (Positive Closure) Speaking Valves (PMV) operated in the closed position can improve voice quality and speech production while, at the same time, improving swallowing and reducing aspiration (Passy-Muir Incorporated, 2004). Aspiration is often problematic in patients who have a tracheostomy. These patients are essentially unable to achieve the apneic interval necessary for an efficient swallow. It is thought that, normalization of subglottic air pressure, achieved through placement of a PMV, reduces the potential for aspiration.

The valve may be attached to the 15mm connector found on most adult tracheostomy tubes (Dettelbach et al., 1995; Passy et al., 1993). With the PMV in place, a noticeable decrease in the amount aspirated has been observed. While wearing the valve, patients also have the opportunity to more easily express themselves verbally (Bell, 1996). Passy et al. (1993) found that patients began speaking almost immediately and their speech improved making it easier for them to communicate with hospital staff, doctors, and family. This ease of communication is very beneficial to the patient's ability to direct their own care related to feeding, swallowing and diet preferences.

Within the literature, the benefits of the PMV have been supported. Manzano et al. (1993) found that patients experienced a decrease in secretions and showed improvement in ability to cough with the PMV in place; further supporting its effectiveness, the volume of secretions appears to increase when the PMV is removed (Lichtman et al., 1995; Passy et al., 1993). The use of a PMV has also been shown to significantly improve the degree of aspiration (Elpern et al., 2000; Stachler et al., 1996), provide the ability to safely ingest thin liquids (Suiter et al., 2003), improve oxygenation, decrease oral and nasal secretions, improve sense of smell, enhance airway clearance, and improve swallowing (Bell, 1996). To determine its effectiveness specifically within the ABI population more research is recommended.

## 5.6 Oral Care Interventions

Oral hygiene and dental care have become an important component of treating individuals post stroke and TBI (Clayton, 2012; Zasler et al., 1993). Proper oral hygiene management decreases the medical risks associated with dysphagia and poor oral care. The actual provision of mouth care is more challenging in patients with TBI given the frequent presentation of significant cognitive-communication issues including: fatigue, reduced level of alertness, cooperation and comprehension, as well as a lack of physical recovery necessary to complete the task of brushing independently (Zasler et al., 1993). For the reasons listed, as well as improper or insufficient staff training, there may be less priority placed on providing mouth care as part of the overall care routine. It becomes important then, to provide regular education about the beneficial effects of strong oral hygiene practices from a social integration, comfort, medical, and safety management standpoint.

Oral biofilm (or plaque) is a combination of proteins/glycoproteins and bacteria. Following oral care, oral biofilm/plaque begins forming again in as little as 15 minutes. Within two hours, bacteria have

multiplied and this biofilm may even double in mass and begin forming complex networks of bacteria colonies that are able to communicate with each other. There is a four to six-fold increase in the incidence of aspiration pneumonia in patients with periodontal disease and/or poor oral care (Maddi & Scannapieco, 2013). In patients who are NPO (nothing by mouth) with enteral feeding for total nutrition there is no mechanical disruption of the biofilm through movement of food and liquid or by the tongue and oral muscles; therefore, biofilm accumulates more easily (including formation on the soft tissues). For this reason, the role of thorough mouth care for patients who are NPO becomes even more critical (written communication from Dr. Greenhorn-November 23, 2012). With our current understanding of the oral-systemic link, improved oral care also has a positive impact on the reduction of aspiration pneumonia rates, particularly in those patients with dysphagia.

As noted earlier, many patients with TBI may be more difficult to approach with regards to mouth care. For this reason, the key elements of care must be known so care is as efficient as possible. Clayton (2012) states *“education of staff regarding the importance of oral hygiene and obtaining quality oral care equipment is vital.”* Currently, there is very little evidence in the literature to support the fact that oral care is routinely performed, particularly when the patient with TBI is in hospital or long-term care (Kelly, 2010; Landesman et al., 2003; Talbot et al., 2005). Education in oral health and good oral care is needed to reduce the risk of dysphagia and other associated complications that can result from a brain injury.

**Table 5.12 Oral Hygiene Post ABI**

Author/Year/ Country/Study Design/PEDro Score/N	Methods	Outcome
<a href="#">Zasler et al.</a> (1993) RCT USA PEDro=4 N=20	<b>Population:</b> TBI; Mean Age=30 yr; Gender: Male=14, Female=6; Time Post-Injury >1 mo; <i>Intervention Group (n=10):</i> Mean GCS=7; <i>Control Group (n=10):</i> Mean GCS=6. <b>Intervention:</b> Patients in the intervention group received verbal oral hygiene instructions and were supervised in the removal of plaque. Those in the control group did not receive any oral hygiene instructions. Assessments were done at baseline and follow-up (5-6 wk). <b>Outcome Measure:</b> Plaque index score.	1. No differences were found between the intervention and control group when examining the mean plaque scores at baseline (1.94 versus 2.12, $p>0.05$ ). 2. Following intervention, the mean plaque index scores for the treatment group was significantly lower than those of control group (1.06 versus 2.19, $p<0.01$ ).
<a href="#">Lam et al.</a> (2013) China RCT PEDro=6 N=102	<b>Population:</b> Stroke. <b>Intervention:</b> Patients randomized to one of three groups: 1) oral hygiene instruction (OHI) only; 2) OHI and mouth rinse (0.2% chlorhexidine 2x/day); or 3) OHI, mouth rinse and assistance with tooth brushing 2x/wk. Outcomes assessed at baseline and at 3 wk. <b>Outcome Measure:</b> Oral bacteria levels.	1. Of the 102 patients, 72.8% were found to have oral anaerobic gram-negative bacilli at the baseline period. 2. Pathogen counts were stabilized in each of the groups regardless of the oral care they were performing.

Author/Year/ Country/Study Design/PEDro Score/N	Methods	Outcome
<a href="#">Prendergast et al.</a> (2011) USA RCT PEDro=6 N=47	<b>Population:</b> Stroke (78.7%). <b>Intervention:</b> Patients were randomly assigned to a tooth brushing program with either an electric toothbrush (treatment group) or a manual toothbrush (control group). Oral care was conducted twice a day by trained nurses. <b>Outcome Measure:</b> Intracranial pressure (ICP), cerebral perfusion pressure (CPP).	<ol style="list-style-type: none"> <li>1. No significant between group differences were found in ICP values (<math>p=0.72</math>) or CPP values (<math>p=0.68</math>).</li> <li>2. When looking at the two groups together, results showed ICP levels increased before and during oral care (<math>p=0.001</math>), and decreased from during care to after oral care was completed (<math>p&lt;0.001</math>).</li> </ol>

PEDro = Physiotherapy Evidence Database rating scale score (Moseley et al., 2002).

## Discussion

In the Zasler study (1993), patients who were provided verbal oral hygiene instructions and taught to remove plaque had significantly less plaque on their teeth post intervention compared to the control group. Study authors suggest that this improvement can lead to greater integration back into society, as the potential negative consequences associated with poor oral hygiene have been addressed (Zasler et al., 1993). Verbal education appears to be sufficient to improve dental plaque control (Zasler et al., 1993). In an RCT conducted by Lam et al. (2013), multiple oral care protocols were examined including various combinations of instruction, mouth rinse and assisted tooth brushing. No significant differences were found between the three protocols when looking at the amount of oral opportunistic pathogens that developed.

Of note, Prendergast et al. (2011) found individuals in a neuroscience intensive care unit, who were still intubated, were able to tolerate tooth brushing (manual and electric). Intracranial pressure and cerebral perfusion pressure monitoring showed no significant differences between the groups before, during, or after the procedure. Overall results suggest tooth brushing is possible in an intensive care unit, and patients post-ABI can tolerate it without any adverse effects.

## Conclusion

***There is Level 1b evidence that oral care assistance, at any level, does not increase oral pathogen count.***

***There is Level 1b evidence that the use of a manual compared to an electric toothbrush has no significant effect on ICP and CPP.***

***There is Level 2 evidence that providing oral hygiene education to patients post TBI results in a significant reduction of dental plaque, measured by the Plaque Index Score.***

**Oral hygiene alone results in a significant decrease in dental plaque.**

**There are no differences in efficacy between the use of a manual or electric toothbrush on ICP or CPP**

### 5.6.1 Provision of Mouth Care as a Means of Managing Aspiration Pneumonia Risk

In the clinical practice of SLPs, good mouth care is a significant component of treating swallowing disorders (Eisenstadt, 2010). Oral care has generally focused on oral cleaning; however, it includes both oral hygiene and training for oral function (swallowing, mastication, and saliva secretion) (Tada & Miura, 2012).

In individuals without swallowing difficulty, oral bacteria routinely travel along with the food ingested through the esophagus to the stomach, where it is neutralized and presents less threat to the health of the lungs. Even in healthy individuals the importance of a proper mouth care program can not be understated. In patients who are NPO, problems are compounded by xerostomia (dry mouth).

Xerostomia is an undesirable side effect associated with up to 500 medications (e.g., anti-hypertensives, anticonvulsants, antidepressants) (Bartels, 2005; Canadian Dental Association, 2009; Nicol et al., 2005), many of which are administered to those who sustain an ABI. In these patients, reduced salivary flow and thicker secretions contribute to increased micro-organisms and increased risk of infection (Bartels, 2005).

Unlike the general population, mouth care in patients with dysphagia is best performed before eating/drinking. The rationale is that the introduction of oral bacteria to the lungs via aspiration is more problematic than the food or liquid that is aspirated alone. Brushing before eating/drinking for patients with dysphagia means that bacteria have no opportunity to be introduced to the lungs even in “known aspirators”, thereby reducing the incidence of pneumonia (Seguin et al., 2014).

**Table 5.13 Oral Care for the Treatment of Dysphagia-Related Complications Post ABI**

Author/Year/ Country/Study design/PEDro Score/N	Methods	Outcomes
<a href="#">Seguin et al.</a> (2014) France RCT PEDro=7 N=167	<b>Population:</b> <i>Povidone-iodine group (n=85):</i> TBI=62, Stroke=23; Mean Age=48 yr; Gender: Male=60, Female=25; Mean Time Post Injury=6 hr; Mean GCS=6. <i>Placebo group (n=82):</i> TBI=61, Stroke=21; Mean Age=48 yr; Gender: Male=64, Female=18; Mean Time Post Injury=6 hr; Mean GCS=6. <b>Intervention:</b> Patients were randomly assigned to either receive povidone-iodine for decontamination of the oropharyngeal tract, or placebo. <b>Outcome Measure:</b> Incidence of ventilator-associated pneumonia (VAP).	1. VAP occurred in 31% of patients in the povidone-iodine group and 28% of patients in the placebo group (p=0.69).
<a href="#">Cabov et al.</a> (2010) Croatia RCT PEDro=8 N=60	<b>Population:</b> Neoplasms (61.7%), Head trauma (28.3%), Polytrauma (10%). <b>Intervention:</b> Patients were randomized to either the chlorhexidine group or the placebo group. Those in the chlorhexidine group had antiseptic decontamination of dental plaque and the oral mucosa by applying the gel to their oral cavity. The gel was not rinsed off after application. <b>Outcome Measure:</b> Rate of infections, Plaque score.	1. The plaque score significantly increased in the placebo group and decreased in the chlorhexidine group (p<0.05). 2. Post treatment results indicate that the placebo group acquired nosocomial infections, including nosocomial pneumonia, more often than in the chlorhexidine group. 3. Mortality in the treatment group was lower (3.3% vs 10%), as was the length of stay (5.1±1.6 versus 6.8±3.5, p=0.0187), compared to the placebo group.

<a href="#">Yoneyama et al.</a> (2002) Japan RCT PEDro=6 N=366	<b>Population:</b> Nursing home patients. <b>Intervention:</b> Patients were randomly allocated to receive oral care (n=184) or no oral care (n=182). <b>Outcome Measure:</b> Pneumonia, febrile days, death from pneumonia, Activities of Daily Living Scale, Mini Mental State Exam (MMSE).	<ol style="list-style-type: none"> <li>1. Pneumonia was more common in those who did not receive oral care, compared to those that did (34 cases versus 21 cases).</li> <li>2. Scores on the activities of daily living scale and the MMSE improved in those receiving oral care.</li> <li>3. During follow up 54 (29%) patients had febrile days in the non-oral care group, and 27 (15%) in the oral care group.</li> <li>4. Of those who had pneumonia, 30 (16%) in the non-oral care group, and 14 (7%) in the oral care group died.</li> </ol>
<a href="#">Fourrier et al.</a> (2000) France RCT PEDro=5 N=60	<b>Population:</b> Intensive Care Unit patients. <b>Intervention:</b> Chlorhexidine 0.2% (dental gel) group or the control group where dental care consisted of standard oral care including rinsing the mouth with bicarbonate isotonic serum, followed by oropharyngeal sterile aspiration 4x/day. <b>Outcome Measure:</b> The development of nosocomial infections, Caries-Absent-Occcluded Index.	<ol style="list-style-type: none"> <li>1. The rate of nosocomial infection acquired in the ICU was significantly higher for the control group (p=0.018).</li> <li>2. Those in the treatment groups also had a reduced ICU stay compared to the placebo group.</li> </ol>
<a href="#">Robertson and Carter</a> (2013) Canada Case Control N=83	<b>Population:</b> TBI, Intracranial hemorrhage, tumour, Other. <i>Standard oral care (SOC) Group (n=51):</i> Mean Age=57 yr; Gender: Male=27, Female=24. <i>Enhanced oral care (EOC) group (n=32):</i> Mean Age=61 yr; Gender: Male=23, Female=9. <b>Intervention:</b> Patients in the SOC group received a standard protocol for oral hygiene and were reviewed retrospectively; patients in the EOC group were prospectively studied and received an enhanced oral hygiene protocol. The oral care kit was kept beside the patient's bed and nurses were trained prior. The EOC consisted of brushing, mouth rinse, and swabs. <b>Outcome Measure:</b> Incidence of non-ventilator hospital-acquired pneumonia (NV-HAP).	<ol style="list-style-type: none"> <li>1. A significant decrease in in the rate of NV-HAP was observed in the EOC group compared to the SOC group (p=0.039).</li> </ol>

PEDro = Physiotherapy Evidence Database rating scale score (Moseley et al., 2002)

## Discussion

Research conducted in long-term care or acute care facilities report a decline in mortality rates, risk for developing dysphagia, and risk of aspiration pneumonia with the introduction of an oral care program (Sarin et al., 2008; Watando et al., 2004). Patients in a nursing home who received oral care had fewer febrile days and cases of pneumonia, and fewer patients were dying from pneumonia (Yoneyama et al., 2002).

Two RCTs were have investigated the effectiveness of chlorhexidine gel on the development of nosocomial infections in patients assigned to the intensive care unit (Cabov et al., 2010; Fourrier et al., 2000). Both studies showed that chlorhexidine gel was effective in reducing the number of nosocomial infections and overall length of stay compared to placebo or standard oral care.



In the Seguin study (2014), authors investigated the efficacy of povidone-iodine versus a placebo drug in reducing ventilator-associated pneumonia. The occurrence of ventilator-associated pneumonia, although reduced in the experimental group, was not significantly different from the control group (Seguin et al., 2014). Povidone-iodine was also shown to increase the risk of secondary infections including acute respiratory distress syndrome (Seguin et al., 2014). However, another study demonstrated reduced rates of non-ventilator hospital-acquired pneumonia among patients receiving enhanced oral care; Robertson and Carter (2013) found that patients receiving the enhanced oral care protocol had a significant decrease in acquired pneumonia when compared to the standard oral care group.

### **Conclusions**

***There is level 1b evidence that 0.2% chlorhexidine gel is beneficial for reducing nosocomial infections and hospital length of stay compared to placebo in non-ABI populations.***

***There is level 1b evidence that povidone-iodine may be effective for reducing the incidence of ventilator-associated pneumonia compared to placebo post stroke or ABI.***

***There is level 1b evidence that oral care may reduce rates of pneumonia, febrile days, and pneumonia-related deaths in mixed populations.***

***There is level 3 evidence that enhanced oral care may reduce rates of non-ventilator hospital-acquired pneumonia compared to standard oral care in mixed brain injury populations.***

**Maintaining good oral health during hospitalization has been shown to reduce the risk of nosocomial infections and pneumonia post ABI.**

### **5.7 Nutritional Management**

Ensuring patients with ABI have adequate nutrition is an important part of their medical management (Denes, 2004), as it has a critical impact on the patient's recovery process and final outcome (Elovic, 2000). Denes (2004) stated that rehabilitation problems associated with severely malnourished ABI patients include an increased occurrence of complications, a greater challenge in patient mobilization, an increased frequency for the need to operate on contractures, and a longer length of stay in a rehabilitation unit. Despite clinicians' efforts several factors make it difficult to avoid malnutrition in patients with ABI, beginning with the metabolic changes that occur post injury (Elovic, 2000). Post ABI, the damage to the metabolic control center causes more severe and protracted systematic responses than seen in many other forms of injuries. The former is a possible consequence of the change in feedback mechanisms post injury and the brain's critical role in triggering the metabolic response (Young et al., 1992).

Secondary to ABI, a catabolic and counter regulatory hormone (glucagon and cortisol) increase takes place (Loan, 1999). Deficiencies of follicle-stimulating hormones, luteinizing hormone, and growth hormone (GH) indicate alteration in the hypothalamic-pituitary feed-back mechanism that normally regulates metabolism (Loan, 1999). As a result of hypermetabolism and hypercatabolism, both energy

and protein requirements will be elevated in the first several weeks following injury. Negative energy and nitrogen balance, which may exceed 30 grams per day, have been reported within the first week following injury (Bruder et al., 1994; Weekes & Elia, 1996; Wilson et al., 2001; Young et al., 1985). Unfortunately, although muscle wasting occurs as a consequence of bed rest and immobilization, only a portion of these losses are responsive to nutritional interventions (Behrman et al., 1995).

A case control study examined the cost associated with enteral nutrition (EN) compared to parenteral nutrition (PN) treatment (Ott et al., 1999). It was found that on average the cost of PN was almost double of the cost of EN. However, it should be emphasized that cost is not a sufficient determinant of which treatment should be allocated to an individual as that is determined by their physiological state and their ability to absorb nutrients.

### 5.7.1 Incidence of Malnutrition

The incidence of malnutrition following ABI is difficult to estimate as there are no consistent criteria used, and relatively few studies have examined the issue. Given that ABI tends to occur in younger, previously healthy individuals, it is unlikely that pre-existing nutritional deficits are prevalent at the time of injury. Therefore, declines in nutritional parameters are most likely directly related to the metabolic effects of the injury. Brooke et al. (1989) reported an average weight loss of 13.2 kg from injury to rehabilitation admission, while Weekes and Elia (1996) reported 9.8 kg of weight loss from the time of injury to day 19 in four previously healthy young males. In the early rehabilitation phase, a substantial amount of patients are underweight (approximately 60%) (Brooke et al., 1989; Haynes, 1992); however, obesity has also been reported among patients, typically in the chronic phase of recovery (Henson et al., 1993).

### 5.7.2 Hypermetabolism Post ABI

Hypermetabolism is a well-known metabolic sequelae of ABI. Hypermetabolism has been defined as an increase in metabolic rate above that which is predicted using equations, which take into account age, sex, height, and weight (Souba & Wilmore, 1999). The hypermetabolic state, which is characterized by increased oxygen consumption and nitrogen excretion following injury, is thought to be mediated by an increase in i) counterregulatory hormones such as epinephrine, norepinephrine and cortisol; ii) corticosteroids; and iii) proinflammatory mediators and cytokines (Pepe & Barba, 1999). Tremendous variability has been reported regarding the magnitude of the hypermetabolic state post ABI. The variations are likely due to the timing of the measurements, patient characteristics (i.e., initial level of injury, concomitant infections) and management (i.e., craniotomy, intubation and sedation and/or barbiturate use, ambient temperature).

Resting energy expenditure (REE) represents the amount of calories required for a 24-hour period by the body during a non-active period. Young et al. (1985) found REE to decrease consistently over time post ABI (151% to 116% over 22-day evaluation). Bruder et al. (1994) compared REE in ABI patients who were weaned off from sedation, while others were re-sedated. REE increased to 143% of predicted values in those who were weaned from sedations, while the increases in REE were only 122% of predicted values in those who received additional sedation (Bruder et al., 1994), demonstrating that sedation can impact metabolic rates. Barbiturate use as it relates to REE was examined by Dempsey et al. (1985); the findings showed that mean REE was significantly lower during barbiturate therapy than without barbiturate therapy, when it was administered to those with failing intracranial pressure (ICP) ( $p < 0.01$ ). Other factors that affected REE after head injury were evaluated by Robertson et al. (1984); the authors found



that patients with GCS 4-5 had the highest REE at  $168 \pm 53\%$  of expected values, and was lowest in patients with GCS 6-7 at  $129 \pm 31\%$  of expected values (Robertson et al., 1984).

The evidence suggests that patients with ABI are often hypermetabolic, with significantly higher resting energy expenditure in the acute period following the injury. Continued research in this area will help to establish meaningful guidelines regarding use of barbiturates and sedations as modifiable factors.

### 5.7.3 Fluid Consumption and the Frazier Free Water Protocol

To increase fluid consumption and decrease the risk of dehydration, the Frazier Free Water Protocol allows patients who are receiving thickened liquids to be given regular, thin water in between meals. Thickened fluids do not quench thirst in the same way that regular thin water does; therefore, the regular water, in combination with the recommended thickened fluids, works to assist some patients in better meeting their daily hydration needs. Patients who are NPO are often permitted to have water (following screening) and those who have found success using various postural changes are asked to use these postural maneuvers when drinking water. The Frazier Free Water protocol states that, by policy, water is allowed for any patient NPO or on a dysphasic diet (Panther, 2005).

### 5.7.4 Routes and Timing of Non-Oral Nutritional Interventions

In the early stages of recovery, a significant percentage of patients will be comatose and mechanically ventilated, precluding oral feeding. While enteral feeding is the preferred route of nutrient administration, feeding intolerance due to gastroparesis and ileus are common. Enteral feeding has been associated with a decrease in bacterial translocation and a reduced incidence of infection.

One study found that enteral feeding intolerance may be related to increased intracranial pressure (Ott et al., 1990). Medications may also play a role in delayed gastric emptying. Although the placement of feeding tubes into the small bowel may theoretically improve tolerance, placement can be difficult and empirical evidence of superiority is lacking. If intolerance is prolonged, parenteral feeding may be indicated (Cerra et al., 1997), although the risk of hyperglycemia and cerebral edema is increased.

#### 5.7.4.1 Enteral Nutrition Administration

EN consists of delivering complete nutritional requirements directly into the stomach, duodenum, or jejunum using a gastroenteric tube. EN is beneficial when patients are unable to ingest nutrients independently but their bodily functions still allow for the digestion of food. However, post-ABI caloric and nutrient requirements may not always be met and PN is used as supplementation. Patients should be routinely monitored for signs of malnutrition and dehydration. Studies examining the efficacy of enteral nutrition are presented in Table 5.14.

**Table 5.14 Enteral Feeding for Nutritional Management Post ABI**

Author/Year/ Country/Study design/PEDro Score/N	Methods	Outcome
<a href="#">Horn et al.</a> (2015) USA Prospective Controlled Trial N=1701	<b>Population:</b> TBI=1701; <i>Enteral Nutrition (EN;</i> <i>n=451</i> ): Mean Age=38.5 yr; Gender: Male=326, Female=125; Mean Time Post Injury=31.9 days; <i>No EN (n=1250)</i> : Mean Age=47.1 yr; Gender: Male=895, Female=355; Mean Time Post Injury=19.8 days.	<ol style="list-style-type: none"> <li>1. Upon admission, high brain injury score on CSI, low FIM motor score, and having moderate-severe dysphagia were the strongest predictors of needing EN (<math>p &lt; 0.001</math>; c statistic=0.903).</li> <li>2. EN patients had borderline better scores compared to no EN upon discharge on FIM-motor (<math>p=0.055</math>) and cognition (<math>p=0.050</math>),</li> </ol>

Author/Year/ Country/Study design/PEDro Score/N	Methods	Outcome
	<p><b>Treatment:</b> Patients admitted to an inpatient rehabilitation center post TBI were grouped into either EN (&gt;1 days on EN) or no EN (&lt;1 day or no days). Analysis of demographic and treatment data to determine the relationship between EN and patient outcomes.</p> <p><b>Outcome Measure:</b> Functional Independence Measure (FIM), Comprehensive Severity Index (CSI), chart reviews, weight loss, length of stay (LOS).</p>	<p>longer LOS (<math>p=0.062</math>), and smaller weight changes (<math>p=0.075</math>).</p> <p>3. Patients that received EN at standard or high protein concentrations for &gt;25% of their stay (mean=19 days) had better FIM discharge scores (<math>p&lt;0.030</math>).</p>
<p><a href="#">Clifton et al.</a> (1984) USA Case Series N=14</p>	<p><b>Population:</b> Head Injury; Mean Age=27.8 yr; Gender: Male=12, Female=2; GCS Score Range=3-8; Mean Time Post Injury=2 hr.</p> <p><b>Intervention:</b> The REE of enteral nutrition fed patients was measured by indirect calorimetry, over the first 9 days of onset (<math>n=14</math>), up to 28 days post injury (<math>n=4</math>).</p> <p><b>Outcome Measure:</b> Resting Energy Expenditure (REE).</p>	<p>1. Mean values of REE ranged from <math>2135\pm374</math> Kcal on 1-3 days to <math>2504\pm582</math> Kcal on 7-9 days, which was not statistically significant.</p> <p>2. The mean REE ranged from 102%-170% of predicted values, over the 9 days of study.</p> <p>3. A single patient who received barbiturates had a REE lower than predicted (79%).</p> <p>4. Among patients who were non-sedated and non-paralyzed, REE was 138% of predicted values.</p> <p>4. There were no significant changes in REE over the 9 days and no associations were noted between GCS and REE.</p>

## Discussion

To date only two studies have looked at the general effectiveness of EN in an ABI population (Clifton et al., 1984; Horn et al., 2015). It was found that EN, when compared to no EN, resulted in trends towards smaller weight changes, improved FIM scores (motor and cognitive function), and longer length of stay, although these between-group differences did not reach statistical significance (Horn et al., 2015). Clifton et al. (1984) examined the REE of those being treated with EN and found that REE was higher than predicted, specifically with those patients who were not sedated. Further research is needed to better understand any potential benefits of EN outside of direct caloric or weight measures.

## Conclusions:

*There is level 2 evidence that enteral nutrition may not reduce weight loss or improve FIM scores compared to no EN in patients post ABI.*

*There is level 4 evidence that patients with ABI may expend more energy when on enteral nutrition than predicted by equations, and that this effect may be greater for non-sedated individuals.*

**Enteral nutrition may not reduce weight loss in individuals post ABI.**

**For those with ABI and being provided with enteral nutrition, energy expenditure levels may be beyond those predicted by equations.**

### 5.7.4.2 Parenteral Nutrition Administration

PN consists of receiving nutrition directly through the vein. PN is usually initiated when a patient's stomach or bowel is not functioning properly (American Society for Parenteral and Enteral Nutrition, 2018). PN includes protein, carbohydrates, fats, minerals, vitamins, and electrolytes (Mousavi et al., 2014). It is important to determine as early as possible if a patient should be placed on PN in order to meet their nutritional and caloric requirements as a delay in nutrition can result in complications, and delayed discharge and rehabilitation.

**Table 5.15 Parenteral Nutrition for Nutritional Management Post ABI**

Author/Year/ Country/Study design/PEDro Score/N	Methods	Outcome
<a href="#">Mousavi et al.</a> (2014) Iran RCT PEDro=6 N=26	<p><b>Population:</b> TBI; Gender: Male=26, Female=0. <i>Intervention Group (n=13):</i> Mean Age=31 yr; Mean GCS Score=7.3. <i>Conventional Group (n=13):</i> Mean age=36.6 yr; Mean GCS Score=8.4.</p> <p><b>Intervention:</b> Patients on parenteral nutrition were randomly allocated to receive continuous infusion of 50 IU insulin (IIT; intervention) or conventional glucose treatment (CGC; control). IIT group had blood glucose (BG) levels maintained at 80 mg/dl–120 mg/dl. Patients were followed up on day 7 and 14.</p> <p><b>Outcome Measures:</b> Frequency of hypoglycemic episodes, BG concentration, mid-upper arm circumference (MAC), C-reactive protein (CRP), lipid profile, blood electrolytes, and liver function tests.</p>	<ol style="list-style-type: none"> <li>1. Mean BG concentration was significantly lower in the IIT group compared to the CGC group (118±28 mg/dl versus 210±31 mg/dl; <math>p&lt;0.01</math>). The CGC group had more hyperglycemic episodes.</li> <li>2. There were no significant between group differences in any of the secondary outcome measures on day 7 follow-up (<math>p&gt;0.05</math>).</li> <li>3. On day 14, patients receiving IIT had significantly lower levels of CRP (<math>p=0.0001</math>), triglycerides (<math>p=0.02</math>), magnesium (<math>p=0.03</math>), and phosphorus (<math>p=0.01</math>). Chloride levels were significantly elevated in IIT patients compared to CGC patients (<math>p=0.02</math>). These changes were largely in accordance with the hormonal effects of insulin.</li> </ol>

### Discussion

An RCT assessing the effect of glycemic control on PN complications in hospitalized patients with brain injury demonstrated that treatment using an insulin infusion significantly decreased blood glucose levels when compared to a conventional glucose treatment (Mousavi et al., 2014). The experimental group also had significantly lower concentrations of C-reactive protein and triglycerides compared to the control group (Mousavi et al., 2014). The study authors concluded that although more research is needed, insulin infusions improved some parenteral nutrition complications (Mousavi et al., 2014).

### Conclusions

***There is level 1b evidence that insulin infusions significantly decrease blood glucose levels when compared to a conventional glucose treatment in TBI patients.***

**Parenteral nutrition with a continuous infusion of insulin may lower blood glucose levels in ABI populations.**

### 5.7.4.3 Combination or Comparative Nutrition Administration Strategies

Often times it is necessary to use both EN and PN administration strategies to ensure that an individual is meeting their caloric needs. For this reason, many studies compare the effect of these interventions as well as measure their combined effect (Table 5.16).

**Table 5.16 Combination or Comparative Nutritional Strategies for Nutritional Management Post ABI**

Author/Year/ Country/Study design/PEDro Score/N	Methods	Outcome
<a href="#">Meirelles and de-Aguilar-Nascimento</a> (2011) Brazil RCT PEDro=5 N=22	<p><b>Population:</b> TBI; <i>Enteral Nutrition (EN) Group:</i> Mean Age=31 yr; Gender: Male=11, Female=1; Mean GCS Score=9. <i>Parenteral Nutrition (TPN) Group:</i> Mean Age=31 yr; Gender: Male=9, Female=1; Mean GCS Score=9.</p> <p><b>Intervention:</b> Patients were randomized to receive either EN or TPN. Both groups received a 25-30 kcal/kg/day and 1.5 g/kg/day of protein. EN was administered via 8 or 10F oro- or naso-enteral feeding tube in gastric position with pump infusion. TPN was administered via central venous access. Patients assessed daily for 5 days.</p> <p><b>Outcome Measure:</b> Mortality, morbidity, Length of stay (LOS) in ICU, days of mechanical ventilation, amount of calories and protein received/d, blood samples of glucose, albumin, urea, creatinine, C-reactive protein (CRP), urinary urea (N).</p>	<ol style="list-style-type: none"> <li>1. No significant differences were found in morbidity and mean ICU LOS between the EN and TPN group.</li> <li>2. Although the amount of calories increased significantly (<math>p&lt;0.01</math>) each day of the study, there was a progressive caloric deficit (<math>p=0.001</math>) in the two groups without any significant difference between them.</li> <li>3. Those in the TPN group received significantly more (<math>p&lt;0.006</math>) nitrogen than the EN group.</li> <li>4. Despite the increased loss of nitrogen, all patients showed significant improvement (<math>p=0.001</math>) in the nitrogen balance as a result of nutritional therapy.</li> <li>4. Even though each nutritional therapy offered increasing quantities of nitrogen and calories, the TPN therapy delivered nitrogen more efficiently compared to the EN therapy.</li> </ol>
<a href="#">Nataloni et al.</a> (1999) Italy RCT PEDro=4 N=45	<p><b>Population:</b> Head injury; Mean Age=28 yr; Gender: Male=31, Female=14. <i>Group A (n=15):</i> Mean GCS Score=6. <i>Group B (n=15):</i> Mean GCS Score=6. <i>Group C (n=15):</i> Mean GCS Score=5.</p> <p><b>Intervention:</b> Patients were randomly administered one of the following feeding conditions: enteral (Group A), parenteral (Group B), or both enteral and parenteral (Group C). Those who participated were expected to stay in ICU for <math>\geq 3</math> days. Feeding began within 2 days of ICU admission and continued for the length of stay.</p> <p><b>Outcome Measure:</b> Serum pre-albumin, retinol-binding protein (RBP), nitrogen balance. Assessments were made at baseline and after (day 3, 7 and 11).</p>	<ol style="list-style-type: none"> <li>1. Nitrogen balance, which was negative for all groups, improved over the course of treatment; however, it only significantly improved in Group A by day 11 (<math>p&lt;0.0001</math>).</li> <li>2. Pre-albumin and RBP significantly increased in Group A compared to both Group B (<math>p&lt;0.001</math>) and Group C (<math>p&lt;0.01</math>). Significant differences in the level of pre-albumin began at day 3 (<math>p&lt;0.01</math>) while the differences in the level of RBP began at day 7 (<math>p&lt;0.01</math>).</li> </ol>
<a href="#">Borzotta et al.</a> (1994) USA RCT PEDro=4 N=49	<p><b>Population:</b> Closed Head Injury; Gender: Male=40, Female=9; <i>Early Parenteral Nutrition (TPN) Group (n=21):</i> Mean Age=28.9 yr; Mean GCS Score=5.4. <i>Enteral Feeding (ENT) Group (n=28):</i> Mean Age=26.2 yr; Mean GCS Score=5.2.</p> <p><b>Intervention:</b> Patients in the TPN group were treated with early parenteral nutrition which at day 5 began conversion to gastric feeding with tapering of TPN. The ENT group</p>	<ol style="list-style-type: none"> <li>1. No significant differences noted for nitrogen excretion or balance, energy expenditures, meeting nutritional goals, and frequency of infections.</li> <li>2. Patient complications such as hyperglycemia (<math>p&lt;0.05</math>) and diarrhea (<math>p&lt;0.05</math>) were more common among patients receiving TPN.</li> <li>3. Efficiency of feeding, measured by ratio of calories to MREE, showed an advantage for TPN at day 3, but none after.</li> </ol>

Author/Year/ Country/Study design/PEDro Score/N	Methods	Outcome
	had enteral feeding through jejunal tubes. Assessments made daily for 10 days and weekly for 5 wk thereafter. <b>Outcome Measure:</b> Measured Energy Expenditure (MREE), nitrogen excretion, complications.	4. There were no differences in mortality at the end of follow-up.
<a href="#">Young et al.</a> (1987) USA RCT PEDro=5 N=96	<b>Population:</b> Severe Head Injury. <i>Parenteral nutrition (TPN) Group:</i> Mean Age=29.9 yr. <i>Enteral feeding (EN) Group:</i> Mean Age=33.8 yr. <b>Intervention:</b> Patients were randomly assigned to receive either TPN or EN. TPN was initiated within 48 hr post-injury. EN was initiated when tolerated by patients. Study went from admission to day 18. Assessments made every 6 hr in the ICU, or 1x/day in the hospital ward. <b>Outcome Measure:</b> Intracranial pressure (ICP), serum glucose levels.	1. No significant differences were found between groups in peak daily ICP; ICP was >20 mmHG in 75% of the TPN patients and 73% of the EN patients. 2. Standard therapy was ineffective in controlling elevated ICP in 36% of the TPN and in 38% of the EN group. 3. There were no significant between-group differences in serum osmolality. 4. For the first 12 days, the TPN group received more calories and protein than the EN group ( $p=0.0001$ ). 5. There was a significant day $\times$ nutrition group interaction ( $p<0.0001$ ); serum glucose levels were higher in the TPN group for the first 13 days post injury than EN group who had increased mean serum glucose content after 13 days.
<a href="#">Hadley et al.</a> (1986) USA RCT PEDro=4 N=45	<b>Population:</b> TBI; Median Age=28 yr; Gender: Male=40, Female=5; Mean GCS Score=5.8; Time Post Injury=6 hr. <b>Intervention:</b> Patients were randomly assigned to receive either total parenteral nutrition (TPN; $n=24$ ) or enteral nutrition (NG; $n=21$ ). Patients received high nitrogen and calorie feedings for a 14 days period of the study to try to obtain a positive nitrogen and calorie balance. Nitrogen loss was measured every other day. <b>Outcome Measure:</b> Urinary nitrogen levels.	1. Patients who received TPN achieved significantly higher mean daily nitrogen intakes ( $p<0.01$ ) and losses ( $p<0.001$ ) compared to those who received NG. 2. There was no significant between-group difference in nitrogen balance.
<a href="#">Hausmann et al.</a> (1985) Germany RCT PEDro=4 N=20	<b>Population:</b> ABI; Mean Age=28.65 yr; Gender: Male=20; GCS Range=5-7. <b>Intervention:</b> Patients were randomly assigned to one of the following feeding regimes: total parenteral nutrition (TPN; $n=10$ ) or the combined enteral-parenteral nutrition (CN; $n=10$ ). All received maximal glucose intake of 500 g/day and sorbitol of 100 g/d. Parenteral nutrition was administered continuously via a central venous line over 24 hr. Enteral feeding was administered through a nasogastric tube at 2 hr intervals. Daily fluid balance was corrected with electrolyte solutions or through the use of diuretics. Patients were assessed up to 8 days post injury. <b>Outcome Measure:</b> Nitrogen Balance, protein concentration.	1. In the CN group, 4 (40%) patients died, whereas in the TPN group, 2 (20%) patients died. The difference in mortality was not significant. 2. Regurgitated gastric fluid was lower in the TPN group compared to the CN group going into day 7 ( $p<0.05$ ). 3. Protein concentration of the reflux fluid in the CN group (1.1-4.2 g/dl) was significantly elevated compared to the TPN group (0.53-0.84 g/dl) ( $p<0.05$ ). 4. Regardless of the feeding regime, nitrogen balance (NB) could not be reached.

Author/Year/ Country/Study design/PEDro Score/N	Methods	Outcome
<a href="#">Rapp et al.</a> (1983) USA RCT PEDro=4 N=38	<b>Population:</b> Head injury; <i>Standard enteral nutrition (SEN) Group (n=18)</i> : Mean Age=34.9 yr; Mean GCS Score=7.2. <i>Total Parenteral nutrition (TPN) Group (n=20)</i> : Mean Age=29.2 yr; Mean GCS Score=7.7. <b>Intervention:</b> Patients were randomly assigned to either the SEN or TPN group. TPN therapy was initiated within 48 hr of admission. EN was given via nasogastric tubes and initiated when tolerated. <b>Outcome Measure:</b> Nutritional status (serum albumin, nitrogen balance, and daily calorie and nitrogen intake).	<ol style="list-style-type: none"> <li>1. No baseline between-group differences with the exception of mean peak temperature during the first 24 hr of hospitalization; TPN group had a higher mean temperature than SEN group (38.6°C versus 38.0°C; <math>p=0.02</math>).</li> <li>2. Within the 18 day period, 8 of the 18 patients died in the SEN group compared to 0 deaths in the TPN group (<math>p&lt;0.0001</math>).</li> <li>3. The TPN group had a significantly greater mean intake in nitrogen/d then the SEN group (10.2 gm versus 4.0 gm; <math>p=0.002</math>); the overall nitrogen balance was also significantly different between groups (<math>p=0.002</math>).</li> <li>4. No significant between group difference was found in serum albumin levels over time.</li> </ol>
<a href="#">Chapple et al.</a> (2016) Australia Case Control N=37	<b>Population:</b> TBI=37; Mean Age=45.3 yr; Gender: Male=32, Female=5; Severity: Moderate=12, Severe=24. <b>Intervention:</b> Nutrition was delivered enterally (EN), parenterally (PN), or orally. Protein intake and energy levels quantified during patients' stay in the ICU (530 days) and once moved to ward-based care (982 days) for a total of 1512 days. Protein and nutrients consumed calculated by comparison of weight before and after each meal for 3 days/wk. <b>Outcome Measure:</b> Dietitian clinical assessments via FoodWorks 8 (FW8) dietary analysis software.	<ol style="list-style-type: none"> <li>1. EN was administered to 34 patients while in ICU and 18 in the ward. No patients received PN during the study period.</li> <li>2. Thirty-two patients completed oral feeding at least once (mean=17.5 days), with 20 beginning in ICU and 12 in the ward.</li> <li>3. Less absolute energy (<math>p=0.015</math>) and protein (<math>p=0.001</math>) intake in ICU than the ward according to FW8.</li> <li>4. Patients met their absolute requirements for energy and protein 83% and 75% of the time, respectively.</li> <li>5. Larger difference in prescribed vs actual energy intake in the ward than ICU (<math>p=0.039</math>), with no significance for protein intake (<math>p=0.278</math>).</li> <li>6. More contribution from EN than oral for both energy (1778 vs 1259 kcal/d; <math>p=0.488</math>) and protein (88 vs 57 g/d; <math>p=0.373</math>), and those that exclusively were EN had smaller energy deficits than oral feeding (<math>p=.016</math>).</li> </ol>
<a href="#">Fan et al.</a> 2016 China Prospective Controlled Trial N=40	<b>Population:</b> Mean Age=41.69 yr; Gender: Male=62, Female=58. <b>Intervention:</b> Patients were assigned to receive nutrition enterally (EN), parenterally (PN), or both (EN+PN), supported by nutritional therapies. Measures were taken at day 1 and day 20. <b>Outcome Measure:</b> Nutritional status, complications, clinical outcomes.	<ol style="list-style-type: none"> <li>1. Total serum protein was significantly decreased in the PN group (<math>p&lt;0.01</math>) compared to serum protein on day 1, whereas total serum protein was significantly increased in EN and EN+PN groups (<math>p&lt;0.01</math>).</li> <li>2. The EN group had significantly higher rates of diarrhea (<math>p&lt;0.01</math>) compared to the PN and EN+PN group.</li> <li>3. Stress ulcers were significantly higher in the PN group (<math>p&lt;0.01</math>) than the other two groups.</li> <li>4. The EN group had significantly higher rates of aspirated pneumonia (<math>p&lt;0.01</math>). The EN group had the lowest rates of pyemia (<math>p&lt;0.01</math>).</li> <li>5. The EN+PN group had the lowest rates of hypoproteinemia (<math>p&lt;0.01</math>) and intracranial infection (<math>p&lt;0.01</math>).</li> </ol>



Author/Year/ Country/Study design/PEDro Score/N	Methods	Outcome
<a href="#">Krakau et al.</a> (2007) Sweden Case Control N=64	<b>Population:</b> TBI; Mean Age=35 yr; Gender: Male=53, Female=11; GCS Score Range=3-8. <b>Intervention:</b> Patients received parenteral nutrition (PN) and enteral nutrition (EN), use of gastrostomy, course of assisted feeding. <b>Outcome Measure:</b> Malnutrition Universal Screening Tool.	<ol style="list-style-type: none"> <li>1. While in intensive care, patients received nutrition PN for mean of 19 days.</li> <li>2. Most patients (86%) also received EN which was started on average 4 days after injury.</li> <li>3. Patients received EN from 1-178 days post PN.</li> <li>4. Of the 55 patients receiving EN, 14 received a gastrostomy approximately 1 mo post injury (4 patients continued to depend on gastrostomy at 6 mo).</li> <li>5. By 6 mo post injury, 54 (84%) patients were nutritionally independent.</li> <li>6. Of the 56 patients assessed for malnourishment, 38 (68%) met the criteria.</li> </ol>

PEDro = Physiotherapy Evidence Database rating scale score (Moseley et al., 2002).

## Discussion

Nataloni et al. (1999) studied the effects of EN, PN, or both in a group of ABI patients while in the intensive care unit. Even though there was a negative nitrogen balance in all groups, all showed improvement over the course of the study, however a positive nitrogen balance was only seen in the enteral group. With respect to nitrogen balance, Justo Meirelles and de Aguilar-Nascimento (2011) also evaluated the effects of EN and PN in 22 patients with moderately severe TBI and found that parenteral nutrition delivered nitrogen more effectively. Both groups received increasing quantities of nitrogen each day, with those in the total parenteral nutrition (TPN) group receiving significantly more. Despite the increased daily loss of nitrogen, all patients showed significant improvement in nitrogen balance as a result of nutritional therapy (Justo Meirelles & de Aguilar-Nascimento, 2011). A RCT by Rapp et al. (1983) investigating EN versus PN demonstrated a significantly different overall nitrogen balance between groups, in favour of PN ( $p=0.002$ ). Other studies have found no difference in nitrogen balance between PN and EN (Borzotta et al., 1994; Hadley et al., 1986; Hausmann et al., 1985).

The RCT by Rapp et al. (1983) also reported fewer deaths occurring among individuals receiving TPN compared to standard EN (0 versus 44%,  $p<0.0001$ ). However, there were no significant differences in terms of serum albumin levels over time. This is contrary to a later study which found that patients who received EN showed significant increases in serum pre-albumin and retinol-binding protein compared to the PN or combined EN and PN (Nataloni et al., 1999).

Hausmann et al. (1985) conducted an RCT to investigate the effects of combined EN and PN compared to TPN on protein catabolism. Findings from the study noted the difference in the nitrogen balance between the two feeding regimes; however, these differences were not significant. The combination EN and PN group did have significantly higher protein concentrations compared to the TPN group, but no other relevant differences in the metabolic data or mortality between each of these treatment groups was found (Hausmann et al., 1985).

A case control study by Chapple et al. (2016) investigated EN versus oral feeding; the results demonstrated a significantly greater energy deficit for patients receiving nutrition orally versus EN ( $p=0.016$ ), however, protein deficits were similar. However, it was found that ward admission had significantly higher levels of caloric intake prescribed than intensive care unit (ICU) admission overall. Fan et al. (2016) conducted a prospective controlled trial comparing EN versus PN versus combined EN

and PN. Total serum protein, prealbumin, and hemoglobin were significantly decreased in the PN group ( $p < 0.01$ ), which corresponds to a degradation in nutritional status; in the EN and EN+PN groups, total serum and protein levels significantly increased ( $p < 0.01$ ) after nutritional treatment. Therefore, the authors suggest a combination of EN+PN to improve prognosis and nutritional status for post-ABI patients. A case control conducted by Krakau et al. (2007) found that 68% of patients who had sustained an ABI showed signs of malnutrition within the first two months of injury. When first admitted to hospital, all patients initially received nutrition parenterally for the first 19 days following injury. The majority of these patients (86%) then received EN (Krakau et al., 2007).

### **Conclusions**

***There is level 2 evidence that enteral in combination with parenteral nutrition may be effective for increasing protein levels compared to parenteral nutrition alone in patients with ABI.***

***There is conflicting evidence regarding whether or not one nutrition administration method (enteral or parenteral) is more effective compared to the other for improving the nitrogen balance of patients with ABI.***

***There is conflicting evidence regarding whether or not one nutrition administration (enteral or parenteral) is more effective compared to the other for improving serum albumin levels in patients with ABI.***

***There is level 2 evidence that enteral nutrition results in higher mortality compared to parenteral nutrition in patients with ABI, however enteral and parenteral nutrition may have similar effects on morbidity.***

***There is level 2 evidence that enteral nutrition in combination with parenteral nutrition versus parenteral nutrition alone have a similar effect on mortality in patients with ABI.***

***There is level 2 evidence that parenteral nutrition can safely be administered without causing serum hyperosmolality compared to enteral nutrition, and that neither treatment influences intracranial pressure levels, in patients post ABI.***

**A combination of both enteral and parenteral nutrition has been shown to provide an increase in protein levels post ABI.**

**Further research is needed to clarify the effect of both feeding routes on nitrogen balance and albumin levels post ABI.**

#### **5.7.4.4 Enhanced Enteral Nutrition**

EN feeding solutions enriched with immune-enhancing nutrients may decrease the occurrence of sepsis and reduce the inflammatory response. Theoretically, glutamine may improve the nutrition of both the gut mucosa and immune cells, while probiotic bacteria could favorably alter the intraluminal environment, competing for nutrients and adhesion sites with pathogenic bacteria. These co-operative actions may reduce the rate of bacterial translocation and, thus, decrease both the incidence of



infection and the length of hospitalization (Falcao de Arruda & de Aguilar-Nascimento, 2004). Studies examining the effects of enhanced enteral nutrition are presented in Table 5.17.

**Table 5.17 Enhanced Enteral Nutrition for Nutritional Management Post ABI**

Author/Year/ Country/Study design/PEDro Score/ N	Methods	Outcomes
<a href="#">Falcao de Arruda and Aguilar-Nascimento</a> (2004) Brazil RCT PEDro=7 N=20	<b>Population:</b> TBI; <i>Treatment Group (n=10):</i> Mean Age=27 yr; Gender: Male=10, Female=0; Mean GCS Score=7. <i>Control Group (n=10):</i> Mean Age=26 yr; Gender: Male=9, Female=1; Mean GCS Score=7. <b>Intervention:</b> Patients were randomized to receive either the standard diet (control) or the glutamine- and probiotics-enhanced diet (treatment group). <b>Outcome Measure:</b> Incidence of infection, length of stay (LOS) in ICU, ventilation days.	1. Infection rate was higher in the control than in the treatment group ( $p=0.03$ ). 2. LOS ( $p<0.01$ ), as well as the number of days on ventilation ( $p=0.04$ ), was significantly higher in the control group compared to the treatment group.
<a href="#">Taylor et al.</a> (1999) UK RCT PEDro=4 N=82	<b>Population:</b> Head Injury. <i>Intervention Group (n=41):</i> Median Age=34 yr. <i>Control Group (n=41):</i> Median Age=28 yr. <b>Intervention:</b> Patients were randomly allocated to receive either the standard enteral nutrition (EN) or the enhanced EN (intervention). EN was initiated from day 1 in both groups. In the control group, EN was gradually increased from 15 mL/hr up to estimated energy and nitrogen requirements. In the intervention group, feeding was administered at a rate that met estimated energy and nitrogen requirements. Follow-up at 3 and 6 mo. <b>Outcome Measure:</b> Neurologic outcome, incidence of major infection, Length of stay (LOS).	1. Patients receiving enhanced EN had a significantly higher mean percentage of energy ( $p=0.0008$ ) and nitrogen ( $p<0.0001$ ) requirements met over the initial week following injury when compared to the control group. This finding was mostly attributable to improved NG feeding as only 14 intervention patients (34%) had intestinal tubes successfully placed. 2. The median percentage of energy and nitrogen requirements delivered in control patients remained <60% even by day 7 post injury. 3. Neurologic outcome at 6 mo follow-up (intervention, 68% versus control, 61%; $p=0.64$ ) was similar between the groups, but there was a trend toward improved outcome at 3 mo follow-up in favour of the intervention group (61% versus 39%; $p=0.08$ ). 1. Intervention patients had fewer infections (61% versus 85%; $p=0.02$ ) and earlier discharge ( $p=0.008$ ).
<a href="#">Painter et al.</a> (2015) USA Case Control N=240	<b>Population:</b> TBI=240; <i>Immune Enhancing Nutrition (IEN; n=126):</i> Mean Age=43.7 yr; Mean GSC=6; <i>Standard Formula (SF; n=114):</i> Mean Age=46.7 yr; Mean GCS=7. <b>Intervention:</b> Two groups that received enteral nutrition of either IEN (treatment) or SF (control) were analyzed to determine if immune enhancing nutrients would provide better outcomes. <b>Outcome Measure:</b> Hospital and ICU length of stay (LOS), cultures of blood, urine, and respiratory, temperature, white blood cell (WBC) count, chest X-Ray, nutrition type and measures.	2. IEN had longer LOS in ICU ( $p=0.02$ ) and more days on ventilator ( $p=0.001$ ) than SF, but were less likely to have bacteremia ( $p<0.05$ ). 3. No significant difference between IEN and SF in rates of urinary tract infections ( $p=0.48$ ), <i>Clostridium difficile</i> ( $p=0.63$ ), and pneumonia ( $p=0.89$ ). 4. Similar fungi/bacteria present within both groups. 5. No significant difference in mortality rates during hospital stay ( $p=0.88$ ).

PEDro = Physiotherapy Evidence Database rating scale score (Moseley et al., 2002).

## Discussion

A RCT comparing standard diet to glutamine and probiotic enhanced diet in brain injured patients showed lower infection rates in the enhanced diet group, as well as decreased length of stay (LOS) and

ventilator days for those on enhanced diets (Falcao de Arruda & de Aguilar-Nascimento, 2004). Painter et al. (2015) reviewed patients given either immune enhancing nutrition (IEN) or standard formula. Surprisingly, patients with IEN had longer LOS in ICU ( $p=0.02$ ) and more days on ventilator than SF, but were less likely to have bacteremia ( $p<0.05$ ). This conflicts with another RCT which found that enhanced EN feeding resulted in earlier discharge and fewer infections in ABI patients (Taylor et al., 1999). Taylor et al. (1999) also found that those receiving enhanced EN, compared to standard EN, met significantly more of their daily nitrogen and energy requirements. However, there were no differences in neurological outcome.

Brain injury patients have higher energy and protein expenditures and are prone to infections, thus supplementing diet and enhancing feeding solutions may be a feasible option to consider when improving outcomes.

### Conclusions

***There is conflicting level 1b and level 3 evidence regarding whether or not enhanced enteral nutrition can reduce the incidence of infection, ventilator dependency period, or length of stay compared to standard formula nutrition in patients post ABI.***

**The evidence is conflicting regarding the effect of enhanced enteral nutrition on infection rates, ventilator dependency, and hospital length of stay in patients post ABI.**

#### 5.7.4.5 Timing of Enteral Nutrition

Early enteral feeding (EEF) is desirable as a means to prevent intestinal mucosal atrophy and to preserve gut integrity; although, as previously noted, feeding intolerance occurs frequently. The following table presents literature surrounding the timing of enteral feeding (Table 5.18).

**Table 5.18 Timing of Enteral Feeding for Nutritional Management Post ABI**

Author/Year/ Country/Study design/PEDro score/N	Methods	Outcomes
<a href="#">Chourdakis et al.</a> (2012) Greece RCT PEDro=6 N=59	<b>Population:</b> TBI; <i>Delayed Enteral Feeding (DEF) Group</i> ( $n=25$ ): Mean Age=33.3 yr; Gender: Male=21, Female=4; Mean GCS Score=5.22. <i>Early Enteral Feeding (EEF) Group</i> ( $n=34$ ): Mean Age=36.13 yr; Gender: Male=26, Female=8; Mean GCS Score=5.81. <b>Intervention:</b> Patients admitted to the ICU were randomly allocated to receive either DEF (2-5 days post admission) or EEF (initiated within the first 24-48 hr of admission). Measurements were taken on day 1, 6 and 12. <b>Outcome Measure:</b> Hormone levels, dietary information.	<ol style="list-style-type: none"> <li>1. The EEF group began enteral feeding approximately 31 hr post admission and the DEF group began approximately 77 hr post admission.</li> <li>2. Kilocalories administration was lower in the DEF group compared to the EEF group (<math>p&lt;0.01</math>).</li> <li>3. Several endocrine changes were noted for the groups, with the EEF group showing significant improvements compared to the DEF group (<math>p&lt;0.05</math>).</li> <li>4. No differences were noted in mortality and morbidity in either group despite enteral feeding.</li> </ol>
<a href="#">Minard et al.</a> (2000) USA RCT	<b>Population:</b> TBI; Time Post-Injury= $\leq 6$ hr; <i>Early Group</i> ( $n=12$ ): Mean Age=30 yr; Gender: Male=9, Female=3; Mean GCS	<ol style="list-style-type: none"> <li>1. No significant differences between groups with regard to mortality, length of stay, ventilator</li> </ol>

Author/Year/ Country/Study design/PEDro score/N	Methods	Outcomes
PEDro=5 N=27	Score=7. <i>Late Group (n=15)</i> : Mean Age=36 yr; Gender: Male=10, Female=5; Mean GCS=7. <b>Intervention</b> : Patients were randomly assigned to either early (within 60 hr of injury) or late enteral feeding. The late group received feeding when tolerated by the patient (i.e., gastroparesis was resolved). <b>Outcome Measure</b> : Infection rates, Length of stay, ventilator days, instances of pneumonia, mortality.	days, number of infections per patient or patients with pneumonia. 2. Admission GCS score was a good predictor of infection ( $p<0.003$ ), Length of stay in the ICU ( $p<0.02$ ), and ventilator days ( $p<0.007$ ).
<a href="#">Taylor and Fettes</a> (1998) UK RCT PEDro=4 N=82	<b>Population</b> : Head Injury. <i>Intervention Group (n=41)</i> : Median Age=34 yr. <i>Control Group (n=41)</i> : Median Age=28 yr. <b>Intervention</b> : Patients were randomly assigned to receive either the standard Enteral Nutrition (EN) or the early EN. EN was initiated from day 1; however, in the control group, EN was gradually increased from 15 mL/hr up to estimated energy and nitrogen requirements. In the intervention group, feeding was administered at a rate that met estimated energy and nitrogen requirements. <b>Outcome Measure</b> : Nutritional intake, nitrogen balance, volume of gastric residuals, incidence of pneumonia.	1. Overall, patients received EN during 57% of the potential feeding time, with the longest interruption to feeding time coming from the rest period (13%). 2. Patients receiving early EN had a greater energy and nitrogen intake compared to standard EN patients over the initial week following brain injury ( $p<0.02$ ). 3. Intervention patients received a higher volume of enteral fluid ( $p<0.02$ ) but did not have a higher incidence of pneumonia or aspiration.
<a href="#">Chaudhry et al.</a> (2017) USA Case Series N=3343	<b>Population</b> : TBI; <i>Early (n=877)</i> : Age:( $<18$ )=17, (18-49)=260, (50-64)=162, ( $>65$ )=438; Gender: Male=560, Female=317. <i>Standard (n=1300)</i> : Age: ( $<18$ )=33, (18-49)=309, (50-64)=278, ( $>65$ )=679; Gender: Male=899, Female=401. <i>Late (n=1166)</i> : Age( $<18$ )=49, (18-49)=284, (50-64)=271, ( $>65$ )=562; Gender: Male=807, Female=359. <b>Intervention</b> : A national inpatient sample from 2011-2013 was analyzed. Outcomes of TBI patients that received either early, standard (7-14days) or late percutaneous endoscopic gastronomy (PEG) placement for nutritional support were compared. <b>Outcome Measure</b> : Charleston Comorbidity Index (CCI), Length of Stay (LOS), complications, mortality.	1. Early PEG placement times seemed to correlate with lower CCI scores, while late PEG placement times were correlated with higher CCI scores. 2. Patients in the late PEG group had the longest LOS. 3. Patients in the later PEG group seemed to have more complications. 4. Overall mortality during hospitalization was 6.39% for the early PEG group, 5.08% for the standard PEG group, and 5.67% for the late PEG group.
<a href="#">Azim et al.</a> (2016) United States Case Control N= 90	<b>Population</b> : Mean Age=41.6 yr; Gender: Male=66, Female=24; Mean GCS=3. <b>Intervention</b> : Patients who received early tube feeding ( $<24$ hr) were compared to those who had late tube feeding ( $>24$ hr). <b>Outcome Measure</b> : Mortality, pneumonia, aspiration, bacteremia, ICU-free days, ventilator-free days.	1. There were no significant differences between groups in terms of mortality as a result of early versus late tube feeding. 2. There were no significant differences on any other outcome measures between groups.

Author/Year/ Country/Study design/PEDro score/N	Methods	Outcomes
<a href="#">Dhandapani et al.</a> (2012) India Prospective Controlled Trial N=67	<p><b>Population:</b> TBI; Time Post-Injury <math>\leq 24</math> hr; <i>Total enteral feeding (<math>\leq 3</math> days) Group:</i> Mean Age=31.7 yr. <i>Total enteral feeding (4-7 days) Group:</i> Mean Age=34.4 yr. <i>Total enteral feeding (<math>&gt;7</math> days) Group:</i> Mean Age=37.2 yr.</p> <p><b>Intervention:</b> Participants were administered enteral feeding as early as possible; before 3 days, at 4-7 days, and after 7 days. The volume of feed was increased gradually in keeping with an individual's gastric tolerance.</p> <p><b>Outcome Measure:</b> Glasgow Outcome Scale (GOS), mid-arm circumference (MAC), mid-arm muscle circumference (MAMC), and serum total protein.</p>	<ol style="list-style-type: none"> <li>1. Those receiving total enteral feeding <math>&gt;7</math> days post injury lost significantly more MAC and MAMC compared to those in the earlier fed groups (<math>p \leq 0.001</math>).</li> <li>2. Analysis of total serum protein revealed that more malnutrition was seen in those who received total enteral feeding <math>&gt;7</math> days post-injury (<math>p \leq 0.005</math>).</li> <li>3. At the 3 and 6 mo follow-up, those receiving total enteral feeding within the first 7 days were more likely to have favourable outcomes on the GOS.</li> </ol>

PEDro = Physiotherapy Evidence Database rating scale score (Moseley et al., 2002).

## Discussion

Chourdakis et al. (2012) compared delayed enteral feeding with EEF in 59 individuals post severe TBI. Although rates of complications were comparable between groups, the length of feeding for the EEF group was significantly shorter than the length of feeding for the delayed group. Hormonal measurements also indicated that those in the early group showed significant improvements on several hormonal measures (Chourdakis et al., 2012).

Minard et al. (2000) and Azim et al. (2016) found that timing of enteral feeding had no significant impact on mortality, number of infections, ventilator days, or incidence of pneumonia. Chaudhry et al. (2017) looked at inpatients who received early, standard, or late percutaneous endoscopic gastronomy (PEG) for nutritional support post ABI. Their results showed that late PEG was associated with a higher comorbidity index, longer LOS, and more complications compared to early PEG.

In a prospective study comparing total EN at various time points (within 3 days, 4-7 days, and after 7 days) there were unfavourable outcomes associated with total EN after 3 days (Dhandapani et al., 2012). Those who began later lost significantly more mid-arm circumference and mid arm muscle circumference and had worse malnutrition. At the third and sixth month follow-ups, those receiving total EN within the first 7 days were more likely to have favourable outcomes on the GOS (Dhandapani et al., 2012).

A Cochrane review by Yanagawa et al. (2000) identified six RCTs that addressed the timing to initiation of feeding and mortality as an outcome. The relative risk for death associated with early nutritional support was 0.71 (95% CI 0.43-1.16). The pooled relative risk from three trials, which also assessed death and disability, for early feeding was 0.75 (0.50-1.11). Although the results were not statistically significant, it was concluded that early feeding may be associated with a trend towards better outcomes in terms of survival and disability (Yanagawa et al., 2000).

## Conclusions:

*There is level 1b evidence that early enteral nutrition may improve the hormonal profile of patients with TBI compared to delayed enteral feeding.*

*There is level 2 evidence that early versus late enteral feeding has a similar effect on mortality, number of infections, ventilator days, or incidence of pneumonia in patients with ABI.*

*There is level 2 evidence that early enteral nutrition may improve energy and nitrogen intake compared to standard enteral nutrition in ABI populations.*

*There is level 4 evidence that late percutaneous endoscopic gastrostomy may be associated with a higher comorbidity index, longer length of stay, and more complications compared to early percutaneous endoscopic gastrostomy in patients with ABI.*

*There is level 2 evidence that late total enteral feeding can result in reduced arm circumference, worse malnutrition, and more disability compared to early total enteral feeding in patients with ABI.*

Early enteral nutrition may be more beneficial than standard or late enteral nutrition for several patient outcomes post ABI.

#### 5.7.4.6 Timing of Parenteral Nutrition

Early PN support provided directly following injury could assist in the maintenance of immunocompetence and help reduce the incidence of infection following ABI (Sacks et al., 1995).

**Table 5.19 Timing of Parenteral Feeding for Nutritional Management Post ABI**

Author/Year/ Country/Study design/PEDro Score/ N	Methods	Outcomes
<a href="#">Sacks et al.</a> (1995) USA RCT PEDro=5 N=9	<p><b>Population:</b> Head injury; <i>Early Group</i> (n=4): Mean Age=39.3 yr; Gender: Male=4, Female=0; Mean GCS Score=8. <i>Delayed Group</i> (n=5): Mean Age=35.2 yr; Gender: Male=4, Female=1; Mean GCS Score=7.</p> <p><b>Intervention:</b> Patients were randomly allocated to receive either early parenteral nutrition (PN) at day 1 or delayed PN at day 5. All patients received PN through a central venous catheter with a nutrient goal of 2 g protein/kg/d &amp; 40 non-protein kcal/kg/day for at least the initial 14 days of hospitalization. Assessments were made on entry, and days 3, 7, and 14.</p> <p><b>Outcome Measure:</b> Cell counts of T-lymphocytes with expression of CD4 and CD8 antigens, lymphocyte response following Con A stimulation.</p>	<ol style="list-style-type: none"> <li>From baseline to day 14, there was a significant increase in the total CD4 cell count (<math>p&lt;0.05</math>) and in CD4 (%) (<math>p&lt;0.001</math>) in the early PN group, while remaining relatively stable in the delayed PN group. Differences in total CD4 cell count and in CD4 (%) at day 14 was significant between the groups as well (<math>p&lt;0.05</math>).</li> <li>The CD4-CD8 ratio significantly increased from baseline to day 14 in the early PN group (<math>p&lt;0.05</math>), but not in the delayed PN group. The difference between groups, however, was not significant.</li> <li>From baseline to day 14, following Con A stimulation, an improved lymphocyte response was demonstrated in the early PN group (<math>p&lt;0.05</math>), but not in the delayed PN group.</li> </ol>

PEDro = Physiotherapy Evidence Database rating scale score (Moseley et al., 2002).

## Discussion

A study by Sacks et al. (1995) found that in individuals with closed head injuries, early PN nutrition was beneficial in modifying immunologic function; more specifically, it aided in improving CD4 cells, CD4-CD8 ratios, and T-lymphocyte responsiveness to Con A. Further research is warranted to determine if this is a consistent effect of early versus late PN (Sacks et al., 1995).

### Conclusions:

*There is level 2 evidence that early parenteral nutrition support may improve immunologic function compared to delayed parenteral nutrition in patients with closed head injury.*

**Early parenteral nutrition support of ABI patients may improve immunologic function.**

### 5.7.4.7 Types of Enteral Feeding

EEF has been associated with improved outcomes; however, the effectiveness of the intervention may vary depending on the mode of feeding. Nasogastric feeding tubes have been associated with increased incidence of pneumonia, while theoretically, feeding tubes placed more remotely decrease the risk. Gastronomies are proven to be a safe and dependable process used to provide enteral access for meeting nutritional needs of patients with ABI and delivering essential medications (Harbrecht et al., 1998).

**Table 5.20 Types of Enteral Feeding for Nutritional Management Post ABI**

Author/Year/ Country/Study design/PEDro Score/N	Methods	Outcomes
<a href="#">Kostadima et al.</a> (2005) Greece RCT PEDro=6 N=41	<p><b>Population:</b> Stroke=25, Head Injury=16; Mean Ag=47.3 yr; Gender: Male=32, Female=9.</p> <p><b>Intervention:</b> Ventilator dependant patients received either a gastrostomy or nasogastric tube for enteral feeding. Tubes were inserted within 24 hr of intubation. Patients were followed for 3wk.</p> <p><b>Outcome Measure:</b> Pneumonia rates, length of stay (LOS) in intensive care unit, ventilation days, mortality.</p>	<ol style="list-style-type: none"> <li>1. At the end of wk 2 and 3 the cumulative incidence of pneumonia was significantly higher in the nasogastric, compared to the gastrostomy group (<math>p&lt;0.05</math>).</li> <li>2. At the end of the first week the incidence of pneumonia was higher in the gastrostomy group although the result was not statistically significant.</li> <li>3. No significant difference between groups in LOS, ventilation days, or mortality rates were found.</li> </ol>

PEDro = Physiotherapy Evidence Database rating scale score (Moseley et al., 2002).

### Discussion

One study has examined the effect of early gastrostomy compared to nasogastric tubes on ventilator-associated pneumonia post head injury or stroke. Kostadima et al. (2005) found that those who received a nasogastric tube had significantly higher rates of pneumonia compared to the gastrostomy group at the end of the second and third weeks of treatment. However, no other significant differences were found in terms of LOS, ventilation days, or mortality. Further research should be conducted to examine the effect of type of EN on patient outcomes in ABI populations.

### Conclusions



***There is level 1b evidence that the risk of developing pneumonia is higher among ventilated patients (stroke and head injury) fed by a nasogastric tube compared with a gastrostomy tube.***

**There may be an increased risk of developing pneumonia for ventilated stroke and head injury patients fed by a nasogastric versus a gastrostomy tube.**

#### 5.7.4.8 Metoclopramide and Enteral Feeding

Individuals who sustain a severe TBI often show signs of gastroparesis. For many individuals with a severe ABI, their energy requirements may reach 60% more than predicted. Metoclopramide has been used and continues to be used to enhance the effectiveness of enteral nutrition, despite its limited success and the inconsistent findings supporting its use (Nursal et al., 2007).

**Table 5.21 Metoclopramide and Enteral Nutrition for Nutritional Management Post ABI**

Author/Year/ Country/Study design/PEDro Score/ N	Methods	Outcomes
<a href="#">Nursal et al.</a> (2007) USA RCT PEDro=9 N=19	<b>Population:</b> TBI; <i>Control Group (n=9)</i> : Mean Age=43 yr; Gender: Male=8, Female=1; Mean GCS Score=8.9. <i>Treatment Group (n=10)</i> : Mean Age=43.8 yr; Gender: Male=8, Female=2; Mean GCS Score=7.7. <b>Intervention:</b> Patients in the treatment group were administered 10 mg (2 mL) IV metoclopramide 3x/day for 5 days. The control group received the same volume of control saline solution for the same duration. <b>Outcome Measure:</b> Paracetamol absorption test, amount of calories supplied, intolerance and/or complication rates.	<ol style="list-style-type: none"> <li>1. Amount of oral/enteral calories in relation to the total number of calories received during the first 5 days was higher for those in the control group (<math>p=0.043</math>).</li> <li>2. There were no differences between the groups in both feeding intolerance and complication rates (<math>p=0.543</math> and <math>p=0.930</math>, respectively).</li> <li>3. There was no significant difference between the groups when looking at the results of the paracetamol absorption test.</li> <li>4. When looking at absorption parameters, those in the treatment group had levels that were slightly more pronounced than those in the control group.</li> </ol>

PEDro = Physiotherapy Evidence Database rating scale score (Moseley et al., 2002).

#### Discussion

A single RCT by Nursal et al. (2007) compared a treatment group receiving 10 mg of metoclopramide per day for five days to a control group receiving placebo. All patients were receiving EN through a nasogastric feeding tube. When looking at the absorption parameters of the two groups, a small non-significant difference was found, with the levels in the treatment group being slightly more pronounced. Overall, the study showed no advantages of metoclopramide in a TBI population.

#### Conclusions

***There is level 1b evidence that metoclopramide may not be effective compared to placebo for gastric emptying in patients with TBI.***

**The use of metoclopramide to aid in gastric emptying may not be effective post TBI.**



## 5.7.5 Miscellaneous Therapies

### 5.7.5.1 Zinc Supplementation

Zinc is an essential element for humans as it is vitally important for normal nucleic acid and protein metabolism (McClain et al., 1986). Moderate zinc deficiency has been associated with cell death. Serum hypozincemia and increased urinary zinc excretion are common following head injury and are thought to be an adaptive response to inhibit the proliferation of infective organisms. Levels of serum albumin, the major transport carrier for zinc, are also markedly depressed following brain injury and likely help to explain a portion of the reductions in serum zinc levels. Urinary excretion of zinc appears to be proportional to the severity of head injury (Levenson, 2005).

**Table 5.22 Zinc Supplementation for Nutritional Management Post ABI**

Author/Year/ Country/Study design/PEDro Score/N	Methods	Outcomes
<a href="#">Young et al.</a> (1996) USA RCT PEDro=7 N=68	<p><b>Population:</b> Head injury; <i>Intervention Group</i> (n=33): Mean Age=34.6 yr; Gender: Male=27, Female=6; Mean GCS Score=6.4. <i>Control Group</i> (n=35): Mean Age=35.9 yr; Gender: Male=28, Female=7; Mean GCS Score=6.6.</p> <p><b>Intervention:</b> Patients were randomly assigned to receive either zinc at a standard level (2.5 mg) or zinc-supplementation (12 mg) for 15 days. After 15 days, oral zinc (168 mg zinc gluconate, 22 mg elemental zinc) or matching placebo tablet were given for a total of 3 mo.</p> <p><b>Outcome Measure:</b> Glasgow Coma Scale (GCS), mortality, zinc concentration, serum pre-albumin levels, retinol-binding protein (RBP) concentrations.</p>	<ol style="list-style-type: none"> <li>1. There was no significant difference in 1 mo mortality rates between groups (p=0.09).</li> <li>2. GCS scores of the zinc-supplemented group were greater than the adjusted mean GCS score of the standard group at day 28 (p=0.03).</li> <li>3. Mean serum pre-albumin levels and mean RBP concentrations were significantly higher in the zinc-supplementation group at 3 wk post injury (p=0.003 and p=0.01, respectively).</li> <li>4. The groups were not different in serum zinc concentration, weight, energy expenditure, or total urinary nitrogen excretion after admission.</li> <li>5. The mean 24 hr urine zinc levels were significantly greater in the zinc-supplemented group at days 2 (p=0.0001) and 10 (p=0.01).</li> </ol>

PEDro = Physiotherapy Evidence Database rating scale score (Moseley et al., 2002).

## Discussion

One RCT has examined the effect of parenteral zinc supplementation following ABI (Young et al., 1996). An improvement in protein synthesis and neurological recovery in patients who received supplementation was reported, in comparison to matching placebo tablet. Surprisingly, there were no differences in either the serum or cerebrospinal fluid zinc concentrations between the groups.

## Conclusions

***There is level 1b evidence that zinc supplementation has a positive effect on neurological recovery compared to placebo as measured by the Glasgow Coma Scale in ABI patients.***

**Zinc supplementation in the immediate post-injury period has been shown to be beneficial in terms of neurologic recovery and visceral protein concentrations, but not mortality rates, in ABI patients.**

### 5.7.5.2 Growth Hormone

Anabolic agents have been proposed as a means to improve lean body mass (Behrman et al., 1995). It has been reported that GH mobilizes fat stores as an energy source and enhances whole body and liver mitochondrial protein stores (Maddaiah et al., 1973; Merimee & Rabin, 1973). It is believed that GH exert their effects via insulin-like growth factor-1 (IGF-1), which is synthesized in the liver (Phillips & Vassilopoulou-Sellin, 1980). Several studies in non-stressed postoperative patients have demonstrated improvements in nitrogen balance following the use of GH (Manson et al., 1988; Manson & Wilmore, 1986; Ponting et al., 1988). The effects of GH on the nutritional parameters of injured patients have not been well established; existing studies examining this topic are presented in Table 5.23.

**Table 5.23 Growth Hormone Treatment for Nutritional Management Post ABI**

Author/Year/ Country/Study design/PEDro Score/N	Methods	Outcomes
<a href="#">Hatton et al.</a> (2006) USA RCT PEDro=7 N=97	<p><b>Population:</b> TBI; <i>Treatment Group:</i> Mean Age=30 yr; Gender: Male=38, Female=11; Mean GCS Score=6.4. <i>Control Group:</i> Mean Age=29 yr; Gender: Male=33, Female=15; Mean GCS Score=6.7.</p> <p><b>Intervention:</b> Patients were randomized to receive either IGF-I/GH or placebo within 72 hr of admission to the hospital. Those in the treatment group received 0.01 mg/kg/hr IV IGF-I by continuous infusion for up to 14 days, as well as 0.05 mg/kg/day subcutaneous GH. Controls were given normal saline but insulin was used to keep glucose concentrations &lt;200 mg/dl. Patients also received concomitant nutritional support (enteral or parenteral).</p> <p><b>Outcome Measure:</b> Glucose concentrations, energy expenditure, nitrogen balance, protein and calorie intake.</p>	<ol style="list-style-type: none"> <li>1. Nutritional endpoints: energy expenditure was slightly different for the two groups (2271±575.6 kcal/day in the control group and 2366±627.8 kcal/day in the treatment group).</li> <li>2. In the treatment group, the mean daily glucose concentrations were higher than those of the control group (123±24 mg/dl versus 104±11mg/dl; p&lt;0.03).</li> <li>3. Within the first 24 hr nitrogen balance was positive and it remained positive for the duration of the study.</li> <li>4. Nitrogen balance was higher for the IGH/GH group (p=0.0001). Neither group reached calorie or protein intake goals; groups did not differ significantly in their intake.</li> </ol>
<a href="#">Behrman et al.</a> (1995) USA RCT PEDro=4 N=16	<p><b>Population:</b> Head injury=11, SCI=5; Gender: Male=12, Female=4; Mean GCS score=10. <i>Intervention Group (n=8):</i> Mean Age=23 yr. <i>Control Group (n=8):</i> Mean Age=46 yr.</p> <p><b>Intervention:</b> Patients were randomly allocated to receive either intramuscular growth hormone (GH; 0.2 mg/kg) every day or 1 mL normal saline (control) for 7-10 days. Assessments were made on days 1, 3, 7, and 10.</p> <p><b>Outcome Measure:</b> Nitrogen balance, glucose concentration, triglyceride concentrations, thyroid function, serum protein concentration, lymphocyte count, prognostic nutritional index (PNI).</p>	<ol style="list-style-type: none"> <li>1. GH treatment did not improve nitrogen balance, glucose concentration, triglyceride concentrations or thyroid function.</li> <li>2. GH significantly enhanced constitutive serum protein concentrations (transferrin: p&lt;0.05, albumin: p&lt;0.05).</li> <li>3. Total lymphocyte count was significantly higher in the GH group than in the control group (p&lt;0.05) by day 10.</li> <li>4. PNI was significantly improved in the GH group compared to the control group (p&lt;0.05) by day 10.</li> </ol>
<a href="#">Devesa et al.</a> (2013) Spain Case Series N=13	<p><b>Population:</b> TBI; Mean Age=26.7 yr; Gender: Male=8, Female=5; Time Post Injury=2.5 mo-11 yr.</p> <p><b>Intervention:</b> Patients with a TBI who were with and without acquired growth hormone</p>	<ol style="list-style-type: none"> <li>1. Plasma IGF-1 values increased after GH treatment in GHD and non-GHD patients (p&lt;0.01, p&lt;0.05, respectively).</li> </ol>

Author/Year/ Country/Study design/PEDro Score/N	Methods	Outcomes
	<p>deficiency (GHD) all received the same growth hormone treatment protocol, as well as clinical rehabilitation as necessary per individual.</p> <p><b>Outcome Measure:</b> Plasma insulin-like growth factor 1 (IGF-1), cognitive and motor improvements.</p>	<ol style="list-style-type: none"> <li>2. The increase in plasma IGF-1 values was significantly higher in GHD than non-GHD patients (<math>p&lt;0.01</math>).</li> <li>3. In general, cognitive improvements were better than motor improvements.</li> </ol>

PEDro = Physiotherapy Evidence Database rating scale score (Moseley et al., 2002).

## Discussion

In a study conducted by Behrman et al. (1995), GH treatments administered to patients who were completely immobilized did not improve nitrogen balance. The adjuvant recombinant human GH did, however, improve constitutive serum protein concentrations and the patients' prognostic nutritional index (Behrman et al., 1995). Conversely, another RCT found that individuals who were administered IGF-I/GH had a higher nitrogen balance per day than those in the control group ( $1.20\pm0.84$  versus  $-3.90\pm0.87$ ) (Hatton et al., 2006). Overall, for patients with TBI there was a sustained improvement in metabolic and nutritional status. A study by Devesa et al. (2013) found that GH administration was useful when provided with proper rehabilitation.

## Conclusions

*There is conflicting evidence regarding whether or not insulin-like growth factor-1/growth hormone is effective for enhancing growth hormone concentration and nitrogen balance compared to placebo in those who have sustained an ABI.*

**Growth hormone may enhance nutritional repletion, but it is unclear as to whether or not it improves nitrogen balance in patients post ABI.**

### 5.7.5.3 Increased Nitrogen Feeds

Following brain injury, nitrogen losses result from the conversion of endogenous protein to energy with the extra stress demand of recovery (Graham et al., 1989). The attainment of a positive nitrogen balance is complicated because increasing the amount of nitrogen feeding will not be retained, rather it will cause an increased amount of nitrogen excretion (Hadley et al., 1986). Often this positive balance does not occur until the catabolic stimulus begins to subside (Hadley et al., 1986). One study presented in Table 5.24 has examined nitrogen feeds in ABI populations.

**Table 5.24 Nitrogen Balance for Nutritional Management Post ABI**

Author/Year/ Country/Study design/PEDro Score/N	Methods	Outcomes
<a href="#">Twyman</a> (1997) USA RCT	<p><b>Population:</b> Head injury; Mean Time Post-Injury &lt;72 hr.</p>	<ol style="list-style-type: none"> <li>1. Patients receiving the high-protein tube feeding attained a significantly greater daily (<math>p=0.006</math>) and cumulative (<math>p=0.04</math>) nitrogen</li> </ol>

PEDro=3 N=21	<b>Intervention:</b> Patients were randomly assigned to receive either tube feeding containing 1 g nitrogen/150 cal (control group; n=11) or 1 g nitrogen/90 cal (study group; n=10). <b>Outcome Measures:</b> Nitrogen Balance, calorie intake.	balance despite higher nitrogen excretions, suggesting high nitrogen feedings are required to replace high nitrogen losses following injury. 2. Both groups of patients received similar amounts of cal/kg.
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PEDro = Physiotherapy Evidence Database rating scale score (Moseley et al., 2002).

## Discussion

Following a brain injury, the incidence of metabolic changes can influence cell turnover use of substrate and body composition (Twyman, 1997). Twyman (1997) noted that urinary urea nitrogen levels increase by a factor of three compared with normal levels within 10 days after severe head injury. In this study, high-protein nitrogen feeds improved nitrogen balance daily as well as cumulatively over the course of the study compared to low-protein nitrogen feeds. On average, about 5 to 10 g of urea nitrogen are excreted daily from an individual; however, patients with ABI lose a mean of 21 g urinary urea in a single day (Twyman, 1997).

## Conclusions

***There is level 2 evidence that high-protein nitrogen feedings of approximately 1 g nitrogen/90 calories may be effective for restoring nitrogen losses that occur post ABI compared to low-protein nitrogen feedings.***

**High-protein nitrogen feedings may restore nitrogen losses post ABI.**

### 5.7.5.4 Branched-Chain Amino Acids

Branched-Chain Amino Acids (BCAAs), which include leucine, valine, and isoleucine, make up roughly 35% of the human body's essential amino acids and approximately 14% of skeletal muscle amino acids (Aquilani et al., 2005). Following intake of a meal, the amino acid skeletal muscle uptake is comprised of 50% or more BCAAs (Aquilani et al., 2005). Amino acids are not just nutritionally beneficial, but they may also impact cognitive function (Aquilani et al., 2005). It is thought that the BCAAs improve cognitive functioning by providing substrates and increasing brain insulin availability (Aquilani et al., 2005). Studies examining this topic are presented in Table 5.25.

**Table 5.25 Branched-Chain Amino Acid Treatment for Nutritional Management Post ABI**

Author/Year/ Country/Study design/PEDro Score/ N	Methods	Outcomes
<a href="#">Aquilani et al</a> (2005) Italy RCT PEDro=5 N=40	<b>Population:</b> TBI; Mean Age=32 yr; Gender: Male=40, Female=0; Mean GCS=5.9. <b>Intervention:</b> Patients were randomized to receive either 19.6 g/day IV BCAA supplementation (n=20) or an iso-nitrogenous placebo (n=20) over a period of 15 days. A group of healthy patients (n=20)	1. At 15 days post admission, DRS scores significantly improved in patients with a TBI compared with the control group ( $p<0.02$ ); improvement was greater in the BCAA group than in the placebo group ( $p<0.004$ ). 2. Fifteen days after admission only patients given BCAA supplementation significantly improved their baseline total BCAAs,

	<p>matched for age, sex and sedentary lifestyle served as controls for the study.</p> <p><b>Outcome Measure:</b> Disability Rating Scale (DRS), plasma concentration of BCAAs: tyrosine and tryptophan.</p>	<p>including leucine (<math>p&lt;0.01</math>), isoleucine (<math>p&lt;0.02</math>) and valine (<math>p&lt;0.001</math>).</p> <ol style="list-style-type: none"> <li>3. Level of plasma tyrosine significantly improved in the BCAA group (<math>p&lt;0.01</math>) but remained lower than in health controls.</li> <li>4. Plasma tryptophan concentration was higher in patients on placebo than treatment (<math>p&lt;0.01</math>).</li> <li>5. Nutritional intake and nitrogen balance tended to be higher in patients on placebo than in the BCAA group, but the difference was not significant.</li> </ol>
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PEDro = Physiotherapy Evidence Database rating scale score (Moseley et al., 2002).

## Discussion

To date only one RCT has examined the effect of BCAAs on patient outcomes in an ABI population. Aquilani et al. (2005) supplemented patients with 19.6g of BCAAs daily for 15 days and found that disability rating scale scores significantly improved in the BCAA compared to the placebo group. Baseline total BCAAs significantly improved in patients receiving BCAA supplementation, including leucine, isoleucine, valine, and tyrosine.

## Conclusions

***There is level 2 evidence that branched-chain amino acid supplementation may improve disability scores compared to placebo in patients with ABI.***

**Branched-chain amino acid supplementation in patients with ABI may improve disability scores.**

## 5.8 Conclusions

Treatment of dysphagia and nutritional status post ABI remains understudied. Although there are several available interventions to treat dysphagia and malnutrition post stroke, there is limited clinical evidence to support their effect specifically within an ABI population. This module has demonstrated that both nutrition and oral care are of the utmost importance when maximizing recovery gains following ABI. According to the Canadian Dental Association (2009), diabetes, hypertension, circulatory problems, cognitive and mental health impairments, and stroke are only a few of the common systemic diseases that can negatively affect individuals' oral health as they age. The Canadian Dental Association emphasizes the importance of teaching preventative habits, such as an appropriate diet and patient-specific oral hygiene techniques, to prevent infection and decay.

Until an ABI-specific research knowledge base regarding effective rehabilitative interventions is established for dysphagia, aspiration, oral care, and malnutrition, therapeutic management will continue to be guided by extrapolation from the stroke literature. As such, further research is needed to better determine the appropriateness of generalizing post-stroke dysphagia rehabilitation practices to an ABI population.

## 5.9 Summary

*There is Level 1b evidence that oral care assistance, at any level, does not increase oral pathogen count.*

*There is Level 1b evidence that the use of a manual compared to an electric toothbrush has no significant effect on ICP and CPP.*

*There is Level 2 evidence that providing oral hygiene education to patients post TBI results in a significant reduction of dental plaque, measured by the Plaque Index Score.*

*There is level 1b evidence that 0.2% chlorhexidine gel is beneficial for reducing nosocomial infections and hospital length of stay compared to placebo in non-ABI populations.*

*There is level 1b evidence that povidone-iodine may be effective for reducing the incidence of ventilator-associated pneumonia compared to placebo post stroke or ABI.*

*There is level 1b evidence that oral care may reduce rates of pneumonia, febrile days, and pneumonia-related deaths in mixed populations.*

*There is level 3 evidence that enhanced oral care may reduce rates of non-ventilator hospital-acquired pneumonia compared to standard oral care in mixed brain injury populations.*

*There is level 2 evidence that enteral nutrition may not reduce weight loss or improve FIM scores compared to no EN in patients post ABI.*

*There is level 4 evidence that patients with ABI may expend more energy when on enteral nutrition than predicted by equations, and that this effect may be greater for non-sedated individuals.*

*There is level 1b evidence that insulin infusions significantly decrease blood glucose levels when compared to a conventional glucose treatment in TBI patients.*

*There is level 2 evidence that enteral in combination with parenteral nutrition may be effective for increasing protein levels compared to parenteral nutrition alone in patients with ABI.*

*There is conflicting evidence regarding whether or not one nutrition administration method (enteral or parenteral) is more effective compared to the other for improving the nitrogen balance of patients with ABI.*

*There is conflicting evidence regarding whether or not one nutrition administration (enteral or parenteral) is more effective compared to the other for improving serum albumin levels in patients with ABI.*

*There is level 2 evidence that enteral nutrition results in higher mortality compared to parenteral nutrition in patients with ABI, however enteral and parenteral nutrition may have similar effects on morbidity.*

*There is level 2 evidence that enteral nutrition in combination with parenteral nutrition versus parenteral nutrition alone have a similar effect on mortality in patients with ABI.*

*There is level 2 evidence that parenteral nutrition can safely be administered without causing serum hyperosmolality compared to enteral nutrition, and that neither treatment influences intracranial pressure levels, in patients post ABI.*

*There is conflicting level 1b and level 3 evidence regarding whether or not enhanced enteral nutrition can reduce the incidence of infection, ventilator dependency period, or length of stay compared to standard formula nutrition in patients post ABI.*

*There is level 1b evidence that early enteral nutrition may improve the hormonal profile of patients with TBI compared to delayed enteral feeding.*

*There is level 2 evidence that early versus late enteral feeding has a similar effect on mortality, number of infections, ventilator days, or incidence of pneumonia in patients with ABI.*

*There is level 2 evidence that early enteral nutrition may improve energy and nitrogen intake compared to standard enteral nutrition in ABI populations.*

*There is level 4 evidence that late percutaneous endoscopic gastrostomy may be associated with a higher comorbidity index, longer length of stay, and more complications compared to early percutaneous endoscopic gastrostomy in patients with ABI.*

*There is level 2 evidence that late total enteral feeding can result in reduced arm circumference, worse malnutrition, and more disability compared to early total enteral feeding in patients with ABI.*

*There is level 2 evidence that early parenteral nutrition support may improve immunologic function compared to delayed parenteral nutrition in patients with closed head injury.*

*There is level 1b evidence that the risk of developing pneumonia is higher among ventilated patients (stroke and head injury) fed by a nasogastric tube compared with a gastrostomy tube.*

*There is level 1b evidence that metoclopramide may not be effective compared to placebo for gastric emptying in patients with TBI.*

*There is level 1b evidence that zinc supplementation has a positive effect on neurological recovery compared to placebo as measured by the Glasgow Coma Scale in ABI patients.*

*There is conflicting evidence regarding whether or not insulin-like growth factor-1/growth hormone is effective for enhancing growth hormone concentration and nitrogen balance compared to placebo in those who have sustained an ABI.*

*There is level 2 evidence that high-protein nitrogen feedings of approximately 1 g nitrogen/90 calories may be effective for restoring nitrogen losses that occur post ABI compared to low-protein nitrogen feedings.*



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*There is level 2 evidence that branched-chain amino acid supplementation may improve disability scores compared to placebo in patients with ABI.*

## 5.10 References

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