5. Dysphagia & Nutritional Interventions for Patients with Acquired Brain Injuries

Penny Welch-West M.CI.Sc. SLP, Jo-Anne Aubut BA, Norine Foley MSc, and Robert Teasell MD
# Table of Contents

5.1 Introduction ................................................................................................................................. 10

5.2 Dysphagia Post ABI ..................................................................................................................... 10
   5.2.1 Risk Factors for Dysphagia Post ABI .................................................................................... 13

5.3 Aspiration Post ABI ..................................................................................................................... 13
   5.3.1 Risk Factors of Aspiration Post ABI .................................................................................... 15
   5.3.2 Silent Aspiration ..................................................................................................................... 15
   5.3.3 Pneumonia and Aspiration Post ABI ..................................................................................... 16
   5.3.4 The Relationship between Pneumonia and Dysphagia/Aspiration ....................................... 16

5.4 Assessment of Dysphagia Post ABI using Stroke Models of Care ........................................... 17
   5.4.1 The Bedside Clinical Examination ....................................................................................... 18
   5.4.2 Water Swallowing Test ........................................................................................................ 19
   5.4.3 Videofluoroscopic Modified Barium Swallow Studies ...................................................... 21
   5.4.4 Fiberoptic Endoscopic Evaluation of Swallowing ............................................................... 22
   5.4.5 Pulse Oximetry .................................................................................................................... 24
   5.4.6 Blue Dye Assessment for Swallowing .................................................................................. 26
   5.4.7 Other Methods Using Stroke as a Model of Care ............................................................... 26
      5.4.7.1 Cervical Auscultation .................................................................................................... 27

5.5 Management of Dysphagia .......................................................................................................... 27
   5.5.1 Best Practice Guidelines for Managing Dysphagia ............................................................... 27
   5.5.2 Oral Hygiene ......................................................................................................................... 28
      5.5.2.1 Approaches to Ease the Provision of Oral Care in the TBI Patient ............................... 29
      5.5.2.2 Provision of Mouth Care as a Means of Managing Aspiration Pneumonia Risk .......... 31
   5.5.3 Management of Dysphagia for Patients with ABI ............................................................... 33

5.6 Treatment of Dysphagia Post ABI ............................................................................................. 34
   5.6.1 Oral Motor Exercises ........................................................................................................... 34
      5.6.1.1 Range of Motion Exercises for the Pharyngeal Structures: Airway Entrance ............. 34
      5.6.1.2 Vocal Fold Adduction Exercises .................................................................................... 34
   5.6.2 The Shaker Exercise .............................................................................................................. 34
Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABI</td>
<td>Acquired Brain Injury</td>
</tr>
<tr>
<td>BCAA</td>
<td>Branched-Chain Amino Acids</td>
</tr>
<tr>
<td>FEES</td>
<td>Fiberoptic Endoscopic Examination of Swallowing</td>
</tr>
<tr>
<td>FSH</td>
<td>Follicle-Stimulating Hormones</td>
</tr>
<tr>
<td>GCS</td>
<td>Glasgow Coma Scale</td>
</tr>
<tr>
<td>GH</td>
<td>Growth Hormone</td>
</tr>
<tr>
<td>LH</td>
<td>Leuteinizing Hormone</td>
</tr>
<tr>
<td>MBS</td>
<td>Modified Barium Swallow</td>
</tr>
<tr>
<td>MEBD</td>
<td>Modified Evans Blue Dye</td>
</tr>
<tr>
<td>PMV</td>
<td>Passy-Muir (Positive Closure) Speaking Valves</td>
</tr>
<tr>
<td>RCT</td>
<td>Randomized Controlled Trial</td>
</tr>
<tr>
<td>SLP</td>
<td>Speech Language Pathologist</td>
</tr>
<tr>
<td>TBI</td>
<td>Traumatic Brain Injury</td>
</tr>
<tr>
<td>VFSS</td>
<td>Videofluoroscopic Swallow Study</td>
</tr>
<tr>
<td>VMBS</td>
<td>Videofluoroscopic Modified Barium Bwallowing</td>
</tr>
<tr>
<td>WST</td>
<td>Water Swallow Tests</td>
</tr>
</tbody>
</table>
Table Directory

Table 5.1 The Four Phases of Normal Swallowing
Table 5.2 Incidence and Prevalence of Dysphagia Following ABI
Table 5.3 Risk Factors for Dysphagia Post ABI
Table 5.4 Incidence of Aspiration Post-ABI
Table 5.5 Risk Factors for Aspiration Post ABI
Table 5.6 Criteria for Defining Aspiration Pneumonia in Stroke
Table 5.7 The Relationship Between Pneumonia, GCS and FIM Scores Post ABI
Table 5.8 Aspects Included in Various Bedside Screening/Assessment Tools for Dysphagia
Table 5.9 Sensitivity and Specificity of the Water-Swallowing test
Table 5.10 Radiological Evaluation during VMBS
Table 5.11 Studies Evaluating FEES for Stroke Patients
Table 5.12 Studies Evaluating Pulse Oximetry in Stroke Patients
Table 5.13 Best Practice Guidelines for the Assessment and Management of Dysphagia Post Stroke
Table 5.14 Low Risk Feeding Strategies in Stroke Patients with Dysphagia
Table 5.15 Oral Hygiene Post ABI
Table 5.16 Oral Care and Nosocomial Infections in Non-ABI Participants
Table 5.17 Five Postures to Improve Swallowing Function
Table 5.18 A Description of Four Levels of Diets
Table 5.19 Diet Levels as Defined by a Canadian Hospital
Table 5.20 Nutritional Status of Brain-Injured Patients
Table 5.21 Elevations in Resting Energy Expenditure (REE) Following ABI
Table 5.22 Enteral Nutrition vs. Total Parenteral Nutrition
Table 5.23 Enhanced Feeding Solutions
Table 5.24 Timing of Enteral Feeding

Table 5.25 Timing of Parenteral Feeding

Table 5.26 Early Gastrostomy

Table 5.27 Metoclopramide and Enteral Nutrition

Table 5.28 Zinc Supplementation in patients with ABI

Table 5.29 Growth Hormone Treatment on Nutrition Post-ABI

Table 5.30 Nitrogen Balance

Table 5.31 Branched-Chain Amino Acid Treatment in ABI patients
Figure Directory

Figure 1: The phases of swallowing
Key Points

The incidence of dysphagia in patients post ABI ranges from 26% to 70%. More specifically, the range was between 26% and 42% for individuals entering a rehabilitation facility.

The incidence of dysphagia has been shown to vary depending on the definition of dysphagia used and the acuity of the patient at admission.

Post ABI aspiration improves in many patients over the first year, with many improving within the first three months post injury.

The incidence of silent aspiration among individuals with ABI has not been well documented.

Silent aspiration may be missed in the absence of a modified barium swallow study.

The risk of developing pneumonia appears to be proportional to the severity of the aspiration.

Videofluoroscopic Modified Barium Swallow (or Modified Barium Swallow) studies may be used as a tool to assist in dysphagia management and identification of aspiration in the ABI population.

Although FEES may be less invasive and less costly to complete, further investigation would be beneficial to determine its effectiveness in identifying swallowing difficulties or aspiration post stroke. To determine its effectiveness within the ABI/TBI population, more research needs to be done.

There is limited evidence supporting the use of pulse oximetry to detect aspiration in patients who have had a stroke.

Pulse oximetry does not appear to be as sensitive a test as VMBS in determining aspiration post stroke. Research needs to be completed within an ABI population.

Modified Evans Blue Dye Test may be beneficial if patients aspirate more than trace amounts.

Caution is recommended when using the MEBD test alone to ascertain aspiration in individuals who have a tracheostomy.

There is consensus opinion that patients should be screened for swallowing deficits in a timely manner using a valid screening tool.

There is consensus opinion that a referral to a speech-language pathologist, occupational therapist, dietitian or other trained dysphagia clinician for a detailed assessment and identify the appropriate course of treatment.

Based on the stroke literature, individuals with dysphagia should feed themselves whenever possible. When not possible, low-risk feeding strategies should be used.

Education in oral health and good oral care is needed to reduce the risk of dysphagia and other swallowing complications that can result from a brain injury.
Good oral health can promote recovery and reintegration into society by reducing some of the negative consequences associated with poor oral hygiene.

Maintaining good oral health during hospitalization may help to reduce the risk of nosocomial infections by decreasing dental bacterial colonization and hospital recovery time.

Good oral care has not been shown to have any adverse effects on normal intracranial pressure or cerebral perfusion pressure values in intubated patients.

Although there are several possible interventions to treat dysphagia, there is no clinical evidence to support their efficacy specifically within an ABI population. More research is needed.

Following an ABI, malnutrition may be present in patients with severe injuries within the first months post injury.

The incidence of obesity in the chronic stages of injury was comparable to the normal population.

Both enteral and parenteral are safe and have been shown to provide an increase in caloric intake; however, there is conflicting data as to which method allows for the greatest increase in nitrogen balance.

Enteral feeds are less expensive and maybe more effective than parenteral feeds.

Further research is needed to investigate the effect of both feeding routes on nitrogen balance and mortality.

Early parenteral nutrition support of ABI patients appears to modify immunologic function.

There is an increased risk of developing pneumonia for ventilated patients fed by a naso-gastric versus a gastrostomy tube.

The therapeutic benefits of using metoclopramide to aid in gastric emptying are minimal.

Zinc supplementation in the immediate post injury period has shown to be beneficial in terms of neurological recovery and visceral protein concentrations in ABI patients.

Growth hormone enhances nutritional repletion, but it unclear as to whether or not it improves nitrogen balance.

High nitrogen feedings are necessary to restore massive nitrogen loses post-ABI.

Supplementation of BCAAs in patients with ABI enhances recovery of cognitive function.
5. Dysphagia & Nutritional Interventions for Patients with Acquired Brain Injury

5.1 Introduction
After a traumatic brain injury (TBI) a wide range of swallowing disorders may occur. TBI 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. 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)

<table>
<thead>
<tr>
<th>Phase</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oral Preparatory</td>
<td>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 falling into the pharynx.</td>
</tr>
<tr>
<td>Oral Propulsive</td>
<td>The tongue transfers the bolus of food to the pharynx, triggering the pharyngeal swallow.</td>
</tr>
<tr>
<td>Pharyngeal</td>
<td>Complex and coordinated movements of the tongue and pharyngeal structures propel the bolus into the esophagus, while protecting the airway.</td>
</tr>
<tr>
<td>Esophageal</td>
<td>Coordinated contractions of the muscles of the esophagus move the bolus through the esophagus towards the stomach.</td>
</tr>
</tbody>
</table>

Figure 1: The phases of swallowing

Dysphagia

5.2 Dysphagia Post ABI
Dysphagia post acquired brain injury (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 is can be high following ABI, swallowing function most frequently improves over time.
### Individual Studies

#### Table 5.2 Incidence and Prevalence of Dysphagia Following ABI

<table>
<thead>
<tr>
<th>Authors/Year/ Country/ Study Design/ N</th>
<th>Methods</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Halper et al. (1999) USA Retrospective Review N=148</td>
<td><strong>Population:</strong> TBI; Mean Age=40.21yr; Gender: Male=117, Female=31; Mean Time Post Injury=54d. <strong>Treatment:</strong> Chart review of inpatients treated at an acute rehabilitation facility. <strong>Outcome Measure:</strong> Functional Independence Measure (FIM), Chewing/Swallowing item on the Rehabilitation Institute of Chicago Functional Assessment Scale (RIC-FAS).</td>
<td>1. 96 (65%) were diagnosed with dysphagia at admission (RIC-FAS score of &lt;7). 2. Chewing/swallowing scores at admission were highly correlated with total FIM at admission ($r=0.78$, $p&lt;0.01$) and discharge ($r=0.79$, $p&lt;0.01$). 3. A significant correlation was found between chewing/swallowing and cognitive FIM at admission ($r=0.67$, $p&lt;0.01$) and discharge ($r=0.65$, $p&lt;0.01$).</td>
</tr>
<tr>
<td>Mackay et al. (1999b) USA Observational N=54</td>
<td><strong>Population:</strong> Brain injury; Mean Age=26.8yr; Gender: Male=45, Female=9; Range of GCS Scores=3-8. <strong>Treatment:</strong> Consecutive patients treated with early rehabilitation intervention (initiated &lt;24hr of admission) was assessed for swallowing disorders. <strong>Outcome Measure:</strong> Videofluoroscopic swallow study (VFSS).</td>
<td>1. 33 (61%) patients demonstrated one or more swallowing impairments on VFSS examination. 2. The mean GCS on admission for patients with normal swallowing was significantly higher than that of patients with abnormal swallowing (5.9 vs. 4.6, $p&lt;0.01$). 3. 22 (41%) patients aspirated. The mean admitting GCS score of aspirators (4.45) was lower compared to non-aspirators (5.53).</td>
</tr>
<tr>
<td>Schurr et al. (1999) USA Retrospective Review N=47</td>
<td><strong>Population:</strong> TBI; Mean Age=37yr; Gender: Male=32, Female=15; Mean GCS Score=8. <strong>Treatment:</strong> Chart review of patients who received a bedside evaluation (speech pathologist). Those with abnormal findings were referred for a swallowing assessment. <strong>Outcome Measure:</strong> Videofluoroscopic swallow study (VFSS).</td>
<td>1. 33 (70%) patients had an abnormal bedside evaluation; 2 were deemed unfit for VFSS the remaining 31 patients received VFSS. 2. VFSS was abnormal in 22/31 (71%) patients.</td>
</tr>
<tr>
<td>Cherney and Halper (1996) USA Retrospective Review N=524</td>
<td><strong>Population:</strong> TBI. <strong>Treatment:</strong> Review of data collected from a rehabilitation institute. <strong>Outcome Measure:</strong> Presence of dysphagia.</td>
<td>1. 41.6% (218) patients had dysphagia.</td>
</tr>
<tr>
<td>Cherney and Halper (1989) USA Retrospective Review N=189</td>
<td><strong>Population:</strong> Adults with Head Injury. <strong>Treatment:</strong> Review of 18 months of data from a Rehabilitation Institute. <strong>Outcome Measure:</strong> Presence of dysphagia.</td>
<td>1. Approximately 26% of patients (49 of 189) had dysphagia on admission. 2. Of the 49 of the patients with dysphagia, more than 60% had a severe problem with oral intake, while only 16% displayed a mild or minimal dysfunction.</td>
</tr>
<tr>
<td>Field and Weiss (1989) USA Retrospective Review N=8</td>
<td><strong>Population:</strong> TBI; Gender: Male=6, Female=2; Mean Age=27.3yr. <strong>Treatment:</strong> Review of charts for patients admitted to a head injury rehabilitation program. <strong>Outcome Measure:</strong> Videofluorographic examination of a modified barium swallow.</td>
<td>1. Of 30 patients admitted to the program, 9 (30%) demonstrated swallowing problems (1 excluded due to incomplete data). 2. Most common problems were: prolonged oral transit and delayed swallowing reflex, each observed in 87.5% of cases (7/8 patients). 3. 5/8 (62.5%) of the patients had pooling in the valleculae and in the pyriform sinuses. 4. 4/8 (50%) had late triggering of the swallowing mechanism at the pyriform sinus. 5. 3/8 (37.5%) had the bolus enter the hypopharynx prior to the swallow.</td>
</tr>
</tbody>
</table>
Evidence-Based Review of Moderate to Severe Acquired Brain Injury

Module 5 - Dysphagia and Nutritional Interventions for Patients with an ABI

Updated October 2014

<table>
<thead>
<tr>
<th>Authors/Year/ Country/ Study Design/ N</th>
<th>Methods</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Winston</strong> (1983) USA Retrospective Review N=201</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| **Population:** TBI. *Patients With Dysphagia (n=55):* Gender: Male=45, Female=10; Male Mean Age=26yr, Female Mean Age=25yr. **Treatment:** Chart review of all non-acute patients at an adult trauma service. **Outcome Measure:** Swallowing problems. | | 6. Aspiration occurred in 37.5% of the cases.  
7. Reduced pharyngeal peristalsis was observed in 2/8 (25%) of the cases. |
| | 1. Swallowing problems were present in 55/201 (27%) patients on admission.  
2. Of 55 patients identified with swallowing difficulties, 45 (82%) were not taking an oral diet and the other 10 (18%) were eating at least a pureed diet.  
3. For swallow (n=41): 3 had normal swallow, voluntarily initiated, coordinated motion, good laryngeal excursion; 21 had good reflex, initiated with external stimulation; and 17 had difficulty (e.g., inadequate laryngeal excursions, uncoordinated swallow, poor endurance, etc.).  
4. Of the 55 patients with issues, 84% were oral feeders at discharge. | |

**Discussion**

As previously noted rates of dysphagia are variable, with the literature ranging between 26% and 70% (Cherney & Halper 1996; Cherney & Halper 1989; Field & Weiss 1989; Halper et al. 1999; Mackay et al. 1999b; Schurr et al. 1999; Winston 1983). When specifically examining the rates at rehabilitation centres, the rates range from 26% to 42% (Cherney & Halper 1996; Cherney & Halper 1989; Field & Weiss 1989; Winston 1983). Many of these rates are determined at admission; however, Winston (1983) reported that by time of discharge, 84% of those patients admitted with swallowing problems were eating oral feeds. 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 the study by Mackay et al. (1999b) other swallowing abnormalities included loss of bolus control (79%), reduced lingual control (79%), and 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. 1999b; Winston 1983).

*The incidence of dysphagia in patients post ABI ranges from 26% to 70%. More specifically, the range was between 26% and 42% for individuals entering a rehabilitation facility.*

*The incidence of dysphagia has been shown to vary depending on the definition of dysphagia used and the acuity of the patient at admission.*
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 researched. Within the literature, many researchers have attempted to identify the factors that may affect the presence and severity of dysphagia post ABI (Table 5.3; Cherney & Halper 1996; Halper et al. 1999; Mackay et al. 1999a; Mackay et al. 1999b; Morgan & Mackay 1999).

For example, injuries that result from translaryngeal intubation or tracheostomy may contribute to swallowing dysfunction in ABI patients (Morgan & Mackay 1999).

Table 5.3 Risk Factors for Dysphagia Post ABI
- Extent of brain injury
- Duration of coma (Lazarus & Logemann 1987)
- Lower Glasgow Coma Score on admission (GCS 3-5) (Mackay et al. 1999b)
- Severity of CT Scan findings (Mackay et al. 1999b)
- Duration of mechanical ventilation (Mackay et al. 1999b)
- Tracheostomy
- Translaryngeal (endotracheal) intubation
- Severe cognitive and cognition disorders
- Physical damage to oral, pharyngeal, laryngeal and esophageal structures
- Oral and pharyngeal sensory difficulties

5.3 Aspiration Post ABI
When assessing the patient for signs of aspiration a videofluoroscopic swallowing 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 during the swallow maneuver is observed. This procedure allows for any structural or functional anomalies swallowing, along with any aspiration, to be observed.

Individual Studies

Table 5.4 Incidence of Aspiration Post-ABI

<table>
<thead>
<tr>
<th>Authors/Year/ Country/ Study Design/ N</th>
<th>Methods</th>
<th>Outcomes</th>
</tr>
</thead>
</table>
| **Terre & Mearin (2009)** Spain Longitudinal Follow-up N=26 | Population: TBI; Mean Age=34yr; Gender: Male=20, Female=6; Mean GCS=4; Mean Time Post Injury=3mo. Treatment: Patients with a videofluoroscopic (VFS) diagnosis of aspiration were assessed for aspiration at 1, 3, 6, and 12 mo. Outcome Measure: Rancho Los Amigos Level Cognitive Function Scale (RLCF), Disability Rating Scale (DRS), VFS. | 1. At baseline, aspiration occurred prior to swallowing in 15%, during pharyngeal contraction in 73%, and after swallowing in 12%.
2. At baseline, 35% of patients were silent aspirators. This was resolved in all patients by 3 months.
3. At 3, 6 and 12 follow-up, the number of patients with aspiration was 14, 8 and 6, respectively.
4. Patients who showed aspiration at 1 year had a baseline RLFC score of III and DRS score of 20, while patients without aspiration had RLFC >IV and DRS score of 16. A significant relationship was found between the presence of aspiration and RLFC score (p=0.039), and DRS (p=0.003). |
| **O’Neil-Pirozzi et al. (2003)** USA | Population: TBI; Mean Age=51.17yr; Gender: Male=11, Female=1; GCS | 1. 3 (25%) patients aspirated. All three of these patients aspirated silently. |
### Authors/Year/Country/Study Design/N

<table>
<thead>
<tr>
<th>Study Design</th>
<th>Methods</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observational N=12</td>
<td>Score≤8; Mean Time Post Injury=78.6d. <strong>T</strong>reatment: Post hoc analysis of acute rehabilitation patient data. All patients had a Modified Barium Swallow (MBS) study. <strong>O</strong>utcome <strong>M</strong>easure: Presence of aspiration.</td>
<td>2. After the MBS study none of the subjects developed aspiration pneumonia or other swallowing complications.</td>
</tr>
<tr>
<td>Mackay et al. (1999b) USA Observational N=54</td>
<td><strong>P</strong>opulation: Brain injury; Mean Age=26.8y; Gender: Male=45, Female=9; Mean Time Post Injury=17.6d; Range of GCS Scores=3-8. <strong>T</strong>reatment: Patients treated with early rehabilitation intervention (initiated &lt;24 hr of admission) had their swallowing evaluated. <strong>O</strong>utcome <strong>M</strong>easure: Videofluoroscopic Swallow Study (VFSS).</td>
<td>1. 22(41%) patients aspirated. 2. Patients with aspiration required ventilation more than twice as long as those without aspiration (16.14d vs. 6.84d, p&lt;0.03). 3. Those with aspiration also had lower admission GCS scores and RLA scores compared to those without (GCS, 4.45 vs. 5.53; RLA, 2.2 vs. 2.64). 4. Aspiration occurred most commonly during the swallow (77%), then before (41%) and after (18%) the swallow.</td>
</tr>
<tr>
<td>Schurr et al. (1999) USA Retrospective Review N=47</td>
<td><strong>P</strong>opulation: TBI; Mean Age=37y; Gender: Male=32, Female=15; Mean GCS Score=8 <strong>T</strong>reatment: Review of medical records of patients who had a bedside evaluation completed by a certified speech pathologist. Those with abnormal findings were referred for a Videofluoroscopic Swallow Study (VFSS). <strong>O</strong>utcome <strong>M</strong>easure: Incidence of aspiration.</td>
<td>1. 2 patients had overt aspiration and were not referred for a VFSS test. 2. 31 patients had a VFSS; 22 (71%) had aspiration. 3. 13 patients had either laryngeal penetration or minor aspirations which were responsive to initial positional and dietary modifications and patients could be fed orally. 4. 5 other patients had silent aspiration that was initially non-responsive to initial therapies, but responsive to later dysphagia therapy and later resumed oral diet.</td>
</tr>
</tbody>
</table>

### Discussion
Rates of aspiration within the literature are variable, ranging from 25% to 71% depending on the sample surveyed (Mackay et al. 1999b; O’Neil-Pirozzi et al. 2003; Schurr et al. 1999). Terre and Mearin (2009) followed 26 patients with TBI who aspirated, 35% were silent aspirators, for one year. At 3, 6 and 12 months, the number of patients who aspirated continuously declined; aspiration was present in only 6 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. (2003) studied 12 tracheostomized patients with severely disordered consciousness and found that the MBS was successfully completed with all of them; consequently these patients with TBI are potential MBS candidates. 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. The increased tongue strength is therefore beneficial in improving swallowing and isometric tasks.

**Post ABI aspiration improves in many patients over the first year, with many improving within the first three months post injury.**
5.3.1 Risk Factors of 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 are potential aspirators, there are risk factors that place some patients at higher risk (Table 5.5). Initial severity of the brain injury appears to be the strongest predictor of dysphagia related aspiration. Further, severe ABI patients with neurogenic dysphagia and a tracheostomy are at 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 the cuff (Tolep et al. 1996).

Table 5.5 Risk Factors for Aspiration Post ABI

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Glasgow Coma Score (3-5) (Mackay et al., 1999a)</td>
<td>Coughing/throat clearing or wet/gurgly voice quality after swallowing water</td>
</tr>
<tr>
<td>Presence of a tracheostomy</td>
<td>Choking more than once while drinking 50 ml of water</td>
</tr>
<tr>
<td>Poor cognitive functioning</td>
<td>Weak voice and cough</td>
</tr>
<tr>
<td>Hypoactive gag reflex</td>
<td>Wet- hoarse voice quality</td>
</tr>
<tr>
<td>Prolonged period of mechanical ventilation (Mackay et al., 1999a)</td>
<td>Recurrent lower respiratory infections</td>
</tr>
<tr>
<td>Reduced pharyngeal sensation</td>
<td>Low-grade fever or leukocytosis</td>
</tr>
<tr>
<td>Brainstem involvement</td>
<td>Auscultatory evidence of lower lobe congestion</td>
</tr>
<tr>
<td>Difficulty swallowing oral secretions</td>
<td>Imuncompromised state</td>
</tr>
</tbody>
</table>

The risk of dysphagia related aspiration is proportional to the initial severity of the head injury. A history of a tracheostomy or mechanical ventilation may also be associated with increased risk of aspiration.

5.3.2 Silent Aspiration
Aspiration cannot always be diagnosed by a bedside examination, as patients may aspirate without outward signs. Detailed clinical swallowing assessments have been shown to under diagnose or to miss cases of aspiration (Horner & Massey 1988; Splaingard et al. 1988). 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). 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. Silent aspirators are considered to be at increased risk of developing more serious complications such as pneumonia.

Lazarus and Logemann (1987) identified aspiration in 38% of their ABI sample and found 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 were silent aspirators and issues with aspiration seemed to resolve within the 12 months of the study (Terre & Mearin 2009).

The incidence of silent aspiration among individuals with ABI has not been well documented. Silent aspiration may be missed in the absence of a modified barium swallow study.
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 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 as the best predictors of pneumonia. In a study by Vejdan 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).

The clinical criteria used to define aspiration pneumonia vary between studies, impacting the reported incidence. In the absence of ABI specific studies, the criteria used within the stroke literature has been provided in Table 5.6.

Table 5.6 Criteria for Defining Aspiration Pneumonia in Stroke

<table>
<thead>
<tr>
<th>Author/ Year Country</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Carnaby et al. (2006)</strong> USA; Dziewas et al. (2004) Germany</td>
<td>Three of the following indicators: temp $&gt;$38°C, productive cough with purulent sputum, abnormal respiratory exam including tachypnea, (&gt;22 breaths/min), tachycardia, inspiratory crackles, bronchial breathing, abnormal chest x-ray, arterial hypoxemia (PO$^2 &lt; 9.3$ kPa) and positive chest radiography.</td>
</tr>
<tr>
<td><strong>Teasell et al. (1996)</strong> Canada</td>
<td>Radiological evidence of consolidation, and at least one other clinical feature including granulocytosis, temp $&gt;$38°C and/or shortness of breath.</td>
</tr>
<tr>
<td><strong>Smithard et al. (1996)</strong> UK</td>
<td>Presence of at least two of the following: tachypnea (&gt;22/min), tachycardia, aspiratory crackles, bronchial breathing or antibiotic usage.</td>
</tr>
<tr>
<td><strong>Kidd et al. (1995)</strong> UK</td>
<td>Production of sputum in conjunction with the development of crackles on auscultation, with or without the presence of fever or leucocytosis.</td>
</tr>
<tr>
<td><strong>DePippo et al. (1994); Holas et al. (1994)</strong> USA</td>
<td>A positive chest x-ray or the presence of at least three of the following: temp $&gt;$ 100 °F, drop in PO$^2 &gt; 10$ torr, presence of WBC in sputum and/or positive sputum culture for pathogen.</td>
</tr>
<tr>
<td><strong>Johnson et al. (1993)</strong> USA</td>
<td>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 $&gt;$100 °F, WBC $&gt;$10,000 or hypoxia.</td>
</tr>
</tbody>
</table>

5.3.4 The Relationship between Pneumonia and Dysphagia/Aspiration
In stroke, an association between pneumonia and dysphagia/aspiration has been reasonably well-established. The presence of dysphagia and aspiration has been associated with increased odds of pneumonia. Further research in this area is needed within a TBI population.
Individual Study

Table 5.7 The Relationship Between Pneumonia, GCS and FIM Scores Post ABI

<table>
<thead>
<tr>
<th>Author/ Year/ Country/Study design/N</th>
<th>Methods</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hansen et al. (2008) Denmark Retrospective Review N=173</td>
<td>Population: Severe TBI; Median Age=35yr; Median GCS Score=11. Treatment: Chart review of patients admitted to a subacute rehabilitation facility. All patients had a mouth exam and a clinical examination of swallowing done. Outcome Measure: Diagnosis of pneumonia, Functional Oral Intake Scale (FOIS), GCS, Ranchos Los Amigos Scale (RLAS), Functional Independence Measure (FIM).</td>
<td>1. At admission, 27% had pneumonia and 12% developed pneumonia while on the unit. 2. Of those 21 who had pneumonia on the unit, 81% (17) were totally dependent on tube feeding. 3. Patients admitted with a low GCS (&lt;9) were at a higher risk (25%) of developing pneumonia compared to GCS 9-12 (13%) and GCS&gt;12 (2%). 4. 23% of patients with a lower RLAS score developed pneumonia. 5. Overall, differences in risk of pneumonia among groups was significant for GCS, RLAS and FOIS scores (p&lt;0.01). 6. Pneumonia developed in 18% of patients with low functional ability (FIM &lt;19).</td>
</tr>
</tbody>
</table>

Discussion

In a retrospective sample of 173 patients with severe TBI, 27% of those admitted to the brain injury unit had pneumonia, and other 12% developed pneumonia during their stay (Hansen et al. 2008). Hansen et al. (2008) explored the risk factors associated with pneumonia. The study found that pneumonia was more common among individuals with low levels of consciousness and for those with a feeding or tracheotomy tube. As noted, Glasgow Coma Scale scores and Rancho Los Amigos scale scores were associated with risk of pneumonia, with individuals who had lower Glasgow Coma Scale scores being at high risk, as well as individuals with lower Rancho Los Amigo Scale scores. These two scales, along with the Functional Oral Intake Scale and Functional Independence Measure scores were also found to be predictive of returning to an unrestricted diet (Hansen et al. 2008).

Conclusion

*There is Level 4 evidence indicating that individuals with a low level of consciousness and those with tracheotomy tubes are at greater risk for pneumonia.*

*The risk of developing pneumonia appears to be proportional to the severity of the aspiration.*

5.4 Assessment of Dysphagia 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). Assessments should be completed throughout admission to a rehabilitation program. Deficits or any risk factors for swallowing difficulties must be taken into account when making dietary decisions.
Although ERABI focuses primarily on intervention studies, information pertaining to assessment tools used in dysphagia practice have been included within this section since the authors felt it was clinically relevant. 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 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 5.8). The clinical bedside examination typically involves general observations, an oral motor examination, a review of receptive and expressive language and ability to understand direction, and a review of current medications (Halper et al. 1999). The protocol may or may not include a water-swallowing test, and in some cases various consistencies of food and liquids. While bedside assessment 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 aspiration and, in some cases, needless dietary restrictions (Smith et al. 2000).

The bedside clinical examination is generally completed by a Speech Language Pathologist (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 awareness of secretions; patient awareness of clinician’s approach; and the nature of content of initial verbalization by the patient (Logemann 1989).

### Table 5.8 Aspects Included in Various Bedside Screening/Assessment Tools for Dysphagia

<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Components of Selected Dysphagia Screening/Assessment Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Westergren et al., (2001) (Screening for eating difficulties)</td>
<td>• Ingestion: sitting position, manipulation of food on plate, transport of food to mouth • Deglutition: opening or closing of mouth, manipulating food in the mouth</td>
</tr>
<tr>
<td>Perry (2001) (Screening)</td>
<td>• Conscious level • Trunk control while seated • Volitional cough present • Control of saliva • Tongue control • Ease of breathing • Voice quality • Includes water-swallowing test</td>
</tr>
<tr>
<td>Daniels et al., (1997) (Screening)</td>
<td>• Assessment of mandible, lips, tongue, velum • Gag Reflex • Cough or voice change with swallow • Facial numbness/tingling • Dysphonia • Dysarthria • Volitional cough • Includes water-swallowing test</td>
</tr>
<tr>
<td>Smithard et al., (1996) (Screening)</td>
<td>• Conscious level • Head and trunk control • Breathing pattern • Lip closure • Palate movement • Laryngeal function • Gag • Voluntary cough • Includes water-swallowing test</td>
</tr>
<tr>
<td>DePippe et al., (1992) (The Burke Dysphagia Screening test)</td>
<td>• Bilateral/brainstem stroke • History of pneumonia • Failure to finish ½ of meals • Prolonged time required for feeding</td>
</tr>
</tbody>
</table>
5.4.2 Water Swallowing Test
The water-swallowing test originally required a patient to swallow 3oz (90ml) of water; however, smaller amounts have also been used. Although the water-swallowing test has not been studied in ABI, it warrants inclusion. This sensitivity and specificity of this test have been studied extensively within the stroke population and included in Table 5.9.

Individual Studies

<table>
<thead>
<tr>
<th>Author/Year/ Country/ N</th>
<th>Methods</th>
<th>Outcome</th>
</tr>
</thead>
</table>
| **Osawa et al. (2013)** Japan N=111 | **Population:** Stroke  
**Protocol:** Patients with suspected dysphagia were assessed by videoflurography (VF). Results of this test were compared to a clinical assessment performed by a blinded speech therapist. Scoring for clinical assessment: Choking or gargling voice or decrease in oxygen saturation (SpO2). SpO2 decrease of greater than 2% was classified as abnormal. | 1. The number of aspirations experienced by patients increased as the amount of liquid increased (17 occurrences at 5mL to 70 occurrences at 60mL).  
2. The sensitivity of the WST was greatest at 60mL (55.7%), while the specificity of the WST was greatest at 10mL (93.2%).  
3. Positive predictive value was greatest at 60mL (86.7%) and negative predictive value was greatest at 5mL (91.4%).  
4. A specific volume of water (3mL, 5mL, 10mL, 30mL, 60mL) did not stand out as most appropriate across all psychometric properties of the WST. |
| **Kopey et al. (2010)** USA N=223 | **Population:** Stroke.  
**Protocol:** A retrospective review of patients admitted to an acute rehabilitation unit who were alert, and non-dysarthric. These patients received a 3-sip test on day 2 following admission. A portion of the patients underwent additional VMBS due to continued suspicion of dysphagia. The sensitivity, specificity, positive and negative predictive values (PPV, NPV) of the sip test compared with clinically relevant dysphagia, defined as VMBS findings that precipitated a diet change (i.e. minced or pureed solids) were calculated. | 1. 206 patients passed the 3-sip test.  
2. 67 (32.5%) patients had clinically significant dysphagia.  
3. The reported sensitivity and specificity were 20.8% and 98.7%, respectively.  
4. The PPV and NPV were 88.2% and 72.3%, respectively.  
5. A low (<60) Functional Independence Measure score was also predictive of clinically relevant dysphagia. |
| **Nishiwaki et al. (2005)** Japan N=61 | **Population:** Stroke.  
**Protocol:** Symptoms of oromotor functions were evaluation. The water swallowing test (using 30 mL of water), saliva swallowing test and a VMBS examination were also conducted. Factor analysis was used to predict dysphagia in patients with stroke. | 1. Cough/voice change in the water swallowing test was the only variable that was significantly associated with aspiration on VMBS examination, with a sensitivity of 72% and a specificity of 67%. |
| **Wu et al. (2004)** Taiwan N=59 | **Population:** Stroke.  
**Protocol:** Outpatients with suspected dysphagia underwent a 100 mL water-swallowing test and a VMBS examination were conducted. Factor analysis was used to predict dysphagia in patients with stroke. | 1. 55 patients were identified as having some form of swallowing dysfunction on VMBS examination. |
<table>
<thead>
<tr>
<th>Author/ Year/ Country/ N</th>
<th>Methods</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chong et al. (2003)</strong>&lt;br&gt;Singapore N=50</td>
<td>Population: Stroke.&lt;br&gt;Protocol: Patients with suspected dysphagia, 65 years or older, received a WST (patients were asked to drink 50 mL of water in 10mL aliquots), an oxygen desaturation test (desaturation of ≥ 2% was considered clinically significant) and a fiberoptic endoscopic evaluation of swallowing (FEES), where episodes of aspiration or penetration of various food consistencies were noted. The consistency or results between the tests were compared.</td>
<td>1. The WST had a sensitivity of 79.4% and specificity of 62.5% for the detection of aspiration, with a positive predictive value (PPV) of 81.8% and a negative predictive value (NPV) of 58.8%.&lt;br&gt;2. The oxygen desaturation test had a sensitivity of 55.9% and a specificity of 100% with PPV of 100% and NPV of 51.6%.&lt;br&gt;3. When both tests were combined, a sensitivity of 94.1% and a specificity of 62.5% were attained, with PPV of 84.2% and NPV of 83.3%.&lt;br&gt;4. Using the clinical assessment test, three aspirators were detected who would otherwise have been missed if they were assessed with the water swallow test using thin fluids alone.</td>
</tr>
<tr>
<td><strong>Lim et al. (2001)</strong>&lt;br&gt;Singapore N=50</td>
<td>Population: Stroke.&lt;br&gt;Protocol: Patients received a 50 mL WST (in 10 mL aliquots) and a fiberoptic endoscopic evaluation of swallowing examination. Patients also received an oxygen desaturation test.</td>
<td>1. The 50-ml WST had a sensitivity of 84.6% and specificity of 75.0%.&lt;br&gt;2. The oxygen desaturation test had a sensitivity of 76.9% and specificity of 83.3%.&lt;br&gt;3. When the two tests were combined into one test called &quot;bedside aspiration,&quot; the sensitivity rose to 100% with a specificity of 70.8%.</td>
</tr>
<tr>
<td><strong>Garon et al. (1995)</strong>&lt;br&gt;USA N=100</td>
<td>Population: Stroke (50%).&lt;br&gt;Protocol: All patients were asked to drink 3 oz. of water from a cup without interruption. Any coughing or throat clearing was indicative of an abnormal WST. The results of the WST were compared to the VMBS study.</td>
<td>1. Fifty-four patients aspirated. Of these, only nineteen (35%) coughed, leaving thirty-five, or 65%, who were not identified by the WST.&lt;br&gt;2. There was a significant difference between patients identified by the WST compared with the VMBS (p&lt;0.005).&lt;br&gt;3. The sensitivity and specificity of the tool to identify confirmed aspirators were 54% and 79%, respectively.</td>
</tr>
<tr>
<td><strong>DePippo et al., (1992)</strong>&lt;br&gt;USA N= 44</td>
<td>Population: Stroke.&lt;br&gt;Protocol: Patients were given 3 oz of water from a cup and asked to drink without interruption. Coughing for up to 1 minute after the test or a wet-horse voice was considered abnormal. Patients also received a VMBS study and the results from the 2 tests were compared.</td>
<td>1. 27 patients had an abnormal WST.&lt;br&gt;2. 20 patients were proven aspirators on the basis of the VMBS study. The 3 oz. WST identified 16/20 aspirators. 11 patients without evidence of aspiration on VMBS had an abnormal WST.&lt;br&gt;3. The sensitivity and specificity of the WST was 76% and 59%, respectively.</td>
</tr>
</tbody>
</table>

Note: WST=Water Swallowing Test; VMBS=Videofluoroscopic Modified Barium Swallow.
Discussion
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 developed. Many institutions use informal processes, or simply restrict all food and drink until complete assessment by an SLP.

The results of a systematic review by Martino et al. (2000) evaluating the screening 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 water-swallowing test. 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. Limited evidence for screening benefit suggested a reduction in pneumonia, length of hospital stay, personnel costs and patients. More recently, 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 50mL and repeated 5 mL water swallowing test, 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.

5.4.3 Videofluoroscopic Modified Barium Swallow Studies
When aspiration is suspected, the Videofluoroscopic Modified Barium Swallow Studies (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 5.10). In some cases, the VMBS study can then be followed by 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 5.10 Radiological Evaluation during VMBS (Bach et al. 1989)

<table>
<thead>
<tr>
<th>Oral Phase</th>
<th>Lips</th>
<th>Closure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tongue</td>
<td>Anterior and posterior motion with consonants; motion and coordination during transport, and manipulation of the bolus</td>
<td></td>
</tr>
<tr>
<td>Soft Palate</td>
<td>Evaluation and retraction with consonants</td>
<td></td>
</tr>
<tr>
<td>Jaw</td>
<td>Motion</td>
<td></td>
</tr>
<tr>
<td>Oral</td>
<td>Pocketing</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pharyngeal Phase</th>
<th>Swallow</th>
<th>Delay, absence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peristalsis or pharyngeal stripping</td>
<td>Residue in valleculae, pyriform sinuses, nasopharyngeal regurgitation</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Laryngeal Phase</th>
<th>Elevation of larynx</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penetration into laryngeal vestibule</td>
<td></td>
</tr>
<tr>
<td>Aspiration</td>
<td>Presence, delay, effectiveness/productiveness</td>
</tr>
<tr>
<td>Cough</td>
<td>Vocal cord function</td>
</tr>
<tr>
<td>Vocal cord function</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Post Exam Chest X-Ray</th>
<th>Chronic Stages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presence of barium in valleculae, pyriform sinuses, tracheobronchial tree, lungs</td>
<td></td>
</tr>
</tbody>
</table>

_Videofluoroscopic Modified Barium Swallow (or Modified Barium Swallow) studies may be used as a tool to assist in dysphagia management and identification of aspiration in the ABI population._

### 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, and easier to administer. FEES, also referred to as flexible endoscopic evaluation of swallowing, is recognized as an objective tool for the assessment of swallowing function and aspiration. FEES is a procedure that allows for the 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.
Individual Studies

Table 5.11 Studies Evaluating FEES for Stroke Patients

<table>
<thead>
<tr>
<th>Author/Year Country/Study Design/N</th>
<th>Methods</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Leder &amp; Espinosa (2002)</strong> Case Series N=49</td>
<td><strong>Population</strong>: Stroke. <strong>Protocol</strong>: Patients referred for swallowing assessment were evaluated for the presence of aspiration using a bedside evaluation which was immediately followed by a Fiberoptic endoscopic examination of swallowing (FEES) test. FEES was used as the diagnostic standard.</td>
<td>1. The clinical exam incorrectly identified 19 of 22 patients considered at risk for aspiration. 2. The clinical exam correctly identified 8 of 27 patients not at risk of aspiration. 3. The sensitivity and specificity of the clinical assessment were 86% and 30%, respectively. 4. The corresponding positive and negative predictive values were 50% and 73%.</td>
</tr>
<tr>
<td><strong>Aviv (2000)</strong> USA Cohort N=126</td>
<td><strong>Population</strong>: Stroke (35.7%), Chronic Neurologic Disease (28.6%), Other (35.7%). <strong>Protocol</strong>: 76 outpatients referred for dysphagia evaluation were assigned to a Modified Barium Swallow (MBS) group to guide swallowing management, while 50 patients received Fiberoptic endoscopic examination of swallowing with sensory testing (FEESST). The incidence of pneumonia over a one-year period between groups was compared. Patients received feeding tubes, therapy from a speech-language pathologist based on the results obtained from the MBS/FEESST results.</td>
<td>1. There was no difference in the incidence of pneumonia between the groups. 2. At the end of one-year 14 (18.4%) patients whose management had been guided by MBS developed pneumonia, compared with 6 (12%) patients in the FEES group (p=0.33). 3. Among 45 stroke patients the incidence of pneumonia was lower among FEES group patients (1/21 vs. 7/24, p&lt;0.05).</td>
</tr>
</tbody>
</table>

Discussion

Aviv (2000) compared the incidence of pneumonia over a one-year period between patients managed by MBS or FEES with sensory testing. Among the stroke patients, the incidence of pneumonia managed by FEES with sensory testing was significantly lower. 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 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. Two studies suggest FEES as the gold standard to assess the accuracy of either the water-swallowing test and/or pulse oximetry to detect aspiration within the stroke population (Chong et al. 2003; Lim et al. 2001).

Although FEES may be less invasive and less costly to complete, further investigation would be beneficial to determine its effectiveness in identifying swallowing difficulties or aspiration post stroke. To determine its effectiveness within the ABI/TBI population, more research needs to be done.
5.4.5 Pulse Oximetry

Pulse oximetry has also been suggested as an alternative to 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, Chang, Chen, and Hsiao (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.

Individual Studies

Table 5.12 Studies Evaluating Pulse Oximetry in Stroke Patients

<table>
<thead>
<tr>
<th>Author/Year/Country/Study Design/N</th>
<th>Population</th>
<th>Methods</th>
<th>Outcome</th>
</tr>
</thead>
</table>
| Ramsey et al. (2006) UK N=189     | Stroke.    | Patients received a bedside swallowing assessment (BSA), pulse oximetry and VMBS (n=54) studies. Two cut-points were selected to determine the presence/absence of oxygen desaturation (>2% and >5%). | 1. 15 (28%) demonstrated aspiration on VMBS. Of these, 2% desaturation was seen in 5 (33.3%) of these patients and in 2 (13.3%) when >5% threshold was used.  
2. 7/15 patients (47%) with demonstrated aspiration, failed the BSA.  
3. The sensitivity and specificity associated with >2% desaturation were 33% and 62% and were 13% and 95% for an oxygen desaturation threshold of >5%. |
| Wang et al. (2005) Taiwan Observational N=60 | Stroke (45%). Protocol: Patients received both oxygen saturation and VMBS evaluation. Oxygen saturation was monitored for 5 minutes before and for 5 minutes after the VMBS evaluation. | 1. 23/60 patients enrolled in the study, demonstrated aspiration on VMBS study. Of these patients 9 displayed significant oxygen desaturation (a drop of > 3% was considered significant).  
2. Of the 37 patients who did not demonstrate aspiration on VMBS, 15 had an episode of oxygen desaturation.  
3. The sensitivity and specificity were 39.1% and 59.4%, respectively.  
4. The positive and negative predictive values were 37.5% and 61.1%, respectively. The positive likelihood ratio was 0.96. |
| Smith et al. (2000) UK Observational N=53 | Stroke. Protocol: Patients received a bedside evaluation, pulse oximetry and a VMBS evaluation of swallowing. The sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) were calculated for both the bedside evaluation and pulse oximetry. | 1. 15 of 53 patients aspirated on VMBS examination.  
2. The Sensitivity, Specificity, PPV (Positive Predictive Value) and NPV (Negative Predictive Value) for pulse oximetry to identify aspiration were 87%, 39%, 36% and 88%, respectively. |
| Sherman et al. (1999) USA Observational N=46 | Stroke (34.8%). Protocol: Patients with swallowing difficulties underwent VMBS evaluation with simultaneous oxygen saturation monitoring (with a 5-6 second sampling | 1. 12/46 patients (six with stroke) aspirated on VMBS.  
2. Patients who aspirated had a significantly greater decline in oxygen saturation compared to those who did not aspirate. |
Sellars et al. (1998)  
UK Observational  
N=6  

**Population:** Stroke (66.7%).  
**Protocol:** Patients with established dysphagia underwent both VMBS evaluation with simultaneous oxygen saturation monitoring. A decline in O₂ saturation of 4% from baseline was considered clinically significant.  

1. 4 patients demonstrated aspiration of VMBS. Of these, two exhibited significant O₂ desaturation.

Collins & Bakhei (1997)  
UK Observational  
N=54  

**Population:** Stroke.  
**Protocol:** Patients with swallowing difficulties received a VMBS study and simultaneously had their arterial oxygen saturation measured. The barium meal consisted of 150 mL liquid, 3 oz. mousse and biscuit. A drop of 2% in the arterial oxygen saturation was considered clinically significant. Oxygen saturation was measured during swallowing, 2 minutes after the test meal and 10 minutes after the VMBS study was completed.  

1. 22 patients demonstrated aspiration on VMBS evaluation.  
2. Correlation of the pulse oximetry results with VMBS findings showed that 12 (55%) of the patients who aspirated had a significant degree of oxygen desaturation at the point of swallow/aspiration, but none of the nonaspirators desaturated by ≥2%.  
3. When the results of oximetry at swallow/aspiration and at 2 minutes after swallowing were combined, 16 (73%) of the aspirators could be identified by this method, and 4 (13%) of the nonaspirators also had a significant oxygen desaturation.  
4. 44 patients (81.5%) were accurately predicted as aspirators or nonaspirators (κ=0.61, P<.001). Prediction was better for males compared to females.  
5. The sensitivity and specificity of pulse oximetry were 73% and 87%, respectively.

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 as the low sensitivities/specificities from the above studies will attest to.

**There is limited evidence supporting the use of pulse oximetry to detect aspiration in patients who have had a stroke.**

**Pulse oximetry does not appear to be as sensitive a test as VMBS in determining aspiration post stroke. Research needs to be completed within an ABI population.**
5.4.6 Blue Dye Assessment for Swallowing

The blue dye assessment for swallowing has been used since the early ‘70’s with patients who have a tracheotomy; however, the accuracy of the test has been questioned since the 1980’s (O’Neil-Pirozzi et al. 2003). 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 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). Belafsky et al. (2003) in a study of 30 patients with tracheostomies conclude that the use of the Modified Evans Blue Dye (MEBD) test is beneficial with patients who have a tracheostomy tube (82% sensitivity) and in particular those who receive mechanical ventilation (100% sensitivity). O’Neil-Pirozzi, Momose, et al. (2003) found the blue dye test was unable to correctly identify aspiration in 20% of 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 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 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.

---

**Modified Evans Blue Dye Test may be beneficial if patients aspirate more than trace amounts.**

**Caution is recommended when using the MEBD test alone to ascertain aspiration in individuals who have a tracheostomy.**

5.4.7 Other Methods Using Stroke as a Model of Care

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.

Other forms of clinical assessment have been used to detect the presence of aspiration. Ryu, Park, and Choi (2004) evaluated voice analysis as a means to clinically predict laryngeal penetration among 93 patients (46% of whom had suffered a stroke) using VMBS as the diagnostic gold standard. 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.
5.4.7.1 Cervical Auscultation

Cervical auscultation 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, Lawrie, and Wiles (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). Again, research is needed in this area for individuals who were diagnosed with dysphagia post ABI specifically.

5.5 Management of Dysphagia

5.5.1 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 Stroke 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 Stroke Foundation of Ontario 2002). Similar guidelines have not been developed yet for ABI; however, the general principles outlined in the guidelines are applicable to this population.

Table 5.13 Best Practice Guidelines for the Assessment and Management of Dysphagia Post Stroke (Heart and Stroke Foundation 2014).

- Interprofessional team members should be trained to complete initial swallowing screening for all stroke patients to ensure patients are screened in a timely manner [Evidence Level C].
- Patients should be screened for swallowing deficits within the first 24 hours of admission using a valid screening tool [Evidence Level B]. Patients who are not initially alert should be closely monitored and screened when clinically appropriate [Evidence Level C].
- Abnormal results from the initial or ongoing swallowing screens should prompt a referral to either a speech-language pathologist, occupational therapist, dietician or other trained dysphagia clinician for more detailed assessment and management of swallowing, nutritional and hydration status [Evidence Level C]. An individualized management plan should be developed to address therapy for dysphagia, dietary needs, and specialized nutrition plans [Level C].
- Videofluoroscopic modified barium swallow (MBS), which allows actual visualization of swallowing, should be performed on all patients considered at high risk for aspiration, based on results from a bedside swallowing assessment, stroke location (e.g. brain stem stroke, pseudobulbar palsy), or other clinical features (e.g., multiple strokes) [Evidence Level B].
  - Modified barium swallow may also be used to guide management decisions for patients with dysphagia [Evidence Level C].
- Management of dysphagia includes the use restorative swallowing therapy (e.g., lingual exercises) and/or compensatory techniques, with reassessment as required [Evidence Level C].
  - Compensatory techniques may include upright positioning; double swallow technique, coughing after swallowing, small sips of fluids only, texture-modified solids and altered consistency fluids, and/or restorative swallowing therapy [Evidence Level C].
- To reduce the risk of pneumonia, patients should be permitted and encouraged to feed themselves whenever possible.
Evidence-Based Review of Moderate to Severe Acquired Brain Injury | 2014

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). It is noted that when patients with dysphagia are not able to feed themselves independently, hand-over-hand support should be provided at eye-level positioning. If full feeding assistance is required, it needs to be provided using low-risk feeding strategies.

Table 5.14 Low Risk Feeding Strategies in Stroke Patients with Dysphagia

<table>
<thead>
<tr>
<th>Ability of feeder to deal with emergencies, such as choking.</th>
<th>Drink from wide-mouth cup or a straw to reduce neck extension.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calm eating environment with a minimum of distractions.</td>
<td>Ensure swallowing is complete before offering additional items thorough meals.</td>
</tr>
<tr>
<td>Patient properly position – upright, midline with neck slightly flexed.</td>
<td>Properly position and monitor for swallowing problems for at least 30 minutes after each meal.</td>
</tr>
<tr>
<td>Proper oral care.</td>
<td>Carefully monitor patient’s oral intake.</td>
</tr>
<tr>
<td>Feed at eye-level.</td>
<td></td>
</tr>
<tr>
<td>Metal teaspoons (no tablespoons or plastic).</td>
<td></td>
</tr>
<tr>
<td>Feed slowly.</td>
<td></td>
</tr>
</tbody>
</table>

There is consensus opinion that patients should be screened for swallowing deficits in a timely manner using a valid screening tool.

There is consensus opinion that a referral to a speech-language pathologist, occupational therapist, dietitian or other trained dysphagia clinician for a detailed assessment and identify the appropriate course of treatment.

Based on the stroke literature, individuals with dysphagia should feed themselves whenever possible. When not possible, low-risk feeding strategies should be used.

5.5.2 Oral Hygiene

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, there may be less priority placed on providing mouth care as part of their 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. There is a four to six fold increase in the incidence of aspiration pneumonia in patients with periodontal disease and/or poor oral care. 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 issues). 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). Improved oral care also has a positive impact on the reduction of aspiration pneumonia rates, particularly in those patients with dysphagia.

5.5.2.1 Approaches to Ease the Provision of Oral Care in the TBI Patient

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 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).

Individual Studies

Table 5.15 Oral Hygiene Post ABI

<table>
<thead>
<tr>
<th>Author/Year/Country/Study Design/PEDro Score/N</th>
<th>Methods</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Seguin et al. (2014)</strong>&lt;br&gt;2014 France RCT PEDro=7 N=167</td>
<td><strong>Population:</strong> Povidone-Iodine group (n=85): TBI=62, Stroke=23; Mean Age=48yr; Gender: Male=60, Female=25; Mean Time Post Injury=6hr; Mean GCS=6. <strong>Placebo group</strong> (n=82): TBI=61, Stroke=21; Mean Age=48yr; Gender: Male=64, Female=18; Mean Time Post Injury=6hr; Mean GCS=6. <strong>Intervention:</strong> Patients were randomly assigned to either receive Povidone-Iodine for decontamination of the oropharyngeal tract, or placebo. <strong>Outcome Measures:</strong> Incidence of ventilator-associated pneumonia (VAP).</td>
<td>1. VAP occurred in 31% of patients in the Povidone-Iodine group and 28% of patients in the placebo group (p=0.69).</td>
</tr>
<tr>
<td><strong>Robertson and Carter (2013)</strong>&lt;br&gt;Canada N=83</td>
<td><strong>Population:</strong> TBI, Intracranial hemorrhage, tumour, Other. <strong>Standard oral care (SOC) Group</strong> (n=51): Mean Age=57yr; Gender: Male=27, Female=24. <strong>Enhanced oral care (EOC) group</strong> (n=32): Mean Age=61yr; Gender: Male=23, Female=9. <strong>Intervention:</strong> 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. <strong>Outcome Measures:</strong> Incidence of non-ventilator hospital-acquired pneumonia (NV-HAP).</td>
<td>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).</td>
</tr>
</tbody>
</table>
**Author/Year/Country/Study Design/PEDro Score/N**

<table>
<thead>
<tr>
<th>Zasler et al. (1993)</th>
<th>RCT</th>
<th>USA</th>
<th>PEDro=4</th>
<th>N=20</th>
</tr>
</thead>
</table>

**Methods**

**Population:** TBI; Mean Age=30yr; Gender: Male=14, Female=6; Time Post-Injury>1mo; **Intervention Group (n=10):** Mean GCS=7; **Control Group (n=10):** Mean GCS=6.

**Treatment:** 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 (5-6wks).

**Outcome Measure:** Plaque index score.

**Outcome**

1. No differences were found between the intervention and control group when examining the mean plaque scores at baseline (1.94 vs 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 vs. 2.19, p<0.01).
3. Plaque scores improved significantly from pre- to post-intervention for the intervention group only (p<0.01).

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

**Discussion**

In the Zasler study (1993), patients who were provided verbally with 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 is therefore effective in promoting dental plaque control (Zasler et al. 1993).

In the Seguin study (2014), authors investigate the efficacy of povidone-iodine versus a placebo drug in reducing ventilator-associated pneumonia. It was concluded that the occurrence of ventilator-associated pneumonia, although reduced in the experimental group, was not significantly different from the control group (Seguin et al. 2014). Based on the findings from this study, povidone-iodine was ineffective in preventing ventilator-associated pneumonia, and has shown to increase the risk of secondary infections including acute respiratory distress syndrome (Seguin et al. 2014). Robertson and Carter (2013) found that patients in the enhanced oral care protocol had a significant decrease in acquired pneumonia when compared to the standard oral care group. These results suggest that an enhanced oral care protocol is more beneficial in improving oral hygiene, as well as overall health of patients (Robertson & Carter 2013).

**Conclusion**

*There is Level 1b evidence that povidone-iodine is not beneficial in preventing ventilator-associated pneumonia.*

*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.*

---

http://www.abiebr.com Updated October 2014
Education in oral health and good oral care is needed to reduce the risk of dysphagia and other swallowing complications that can result from a brain injury.

Good oral health can promote recovery and reintegration into society by reducing some of the negative consequences associated with poor oral hygiene.

5.5.2.2 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. Here it is neutralized and presents less threat to the health of our lungs. Even in healthy individuals the importance of a solid mouth care program cannot be understated. In patients who are NPO problems are compounded by xerostomia (dry mouth). Xerostomia is an undesirable side effect in some 400 to 500 medications (Bartels 2005; Canadian Dental Association 2009; Nicol et al. 2005). Many of these medications (e.g., anti-hypertensives, anticonvulsants, antidepressants) 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 the patients with dysphagia is best performed before eating/drinking and not just following these times. 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”.

Individual Studies

Table 5.16 Oral Care and Nosocomial Infections in Non-ABI Participants

<table>
<thead>
<tr>
<th>Author/Year/Country/Study design/PEDro Score/N</th>
<th>Methods</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lam et al. (2013) China RCT N=102</td>
<td>Population: Stroke. Treatment: Patients randomized to one of three groups: 1) oral hygiene instruction (OHI) only; 2) OHI and mouth rinse (0.2% chlorhexidine twice per day); or 3) OHI, mouth rinse and assistance with tooth brushing twice weekly. Outcomes assessed at baseline and at 3wk. Outcome Measure: Oral bacteria levels.</td>
<td>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.</td>
</tr>
</tbody>
</table>
### Evidence-Based Review of Moderate to Severe Acquired Brain Injury

**Prendergast et al.** (2011)
USA
RCT
PEDro=6
N=47

**Population:** Stroke (78.7%).
**Treatment:** 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.
**Outcome Measure:** Intracranial pressure (ICP), cerebral perfusion pressure (CPP).

1. No significant between group differences were found in ICP values ($p=0.72$) or CPP values ($p=0.68$).
2. When looking at the two groups together, results showed ICP levels increased before and during oral care ($p=0.001$), and decreased from during care to after oral care was completed ($p<0.001$).

---

**Cabov et al.** (2010)
Croatia
RCT
N=60

**Population:** Neoplasms (61.7%), Head trauma (28.3%), Polytrauma (10%).
**Treatment:** 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.
**Outcome Measure:** Rate of infections, Plaque score.

1. The plaque score significantly increased in the placebo group and decreased in the chlorhexidine ($p<0.05$).
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 vs. 6.8±3.5, $p=0.0187$), compared to the placebo group.

---

**Yoneyama et al.** (2002)
Japan
Survey
N=366

**Population:** Nursing home patients.
**Treatment:** Patients either received oral care ($n=184$) or did not receive oral care ($n=182$).
**Outcome Measure:** Pneumonia, febrile days, death from pneumonia, Activities of Daily Living Scale, Mini Mental State Exam.

1. Pneumonia was more common in those who did not receive oral care, compared to those that did (34 cases vs. 21 cases).
2. Scores on the activities of daily living scale and the mini mental state examination improved in those receiving oral care.
3. During follow up 54 (29%) patients had febrile days in the non-oral care group, and 27 (15%) in the oral care group.
4. Of those who had pneumonia, 30 (16%) in the no-oral care group, and 14 (7%) in the oral care group died.

---

**Fourrier et al.** (2000)
France
RCT
N=60

**Population:** Intensive Care Unit patients.
**Treatment:** Chlorhexidine 0.2% (dental gel) group or the control group where dental care consisted of rinsing the mouth with bicarbonate isotonic serum, followed by oropharyngeal sterile aspiration 4x/day.
**Outcome Measure:** The development of nosocomial infections, Caries-Absent-Occluded Index.

1. The rate of nosocomial infection acquired in the ICU was significantly higher for the control group ($p=0.018$).
2. The chlorhexidine was found to be effective in reducing the risk of nosocomial infections.
3. Those in the treatment groups also had a reduced ICU stay compared to the placebo group.

---

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

### Discussion

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 affect individuals as they age. Of importance to the Dental Association is the teaching of sound preventative habits, such as an appropriate diet and patient-specific oral hygiene techniques. In a randomized controlled trial (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.
Research conducted in long term care or acute care facilities report mortality rates, risk for developing dysphagia, and risk of aspiration pneumonia decline 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, fewer cases of pneumonia and fewer patients were dying from pneumonia (Yoneyama et al. 2002).

Two RCTs were reviewed investigating 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 chlorhexidine gel was effective in reducing the number of nosocomial infections and overall length of stay. 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.

Maintaining good oral health during hospitalization may help to reduce the risk of nosocomial infections by decreasing dental bacterial colonization and hospital recovery time.

Good oral care has not been shown to have any adverse effects on normal intracranial pressure or cerebral perfusion pressure values in intubated patients.

5.5.3 Management of Dysphagia for Patients with 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 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 only introduced once trials with more traditional behavioural treatment techniques have proven to be unsuccessful.

5.6 Treatment of Dysphagia Post ABI
Several treatments have been found to treat 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.

5.6.1 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).

5.6.1.1 Range of Motion Exercises for the Pharyngeal Structures: Airway Entrance
The individual is placed in a seated position and asked to bear down while holding his or her breath. This exercise is not recommended for those with uncontrolled blood pressure (Logemann 1998). It is recommended this exercise be done 5 to 10 times each day for 5 minutes.

5.6.1.2 Vocal Fold Adduction Exercises
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 “ah” 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 with vocal folds that fail to close completely (Kramer et al. 2007).

5.6.2 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.

5.6.3 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 with 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 do the maneuvers correctly (Kramer et al. 2007).

5.6.3.1 Supraglottic Swallow
This maneuver was 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 caught in the laryngeal vestibule.

5.6.3.2 Super-supraglottic Swallow
This procedure is designed to close the airway entrance both before and during the swallow, increase pressure generation, as well as to clear residue afterwards (Logemann 1998). During this maneuver the patient follows the following steps: 1) take a deep breath in; 2) hold the breath in and hold it 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).

5.6.3.3 Effortful Swallow
Effortful swallow is designed to increase posterior movement of 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).

5.6.3.4 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 Adam’s apple up for two to three seconds, then complete the swallow.

5.6.4 Frazier Free Water protocol
To increase fluid consumption and decrease the risk of dehydration, the Frazier Water Protocol, allows patients who are receiving thickened liquids to be given regular, thin water 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
Evidence-Based Review of Moderate to Severe Acquired Brain Injury 2014

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).

5.6.5 Thermal-tactile Stimulation
Thermal stimulation or thermal-tactile stimulation was developed to stimulate the swallowing reflex of patients who are neurologically impaired (Lazzara et al. 1986). The procedure for thermal-tactile stimulation involves having the patient open their mouth and applying a cold laryngeal mirror at the base of the faucial arches. The mirror, while being in contact with the arch, is then 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 is not triggered at the time of stimulation but its purpose is to heighten the sensitivity for swallowing in 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 can be made.

5.6.6 Postural Techniques
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 reducing the risk of aspiration. There are five postures that have been shown to have some success in assisting individuals improve their swallowing function (Table 5.17; 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 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 5.17 Five Postures to Improve Swallowing Function (Logemann 2008)

<table>
<thead>
<tr>
<th>Posture</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Chin Down Posture</td>
<td>Helpful for those who have tongue base retraction issues;</td>
</tr>
<tr>
<td></td>
<td>Mechanism of change widens the valleculae, allowing the valleculae to</td>
</tr>
<tr>
<td></td>
<td>contain the bolus in event of pharyngeal delay.</td>
</tr>
<tr>
<td>2. Chin Up Posture</td>
<td>Helpful for those who have oral tongue propulsion problems;</td>
</tr>
<tr>
<td></td>
<td>Aids in gaining adequate lingual pressure to drive the food or liquid</td>
</tr>
<tr>
<td></td>
<td>out of the mouth and into the pharynx.</td>
</tr>
<tr>
<td>3. Head Turn (left or right)</td>
<td>Involves rotating the head to the side that is damaged;</td>
</tr>
<tr>
<td></td>
<td>Bolus is then directed down the “normal” safe side.</td>
</tr>
<tr>
<td>4. Head Tilt (left or right)</td>
<td>Head is tilted toward the stronger side, to promote the flow of food and</td>
</tr>
<tr>
<td></td>
<td>liquid to go down that side.</td>
</tr>
<tr>
<td>5. Lying Down</td>
<td>Shown effective in those with posterior pharyngeal wall contraction or</td>
</tr>
<tr>
<td></td>
<td>reduced laryngeal elevation with resulting residue and subsequent</td>
</tr>
<tr>
<td></td>
<td>aspiration after swallowing.</td>
</tr>
<tr>
<td></td>
<td>Residual or pooling of food or liquid in the pharynx is kept from</td>
</tr>
<tr>
<td></td>
<td>falling into the airway as gravity pulls the bolus towards the posterior</td>
</tr>
<tr>
<td></td>
<td>pharyngeal wall and in this way bolus may be more easily moved into the</td>
</tr>
<tr>
<td></td>
<td>esophagus (Drake, O'Donoghue, Bartram, Lindsay, &amp; Greenwood, 1997;</td>
</tr>
<tr>
<td></td>
<td>Rasley et al., 1993).</td>
</tr>
</tbody>
</table>
5.6.7 Diet Modification
The consistency of food should be chosen based on the specific nature of the problem. Although an attempt has been made to standardize dysphagic diets (McCallum 2003), there continues to be a lot of variation in their use in clinical practice and in how these diets are labelled. The following tables illustrate two examples of diets for dysphagia.

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 – purées) 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 5.18 A Description of Four Levels of Diets**

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

**Table 5.19 Diet Levels as Defined by a Canadian Hospital (Parkwood Institute-SJHC)**

<table>
<thead>
<tr>
<th>Dysphagia Diet Fluids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thin Fluids</td>
</tr>
<tr>
<td>All fluids that are thin at room temperature: water/ice chips/juices/ tea/liquid nutritional supplements/ regular or strained soups/ice cream/jello.</td>
</tr>
<tr>
<td>Honey Thick Fluids</td>
</tr>
<tr>
<td>Thin fluids that are thickened to the consistency of liquid honey but can be sipped from a cup: honey thick juices, mild, water, soup.</td>
</tr>
<tr>
<td>Honey Thick/Thin Fluids</td>
</tr>
<tr>
<td>Honey thickened fluids with the addition of thin fluids as determined in consultation with the patients/ resident/SDM and the SLP/RD.</td>
</tr>
<tr>
<td>Honey Thick Clear Fluids</td>
</tr>
<tr>
<td>Only honey thickened CLEAR fluids are allowed (no textures): honey thick apple/orange/cranberry juice and honey thick water.</td>
</tr>
<tr>
<td>Honey Thick Full Fluids</td>
</tr>
<tr>
<td>Only honey thickened FULL fluids are allowed (no textures): honey thick juices/water/mild/soup/hot cereals/custard/pudding/smooth yogurt.</td>
</tr>
<tr>
<td>Pudding Thick Fluids</td>
</tr>
<tr>
<td>Thin Fluids</td>
</tr>
<tr>
<td>Thin Fluids</td>
</tr>
<tr>
<td>Pudding thickened fluids with the addition of thin fluids as determined in consultation with the patient/resident/SDM/and the SLP/RD.</td>
</tr>
<tr>
<td>Pudding Thick Clear Fluids</td>
</tr>
<tr>
<td>Only pudding thickened CLEAR fluids are allowed (no textures): pudding thick/apple/cranberry juices and pudding thick water.</td>
</tr>
<tr>
<td>Pudding Thick Full Fluids</td>
</tr>
<tr>
<td>Only pudding thickened FULL fluids are allowed (no textures): pudding thick juices/water/mild/soups: hot cereals, custard, pudding, smooth yogurt.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dysphagia Diet Textures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regular</td>
</tr>
<tr>
<td>All items are served unmodified.</td>
</tr>
<tr>
<td>Ready</td>
</tr>
<tr>
<td>Same as regular but roast meats are diced.</td>
</tr>
<tr>
<td>Diced Meat/Modified Vegetable</td>
</tr>
<tr>
<td>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.</td>
</tr>
<tr>
<td>Minced meat/Modified Vegetable</td>
</tr>
<tr>
<td>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.</td>
</tr>
</tbody>
</table>
Minced | Minced meats, vegetables, mashed potatoes, potato puffs, scalloped potatoes, cheese, peanut butter sandwiches, fresh bananas, minced strawberries, seedless watermelon.
---|---
Minced/Pureed | Minced meal and vegetables, mashed potatoes (not rice), soft casseroles, scrambled eggs, pureed fruits, strained soups, oatmeal or cream of wheat.
---|---
Pureed Entrée/Modified Bread | Same as above; can add crustless bread toast, moist cakes.
---|---
Pureed with oatmeal | Oatmeal, foods with a pudding type consistency, all entrees must be pureed.
---|---
Pureed | 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

5.6.8 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.

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; however, 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 take thin liquids (Suiter et al. 2003), improve oxygenation, decrease oral and nasal secretions, improve sense of smell, enhance airway clearance, and improved swallowing (Bell 1996). To determine its effectiveness specifically within the ABI population more research is recommended.

**Although there are several possible interventions to treat dysphagia, there is no clinical evidence to support their efficacy specifically within an ABI population. More research is needed.**

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
Evidence-Based Review of Moderate to Severe Acquired Brain Injury

2014 Module 5 - Dysphagia and Nutritional Interventions for Patients with an ABI

http://www.abiebr.com
Updated October 2014

rehabilitation unit. Despite clinicians’ efforts several factors make it difficult to avoid malnutrition in patients with ABI patients, 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 brains’ critical role in triggering the metabolic response (Young et al. 1992).

Secondary to ABI, a catabolic and counter regulatory hormone (glucagons and cortical) increase takes place (Loan 1999). Deficiencies of follicle-stimulating hormones (FSH), leuteinizing hormone (LH), and growth hormone (GH) indicate alteration in the hypothalamic-pituitary feedback 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).

5.7.1 The 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 tend 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).

Individual Studies

Table 5.20 Nutritional Status of Brain-Injured Patients

<table>
<thead>
<tr>
<th>Author/Year/Country/Study Design/N</th>
<th>Methods</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Krakau et al.</strong> (2007) Sweden Retrospective Review N=64</td>
<td>Population: TBI; Mean Age=35yr; Gender: Male=53, Female=11; GCS Score Range=3-8. Treatment: Data was extracted from patient files covering the period from the onset of injury until the patients became nutritionally independent, or until 6 mo post injury. Outcome Measure: Duration of parenteral nutrition (PN) and enteral nutrition (EN), use of gastrostomy, course of assisted feeding, Malnutrition Universal Screening Tool. Malnourishment was: Body Mass Index (BMI)=18.5-20kg/m² AND involuntary weight loss of 5-10% over 3-6 mo; BMI&lt;18.5kg/m²; or involuntary weight loss &gt;10%.</td>
<td>1. While in intensive care, patients received nutrition PN for mean of 19 d. 2. Most patients (86%) also received EN which was started on average 4 d after injury. 3. Patients received EN from 1-178 d post PN. 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). 5. By 6 mo post-injury, 54 (84%) patients were nutritionally independent. 6. Of the 56 patients assessed for malnourishment, 38 (68%) met the criteria.</td>
</tr>
<tr>
<td><strong>French and Merriman</strong> (1999) UK</td>
<td>Population: ABI; Mean Age=33.2yr; Gender: Male=31, Female=2; Mean Time Post Injury=5.75yr.</td>
<td>1. There were no incidences of malnutrition. 2. The incidence of obesity was comparable to the healthy normal population.</td>
</tr>
</tbody>
</table>
Observational  
N=33  

| Treatment: | Height, weight and skin fold thickness were measured for inpatients with brain injury enrolled in rehabilitation.  
Outcome Measure: | Skin Fold measurements, Dietary assessment.  
3. Subjects consumed a nutritionally adequate diet except for non-starch polysaccharides (fibre). |

Discussion
A single study was identified which reported the nutritional state of patients in the chronic phase of recovery and found individuals had adequate nutrition (French & Merriman 1999). The mean time from injury to admission to the unit approached six years. However, a survey conducted by Krakau et al. (2007) found 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 nutrition enterally (Krakau et al. 2007).

Following an ABI, malnutrition may be present in patients with severe injuries within the first months post injury.

The incidence of obesity in the chronic stages of injury was comparable to the normal population.

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).

Individual Studies

Table 5.21 Elevations in Resting Energy Expenditure (REE) Following ABI

| Author/Year/  
Country/Study design/ N | Population: | Methods | Outcomes |
|------------------------|-------------|---------|----------|
| Weekes et al. (1996)   | TBI; Mean Age=23.2yr; Gender: Male=6, Female=0; GCS Score Range=6-8.  
Treatment: Continuous bedside indirect calorimetry (up to 24hr) was performed 3-5d post injury and again at 2-3wk (n=4).  
Outcome Measure: REE. | During the first testing period REE was 130±17% of predicted values (p<0.05) and at the second testing period, REE was only 105±11% of predicted (p<0.05). The decrease from first post-injury assessment to second post-injury assessment was significant (p<0.05).  
2. Calorimetry measurements fluctuated by up to 25% during the day. |
<p>| Bruder et al. (1994)   | Head injury; Mean Time Post Injury=7.6d. Group 1 (n=9): Mean | In both groups REE was close to predicted values (113-115%) at the initiation of the study when |</p>
<table>
<thead>
<tr>
<th>Author/Year/ Country/Study design/ N</th>
<th>Methods</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dempsey et al. (1985) USA Pre-Post N=10</td>
<td>Population: TBI; Mean Age=26.6yr; Gender: Male=6, Female=4; Mean GCS Score=5.2; Time Post Injury=2wk. Treatment: All patients were intubated and received steroids. Concomitant barbiturate therapy was administered to those with failing Intracranial pressure. 30 measurements were made over the study period using indirect calorimetry and were compared to predicted levels. Outcome Measure: REE.</td>
<td>1. 16 measurements were taken during barbiturate use. These were significantly lower compared to the remaining 14 taken in the absence of barbiturate use (86±28% vs. 126±36% of predicted values; p&lt;0.01). 2. Mean REE was significantly lower during barbiturate therapy than without barbiturate therapy (p&lt;0.01).</td>
</tr>
<tr>
<td>Young et al. (1985) USA Case Series N=16</td>
<td>Population: Head injury; Mean Age= 39.8yr; Gender: Male=15, Female=1; GCS Score Range=4-8. Treatment: Indirect calorimetry was performed on 5 occasions from days 1 to 22 post-injury (0-3, 4-7, 8-14, 15-21, and 22 or more days). Each session lasted 15-30 min. Patients were assessed on admission, every 3d until day 18, and then weekly. Outcome Measure: REE and Predicted Energy Expenditure.</td>
<td>1. Compared to PEE, REE was consistently elevated: days 1-3: 151%; days 4-7: 138%; days 8-14: 137%; days 15-21: 140%; and days 22 or more: 116%.</td>
</tr>
<tr>
<td>Robertson et al. (1984) USA Case Series N=55</td>
<td>Population: Head injury; Gender: Male=49, Female=6; GCS&lt;8. Treatment: REE was measured by indirect calorimetry 188 times in patients with penetrating or non-penetrating brain injuries. Measurements were taken from day 1 following injury for 7-28d, or until patients were awake enough to eat. Outcome Measure: REE.</td>
<td>1. Patients with posturing responses to pain (GCS 4-5) had the highest REE at 168±53% of expected. 2. REE was lowest in patients with withdrawal and localizing responses to pain (GCS 6-7) at 129±31% of expected. 3. Patients with a GCS score of 8 had a REE of 150±49%. 4. Sedative use and paralysis were associated with lower REE.</td>
</tr>
<tr>
<td>Clifton et al. (1984) USA Case Series N=14</td>
<td>Population: Head Injury; Mean Age=27.8yr; Gender: Male=12, Female=2; GCS Score Range=3-8; Mean Time Post Injury=2hr. Treatment: The REE of Enteral nutrition fed patients was measured by indirect calorimetry, over the first 9 d of onset (n=14), up to 28 d post injury (n=4). Outcome Measure: REE.</td>
<td>1. Mean values of REE ranged from 2135±374 Kcal on 1-3d to 2504±582 Kcal on 7-9d, which was not statistically significant. 2. The mean REE ranged from 102%-170% of predicted values, over the 9 d of study. 3. A single patient who received barbiturates had a REE lower than predicted (79%). 4. Among patients who were non-sedated and non-paralyzed, REE was 138% of predicted values.</td>
</tr>
</tbody>
</table>
5. There were no significant changes in REE over the 9 d and no associations were noted between GCS and REE.

Note: REE=Resting Energy Expenditure.

Conclusion

There is Level 4 evidence of a hypermetabolic state in the acute period following ABI. The extent of the response can be moderated by barbiturates.

Patients with ABI are often acutely hypermetabolic.

5.8 Routes and Timing of Non-Oral Nutritional Interventions

5.8.1 Routes of Nutrient Administration

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.

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 are increased.

Individual Studies

Table 5.22 Enteral Nutrition vs. Total Parenteral Nutrition

<table>
<thead>
<tr>
<th>Author/Year/Country/Study design/PEDro Score/N</th>
<th>Methods</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mousavi et al. (2014) Iran PEDro=6 RCT N=26</td>
<td>Population: TBI; Gender: Male=26, Female=0. Intervention Group (n=13): Mean age=31yr; Mean GCS Score=7.3. Conventional Group (n=13): Mean age=36.6yr; Mean GCS Score=8.4. Treatment: 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.</td>
<td>1. Mean BG concentration was significantly lower in the IIT group compared to the CGC group (118±28mg/dl vs. 210±31mg/dl; p&lt;0.01). The CGC group had more hyperglycemic episodes. 2. There were no significant differences in any of the secondary outcome measures on day 7 follow-up (p&gt;0.05). 3. On day 14, patients receiving IIT had significantly lower levels of CRP (p=0.0001), triglycerides (p=0.02), magnesium (p=0.03), and phosphorus (p=0.01). Chloride levels were significantly elevated in IIT patients compared to CGC patients (p=0.02). These changes were</td>
</tr>
<tr>
<td>Author/Year/Country/Study design/PEDro Score/N</td>
<td>Methods</td>
<td>Outcome</td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>---------</td>
<td>---------</td>
</tr>
<tr>
<td><strong>Dhandapani et al. (2012)</strong> India Non-RCT N=67</td>
<td>Population: TBI; Time Post-Injury ≤24hr; Total enteral feeding (≤3d) Group: Mean Age=31.7yr. Total enteral feeding (4-7d) Group: Mean Age=34.4yr. Total enteral feeding (&gt;7d) Group: Mean Age=37.2yr. Treatment: Participants were administered enteral feeding through nasogastric tube or orally. The volume of feed was increased gradually in keeping with an individual’s gastric tolerance. Outcome Measure: Glasgow Outcome Scale (GOS), mid-arm circumference (MAC), mid-arm muscle circumference (MAMC), and serum total protein.</td>
<td>1. Those receiving total enteral feeding &gt;7 d post-injury lost significantly more MAC and MAMC compared to those in the earlier fed groups (p&lt;0.001). 2. Analysis of total serum protein revealed that more malnutrition was seen in those who received total enteral feeding &gt;7 days post-injury (p=0.005). 3. At the 3 and 6 mo follow-up, those receiving total enteral feeding within the first 7 d were more likely to have favorable outcomes on the GOS.</td>
</tr>
<tr>
<td><strong>Meirelles and de-Aguilar-Nascimento (2011)</strong> Brazil RCT PEDro=5 N=22</td>
<td>Population: TBI; Enteral Nutrition (EN) Group: Mean Age=31; Gender: Male=11, Female=1; Mean GCS Score=9. Parenteral Nutrition (TPN) Group: Mean Age=31; Gender: Male=9, Female=1; Mean GCS Score=9. Treatment: Patients were randomized to receive either EN or TPN. Both groups received a 25-30kcal/kg/day and 1.5g/kg/day of protein. EN was administered via 8 or 10F oro- or naso-ental feeding tube in gastric position with pump infusion. TPN was administered via central venous access. Patients assessed daily for 5d. Outcome Measure: 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).</td>
<td>1. No significant differences were found in morbidity and mean ICU LOS between the EN and TPN group. 2. Although the amount of calories increased significantly (p&lt;0.01) each day of the study, there was a progressive caloric deficit (p=0.001) in the two groups without any significant difference between them. 3. Those in the TPN group received significantly more (p&lt;0.006) nitrogen than the EN group. 4. Despite the increased loss of nitrogen, all patients showed significant improvement (p=0.001) in the nitrogen balance as a result of nutritional therapy. 5. Even though each nutritional therapy offered increasing quantities of nitrogen and calories, the TPN therapy delivered nitrogen more efficiently compared to the EN therapy.</td>
</tr>
<tr>
<td><strong>Ott et al. (1999)</strong> USA Case Control N=57</td>
<td>Population: Head Injury; Mean Age=31yr; Gender: Male=44, Female=13. Treatment: Patients received enteral nutrition (EN; n=30) or total parenteral nutrition (TPN; n=27). Outcome Measure: Cost of delivering care.</td>
<td>1. Overall cost of EN was $170/patient/d. 2. Overall cost of TPN was $308/patient/d.</td>
</tr>
<tr>
<td><strong>Nataloni et al. (1999)</strong> Italy RCT PEDro=4 N=45</td>
<td>Population: Head injury; Mean Age=28yr; Gender: Male=31, Female=14. Group A (n=15): Mean GCS Score=6. Group B (n=15): Mean GCS Score=6. Group C (n=15): Mean GCS Score=5. Treatment: Patients were randomly administered one of the following feeding</td>
<td>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 (p&lt;0.0001). 2. Plasma albumin levels remained unchanged in all groups. 3. A closer look at the data revealed pre-albumin</td>
</tr>
<tr>
<td>Author/Year/Country/Study design/PEDro Score/N</td>
<td>Methods</td>
<td>Outcome</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>---------</td>
<td>---------</td>
</tr>
<tr>
<td><strong>Borzotta et al.</strong> (1994) USA RCT PEDro=4 N=49</td>
<td><strong>Population:</strong> Closed Head Injury; Gender: Male=40, Female=9; <strong>Early Parenteral Nutrition (TPN) Group (n=21):</strong> Mean Age=28.9yr; Mean GCS Score=5.4. <strong>Enteral Feeding (ENT) Group (n=28):</strong> Mean Age=26.2yr; Mean GCS Score=5.2. <strong>Treatment:</strong> 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 had enteral feeding through jejunal tubes. Assessments made daily for 10 d and weekly for 5 wk thereafter. <strong>Outcome Measure:</strong> Measured Energy Expenditure (MREE), nitrogen excretion, complications.</td>
<td>1. No significant differences noted for nitrogen excretion or balance, energy expenditures, meeting nutritional goals, and frequency of infections. 2. Patient complications such as hyperglycemia (p&lt;0.05) and diarrhea (p&lt;0.05) were more common among patients receiving TPN. 3. Efficiency of feeding, measured by ratio of calories to MREE, showed an advantage for TPN at day 3, but none after. 4. There were no differences in mortality at the end of follow-up.</td>
</tr>
<tr>
<td><strong>Young et al.</strong> (1987) USA RCT PEDro=5 N=96</td>
<td><strong>Population:</strong> Severe Head Injury. Parenteral nutrition (TPN) Group: Mean Age=29.9yr. Enteral feeding (EN) Group: Mean Age=33.8yr. <strong>Treatment:</strong> 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 1×/d in the hospital ward. <strong>Outcome Measure:</strong> Intracranial pressure (ICP), nutrition.</td>
<td>1. No significant differences were found between groups in peak daily ICP; ICP was &gt;20mmHg 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 d, the TPN group received more calories and protein than the EN group (p=0.0001). 5. There was a significant day × nutrition group interaction (p&lt;0.0001); serum glucose levels were higher in the TPN group for the first 13 d post-injury than EN group who had increased mean serum glucose content after 13 d.</td>
</tr>
<tr>
<td><strong>Hadley et al.</strong> (1986) USA RCT PEDro=4 N=45</td>
<td><strong>Population:</strong> TBI; Median Age=28yr; Gender: Male=40, Female=5; Mean GCS Score=5.8; Time Post Injury=6hr. <strong>Treatment:</strong> 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 d period of the study to try to obtain a positive nitrogen and calorie balance. Nitrogen loss was measured every other day.</td>
<td>1. Patients who received TPN achieved significantly higher mean daily nitrogen intakes (p&lt;0.01) and losses (p&lt;0.001) compared to those who received NG. 2. There was no significant between-group difference in nitrogen balance.</td>
</tr>
<tr>
<td>Author/Year/Country/Study design/PEDro Score/N</td>
<td>Methods</td>
<td>Outcome</td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>---------</td>
<td>---------</td>
</tr>
<tr>
<td><strong>Outcome Measure</strong>: Urinary nitrogen levels.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| **Hausmann et al.** (1985) | Population: ABI; Mean Age=28.65yr; Gender: Male=20; GCS Range=5-7. Treatment: 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 500g/d and sorbitol of 100g/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 d post-injury. | 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 (1.1-4.2g/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. |
| **Rapp et al.** (1983) | Population: Head injury; Standard enteral nutrition (SEN) Group (n=18): Mean Age=34.9yr; Mean GCS Score= 7.2. Total Parenteral nutrition (TPN) Group (n=20): Mean Age=29.2yr; Mean GCS Score=7.7. Treatment: 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. | 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 (38.6ºC vs. 38.0ºC; p=0.02). 2. Within the 18 d period, 8 of the 18 patients died in the SEN group compared to 0 deaths in the TPN group (p<0.0001). 3. The TPN group had a significantly greater mean intake in nitrogen/d then the SEN group (10.2gm vs. 4.0gm; p=0.002); the overall nitrogen balance was also significantly different between groups (p=0.002). 4. No significant between group difference was found in serum albumin levels over time. |

PEDro = Physiotherapy Evidence Database rating scale score (Moseley, Herbert, Sherrington, & Maher, 2002).

**Discussion**

An RCT assessing the effect of glycemic control on parenteral nutrition complications in hospitalized patients with brain injury revealed 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, as well as 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).
In a prospective study comparing total enteral feeding at various time points (within 3 days, 4-7 days, and after 7 days) there were unfavourable outcomes associated with total enteral feeding after 3 days (Dhandapani et al. 2012). Those who began later lost significantly more mid-arm circumference and mid-arm muscle circumference and had more malnutrition. At the 3 and 6th month follow-up those receiving total enteral feeding within the first 7 days were more likely to have favorable outcomes on the Glasgow Outcome Scale (Dhandapani et al. 2012).

Nataloni et al. (1999) studied the effects of enteral, parenteral or both enteral and parenteral nutrition on a group of ABI patients while in the ICU. Even though there was a negative nitrogen balance in all groups, all showed improvement over the course of the study. A positive nitrogen balance was only seen in the enteral group. In respect to nitrogen balances, Justo Meirelles and de Aguilar-Nascimento (2011) also evaluated the effects of enteral and parenteral nutrition 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 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). Other studies have found no difference in nitrogen balance between early parenteral nutrition and enteral feeding (Borzotta et al. 1994; Hadley et al. 1986).

In an early study by Rapp et al. (1983) fewer deaths occurred among individuals receiving total parenteral nutrition compared to standard enteral nutrition (0 vs. 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 patients who received enteral nutrition showed significant increases in serum pre-albumin and retinol-binding protein compared to the parenteral or enteral and parenteral groups (Nataloni et al. 1999).

Hausmann et al. (1985) conducted an RCT to investigate the effects of combined enteral –parenteral nutrition (CN) and a total parenteral nutrition (TPN) had 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. In the CN group the mortality rate was 40% and in the TPN group it was 20%. Again these differences were not found to be significant. Study authors found no relevant differences in the metabolic data between each of these treatments (Hausmann et al. 1985).

Conclusions

There is Level 2 evidence suggesting enteral nutrition and parenteral nutrition is effective in providing an increase in calories to patients with ABI.

There is conflicting data when looking at the nitrogen balance of patients with ABI as to which method of feeding is most effective.

Based on a single RCT, there is Level 2 evidence that TPN can safely be administered without causing serum hyperosmolality or influencing intracranial pressure levels in patients post ABI.
Both enteral and parenteral are safe and have been shown to provide an increase in caloric intake; however, there is conflicting data as to which method allows for the greatest increase in nitrogen balance.

Enteral feeds are less expensive and maybe more effective than parenteral feeds.

Further research is needed to investigate the effect of both feeding routes on nitrogen balance and mortality.

5.8.2 Enhanced Enteral Nutrition

Enteral 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).

Individual Studies

Table 5.23 Enhanced Feeding Solutions

<table>
<thead>
<tr>
<th>Author/Year/Country/Study design/PEDro Score/N</th>
<th>Methods</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Falcao de Arruda and Aguilar-Nascimento (2004) Brazil RCT PEDro=7 N=20</td>
<td>Population: TBI; Treatment Group (n=10): Mean Age=27yr; Gender: Male=10, Female=0; Mean GCS Score=7. Control Group (n=10): Mean Age=26yr; Gender: Male=9, Female=1; Mean GCS Score=7. Treatment: Patients were randomized to receive either the standard diet (control) or the glutamine- and probiotics-enhanced diet (treatment group). Outcome Measure: Incidence of infection, length of stay in intensive care unit, ventilation days.</td>
<td>1. Infection rate was higher in the control than in the treatment group (p=0.03). 2. Length of stay (p&lt;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.</td>
</tr>
</tbody>
</table>

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

Conclusion

There is Level 1b evidence, based on a single RCT, that enhanced enteral nutrition can reduce the incidence of infection, and reduce both the ventilator dependency period and length of stay.
5.8.3 Timing of Enteral Nutrition

Early enteral feeding 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 contains literature surrounding the timing of enteral feeding.

**Individual Studies**

**Table 5.24 Timing of Enteral Feeding**

<table>
<thead>
<tr>
<th>Author/Year/ Country/Study design/PEDro score/N</th>
<th>Methods</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chourdakis et al. (2012)</strong>&lt;br&gt;Greece&lt;br&gt;RCT&lt;br&gt;PEDro=6&lt;br&gt;N=59</td>
<td><strong>Population</strong>: TBI; <strong>Delayed Enteral Feeding (DEF) Group (n=25)</strong>: Mean Age=33.3yr; Gender: Male=21, Female=4; Mean GCS Score=5.22. <strong>Early Enteral Feeding (EEF) Group (n=34)</strong>: Mean Age=36.13yr; Gender: Male=26, Female=8; Mean GCS Score=5.81. <strong>Treatment</strong>: Patients admitted to the Intensive Care Unit were randomly allocated to receive either DEF (2-5d post admission) or EEF (initiated within the first 24-48hr of admission). Measurements were taken on day 1, 6 and 12. <strong>Outcome Measure</strong>: Hormone levels, dietary information.</td>
<td>1. The EEF group began enteral feeding approximately 31 hr post admission and the DEF group began approximately 77 hr post admission. 2. Kilocalories administration was lower in the DEF group compared to the EEF group (p&lt;0.01). 3. Several endocrine changes were noted for the groups, with the EEF group showing significant improvements compared to the DEF group (p&lt;0.05). 4. No differences were noted in mortality and morbidity in either group despite enteral feeding.</td>
</tr>
<tr>
<td><strong>Minard et al. (2000)</strong>&lt;br&gt;USA&lt;br&gt;RCT&lt;br&gt;PEDro=5&lt;br&gt;N=27</td>
<td><strong>Population</strong>: TBI; Time Post-Injury= ≤6hr; <strong>Early Group (n=12)</strong>: Mean Age=30yr; Gender: Male=9, Female=3; Mean GCS Score=7. <strong>Late Group (n=15)</strong>: Mean Age=36yr; Gender: Male=10, Female=5; Mean GCS=7. <strong>Treatment</strong>: Patients were randomly assigned to either early (within 60hr of injury) or late enteral feeding. The late group received feeding when tolerated by the patient (i.e. gastroparesis was resolved). <strong>Outcome Measure</strong>: Infection rates, Length of stay, ventilator days, instances of pneumonia, mortality.</td>
<td>1. No significant differences between groups with regard to mortality, Length of stay, ventilator days, number of infections per patient or patients with pneumonia. 2. Admission GCS score was a good predictor of infection (p&lt;0.003), Length of stay in the intensive care unit (p&lt;0.02), and ventilator days (p&lt;0.007).</td>
</tr>
<tr>
<td><strong>Taylor et al. (1999)</strong>&lt;br&gt;UK&lt;br&gt;RCT&lt;br&gt;PEDro=4&lt;br&gt;N=82</td>
<td><strong>Population</strong>: Head Injury. <strong>Intervention Group (n=41)</strong>: Median Age=34yr. <strong>Control Group (n=41)</strong>: Median Age=28yr. <strong>Treatment</strong>: 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 15mL/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 6mo. <strong>Outcome Measure</strong>: Neurologic outcome, incidence of major infection, Length of stay.</td>
<td>1. Patients receiving enhanced EN had a significantly higher mean percentage of energy (p=0.0008) and nitrogen (p&lt;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 &lt;60% even by day 7 post injury. 3. Neurologic outcome at 6 mo follow-up (intervention, 68% vs. 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% vs. 58%).</td>
</tr>
</tbody>
</table>
### Table

<table>
<thead>
<tr>
<th>Author/Year/Country/Study design/PEDro score/N</th>
<th>Methods</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Taylor and Fettes (1998)</strong>&lt;br&gt;UK&lt;br&gt;RCT&lt;br&gt;PEDro=4&lt;br&gt;N=82</td>
<td><strong>Population:</strong> Head Injury. <strong>Intervention Group</strong> (n=41): Median Age=34yr. <strong>Control Group</strong> (n=41): Median Age=28yr.&lt;br&gt;<strong>Treatment:</strong> 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 15mL/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.&lt;br&gt;<strong>Outcome Measure:</strong> Nutritional intake, nitrogen balance, volume of gastric residuals, incidence of pneumonia.</td>
<td>39%; p=0.08).&lt;br&gt;4. Intervention patients had fewer infections (61% vs. 85%; p=0.02) and earlier discharge (p=0.008).&lt;br&gt;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%).&lt;br&gt;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&lt;0.02).&lt;br&gt;3. Intervention patients received a higher volume of enteral fluid (p&lt;0.02) but did not have a higher incidence of pneumonia or aspiration.</td>
</tr>
</tbody>
</table>

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

### Discussion

Chourdakis et al. (2012) compared delayed enteral feeding with early enteral feeding in 59 individuals post severe TBI. Although rates of complications were comparable between groups, the length of feeding for the early enteral feeding group was significantly shorter than the length of feeding for the delayed group (p<0.024). Hormonal measurements also indicated that those in the early group showed significant improvement on several of hormonal measures (Chourdakis et al. 2012). Similarly, Minard et al. (2000) found timing had no significant impact on mortality, length of stay or complications. Further, enhanced enteral nutrition was shown to accelerate neurologic recovery while reducing complications and also inflammatory post injury responses (Taylor & Fettes 1998; Taylor et al. 1999).

A Cochrane review by Yanagawa, Bunn, Roberts, Wentz, and Pierro (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 suggesting the early enteral nutrition results in a better hormonal profile of patients with TBI and may contribute to better clinical outcomes.*

*There is Level 2 evidence suggesting that initiating enteral feeding at goal rate will increase the percentage of prescribed energy and protein actually received.*
5.8.4 Timing of Parenteral Nutrition
Early parenteral nutrition 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).

Individual Studies

Table 5.25 Timing of Parenteral Feeding

<table>
<thead>
<tr>
<th>Author/Year/Country/Study design/PEDro Score/N</th>
<th>Methods</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sacks et al. (1995) USA RCT PEDro=5 N=9</td>
<td>Population: Head injury; Early Group (n=4): Mean Age=39.3yr; Gender: Male=4, Female=0; Mean GCS Score=8. Delayed Group (n=5): Mean Age=35.2yr; Gender: Male=4, Female=1; Mean GCS Score=7. Treatment: 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 2g protein/kg/d &amp; 40 non-protein kcal/kg/day for at least the initial 14d of hospitalization. Assessments were made on entry, and days 3, 7, and 14. Outcome Measure: Cell counts of T-lymphocytes with expression of CD4 and CD8 antigens, lymphocyte response following Con A stimulation.</td>
<td>1. From baseline to day 14, there was a significant increase in the total CD4 cell count (p&lt;0.05) and in CD4 (%) (p&lt;0.001) 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 (p&lt;0.05). 2. The CD4-CD8 ratio significantly increased from baseline to day 14 in the early PN group (p&lt;0.05), but not in the delayed PN group. The difference between groups, however, was not significant. 3. From baseline to day 14, following Con A stimulation, an improved lymphocyte response was demonstrated in the early PN group (p&lt;0.05), but not in the delayed PN group.</td>
</tr>
</tbody>
</table>

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

Discussion
The study by Sacks et al. (1995) found that in individuals with closed head injuries early parenteral 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.

Conclusion

**There is Level 2 evidence that early parenteral nutrition support of closed head-injury patients appears to modify immunologic function by increasing CD4 cells, CD4-CD8 ratios, and T-lymphocyte responsiveness to Con A.**

5.8.5 Types of Enteral Feeding Tubes
Early enteral feeding 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 proved 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).

Individual Studies

### Table 5.26 Early Gastrostomy

<table>
<thead>
<tr>
<th>Author/Year/ Country/Study design/PEDro Score/N</th>
<th>Methods</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kostadima et al. (2005) Greece RCT PEDro=6 N=41</td>
<td><strong>Population:</strong> Stroke=25, Head Injury=16; Mean Age=47.3yr; Gender: Male=32, Female= 9. <strong>Treatment:</strong> Ventilator dependant patients received either a gastrostomy or Nasogastric tube for enteral feeding. Tubes were inserted within 24 hours of intubation. Patients were followed for 3wk. <strong>Outcome Measure:</strong> Pneumonia rates, length of stay (LOS) in intensive care unit, ventilation days, mortality.</td>
<td>1. At the end of weeks 2 and 3 the cumulative incidence of pneumonia was significantly higher in the nasogastric, compared to the gastrostomy group (p&lt;0.05). 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. 3. No significant difference between groups in LOS, ventilation days, or mortality rates were found.</td>
</tr>
</tbody>
</table>

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

Conclusion

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

*There is an increased risk of developing pneumonia for ventilated patients fed by a naso-gastric versus a gastrostomy tube.*

### 5.8.6 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, despite the inconsistent findings supporting its use (Nursal et al. 2007). To enhance the effectiveness of enteral nutrition metoclopramide has been used with limited success (Nursal et al. 2007).
Individual Study

Table 5.27 Metoclopramide and Enteral Nutrition

<table>
<thead>
<tr>
<th>Author/Year/Country/Study design/PEDro Score/N</th>
<th>Methods</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nursal et al. (2007) USA RCT PEDro=9 N=19</td>
<td><strong>Population:</strong> TBI; <strong>Control Group (n=9):</strong> Mean Age=43yr; Gender: Male=8, Female=1; Mean GCS Score=8.9. <strong>Treatment Group (n=10):</strong> Mean Age=43.8yr; Gender: Male=8, Female=2; Mean GCS Score=7.7. <strong>Treatment:</strong> Patients in the treatment group were administered 10mg (2 mL) IV metoclopramide 3×/d for 5d. The control group received the same volume of control saline solution for the same duration. <strong>Outcome Measure:</strong> Paracetamol absorption test, amount of calories supplied, intolerance and/or complication rates.</td>
<td>1. Amount of oral/enteral calories in relation to the total number of calories received during the first 5 d was higher for those in the control group (p=0.043). 2. There were no differences between the groups in both feeding intolerance and complications rates (p=0.543 and p=0.930, respectively). 3. There was no significant difference between the groups when looking at the results of the paracetamol absorption test. 4. When looking at absorption parameters, those in the treatment group had levels that were slightly more pronounced than those in the control group.</td>
</tr>
</tbody>
</table>

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

Discussion

In a single RCT by Nursal et al. (2007) compared a control group and a treatment group that had been receiving 10 mg of metoclopramide. 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 to metoclopramide in a TBI population.

Conclusion

*There is Level 1b evidence indicating that metoclopramide is not effective as an aid to gastric emptying.*

*The therapeutic benefits of using metoclopramide to aid in gastric emptying are minimal.*

5.9 Miscellaneous Therapies

5.9.1 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 hypozinemia and increased urinary zinc excretion are common following head injury and are thought to be an adaptive responsive 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 5.28 Zinc Supplementation in patients with ABI**

<table>
<thead>
<tr>
<th>Author/Year/Country/Study design/PEDro Score/N</th>
<th>Methods</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Young et al. (1996)</strong> USA RCT PEDro=7 N=68</td>
<td><strong>Population:</strong> Head injury; <strong>Intervention Group (n=33):</strong> Mean Age=34.6yr; Gender: Male=27, Female=6; Mean GCS Score=6.4. <strong>Control Group (n=35):</strong> Mean Age=35.9yr; Gender: Male=28, Female=7; Mean GCS Score=6.6. <strong>Treatment:</strong> Patients were randomly assigned to receive either zinc at a standard level (2.5 mg) or zinc-supplementation (12 mg) for 15 d. After 15 d, oral zinc (168 mg zinc gluconate, 22 mg elemental zinc) or matching placebo tablet were given for a total of 3mo. <strong>Outcome Measure:</strong> Glasgow Coma Scale (GCS), mortality, zinc concentration, serum pre-albumin levels, retinol-binding protein (RBP) concentrations.</td>
<td>1. There was no significant difference in 1 mo mortality rates between groups (p=0.09). 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). 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). 4. The groups were not different in serum zinc concentration, weight, energy expenditure, or total urinary nitrogen excretion after admission. 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).</td>
</tr>
</tbody>
</table>

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

**Discussion**

An RCT was identified that 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. Surprisingly, there were no differences in either the serum or cerebrospinal fluid zinc concentrations between the groups.

**Conclusion**

*Based on a single RCT there is Level 1b evidence that zinc supplementation in ABI patients has a positive effect on neurological recovery as measured by the Glasgow Coma Scale. However, no significant improvement in mortality rates could be attributed to zinc supplementation.*

**Zinc supplementation in the immediate post injury period has been shown to be beneficial in terms of neurologic recovery and visceral protein concentrations in ABI patients.**

**5.9.2 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.
Individual Studies

Table 5.29 Growth Hormone Treatment on Nutrition Post-ABI

<table>
<thead>
<tr>
<th>Author/Year/ Country/Study design/PEDro Score/N</th>
<th>Methods</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Devesa et al. (2013)</strong>&lt;br&gt;Spain&lt;br&gt;Case Series</td>
<td><strong>Population</strong>: TBI; Mean Age=26.7yr; Gender: Male=8, Female=5; Time Post Injury=2.5mo-11yr. <strong>Intervention</strong>: TBI patients who were with and without acquired growth hormone deficiency (GHD) all received the same growth hormone treatment protocol, as well as clinical rehabilitation as necessary per individual. <strong>Outcome Measures</strong>: Plasma insulin-like growth factor 1 (IGF-1), cognitive and motor improvements.</td>
<td>1. Plasma IGF-1 values increased after GH treatment in GHD and non-GHD patients (p&lt;0.01, p&lt;0.05, respectively).&lt;br&gt;2. The increase in plasma IGF-1 values was significantly higher in GHD than non-GHD patients (p&lt;0.01).&lt;br&gt;3. In general, cognitive improvements were better than motor improvements.</td>
</tr>
<tr>
<td><strong>Hatton et al. (2006)</strong>&lt;br&gt;USA&lt;br&gt;PEDro=7&lt;br&gt;N=97</td>
<td><strong>Population</strong>: TBI; <strong>Treatment Group</strong>: Mean Age=30yr; Gender: Male=38, Female=11; Mean GCS Score=6.4. <strong>Control Group</strong>: Mean Age=29yr; Gender: Male=33, Female=15; Mean GCS Score=6.7. <strong>Treatment</strong>: 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 0.01mg/kg/hr IV IGF-I by continuous infusion for up to 14 d, as well as 0.05mg/kg/d subcutaneous GH. Controls were given normal saline but insulin was used to keep glucose concentrations &lt;200mg/dl. Patients also received concomitant nutritional support (enteral or parenteral). <strong>Outcome Measure</strong>: Glucose concentrations, energy expenditure, nitrogen balance, protein and calorie intake.</td>
<td>1. Nutritional endpoints: energy expenditure was slightly different for the two groups (2271±575.6 kcal/d in the control group and 2366±627.8 kcal/d in the treatment group).&lt;br&gt;2. In the treatment group, the mean daily glucose concentrations were higher than those of the control group (123±24 mg/dl vs. 104±11mg/dl; p&lt;0.03).&lt;br&gt;3. Within the first 24 hr nitrogen balance was positive and it remained positive for the duration of the study.&lt;br&gt;4. Nitrogen balance was higher for the IGHI/GH group (p=0.0001). Neither group reached calorie or protein intake goals; groups did not differ significantly in their intake.</td>
</tr>
<tr>
<td><strong>Behrman et al. (1995)</strong>&lt;br&gt;USA&lt;br&gt;RCT&lt;br&gt;PEDro=4&lt;br&gt;N=16</td>
<td><strong>Population</strong>: Head injury=11, SCI=5; Gender: Male=12, Female=4; Mean GCS score=10. <strong>Intervention Group (n=8)</strong>: Mean Age=23yr. <strong>Control Group (n=8)</strong>: Mean Age=46yr. <strong>Treatment</strong>: Patients were randomly allocated to receive either intramuscular growth hormone (GH; 0.2mg/kg) every day or 1mL normal saline (control) for 7-10d. Assessments were made on days 1, 3, 7, and 10. <strong>Outcome Measure</strong>: Nitrogen balance, glucose concentration, triglyceride concentrations, thyroid function, serum protein concentration, lymphocyte count, prognostic nutritional index (PNI).</td>
<td>1. GH treatment did not improve nitrogen balance, glucose concentration, triglyceride concentrations or thyroid function.&lt;br&gt;2. GH significantly enhanced constitutive serum protein concentrations (transferrin: p&lt;0.05, albumin: p&lt;0.05).&lt;br&gt;3. Total lymphocyte count was significantly higher in the GH group than in the control group (p&lt;0.05) by day 10.&lt;br&gt;4. PNI was significantly improved in the GH group compared to the control group (p&lt;0.05) by day 10.</td>
</tr>
</tbody>
</table>

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

**Discussion**

In a study conducted by Behrman (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 patient’s prognostic nutritional index.
Evidence-Based Review of Moderate to Severe Acquired Brain Injury 2014

(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±0.84 vs. -3.90±0.87, p<0.0001; 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.

Conclusion

*Based on two RCTs, there is conflicting evidence that IGF-I is effective in enhancing growth hormone in those who have sustained an ABI.*

Growth hormone enhances nutritional repletion, but it unclear as to whether or not it improves nitrogen balance.

5.9.3 Increased Nitrogen Feeds

Following brain injury, nitrogen losses result from the conversion of endogenous protein to energy with the extra stress demand (Grahm 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).

Individual Studies

Table 5.30 Nitrogen Balance

<table>
<thead>
<tr>
<th>Author/Year/Country/Study design/PEDro Score/N</th>
<th>Methods</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Twyman (1997)</strong> USA RCT PEDro=3 N=21</td>
<td>Population: Head injury; Time Post-Injury= &lt;72h. Treatment: Patients were randomly assigned to receive either tube feeding containing 1g nitrogen/150 cal (control group; n=11) or 1g nitrogen/90 cal (study group; n=10). Outcome Measure: Nitrogen Balance, calorie intake.</td>
<td>1. Patients receiving the high-protein tube feeding attained a significantly greater daily (p=0.006) and cumulative (p=0.04) nitrogen 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 calories/kg.</td>
</tr>
</tbody>
</table>

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

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. 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).
Conclusion

*Based on a single RCT, there is Level 2 evidence that high nitrogen feedings of approximately 2 g protein/kg are necessary to restore the substantial nitrogen loses that occur post ABI.*

**High nitrogen feedings are necessary to restore massive nitrogen loses post-ABI.**

5.9.4 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).

Individual Studies

Table 5.31 Branched-Chain Amino Acid Treatment in ABI patients

<table>
<thead>
<tr>
<th>Author/Year/Country/Study design/PEDro Score/ N</th>
<th>Methods</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Population:</strong> TBI; Mean Age=32yr; Gender: Male=40, Female=0; Mean GCS=5.9. <strong>Treatment:</strong> Patients were randomized to receive either 19.6g/d IV BCAA supplementation (n=20) or an iso-nitrogenous placebo (n=20) over a period of 15 d. A group of healthy patients (n=20) matched for age, sex and sedentary lifestyle served as controls for the study. <strong>Outcome Measure:</strong> Disability Rating Scale (DRS), plasma concentration of BCAAs: tyrosine and tryptophan.</td>
<td>1. At 15 d post admission, DRS scores significantly improved in TBI patients compared with the control group (p&lt;0.02); improvement was greater in the BCAA group than in the placebo group (p&lt;0.004). 2. 15 d after admission only patients given BCAA supplementation significantly improved their baseline total BCAAs, including leucine (p&lt;0.01), isoleucine (p&lt;0.02) and valine (p&lt;0.001). 3. Level of plasma tyrosine significantly improved in the BCAA group (p&lt;0.01) but remained lower than in health controls. 4. Plasma tryptophan concentration was higher in patients on placebo than treatment (p&lt;0.01). 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.</td>
<td></td>
</tr>
</tbody>
</table>

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

*There is Level 2 evidence that supplementation of BCAAs in patients with ABI enhances recovery of cognitive function, without negatively effecting tyrosine and tryptophan concentration.*
5.10 Summary

1. There is Level 4 evidence indicating that individuals with a low level of consciousness and those with tracheotomy tubes are at greater risk for pneumonia.

2. There is Level 1b evidence that povidone-iodine is not beneficial in preventing ventilator-associated pneumonia.

3. 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.

4. There is Level 4 evidence of a hypermetabolic state in the acute period following ABI. The extent of the response can be moderated by barbiturates.

5. There is Level 2 evidence suggesting enteral nutrition and parenteral nutrition is effective in providing an increase in calories to patients with ABI.

6. There is conflicting data when looking at the nitrogen balance of patients with ABI as to which method of feeding is most effective.

7. Based on a single RCT, there is Level 2 evidence that TPN can safely be administered without causing serum hyperosmolality or influencing intracranial pressure levels in patients post ABI.

8. There is Level 1b evidence, based on a single RCT, that enhanced enteral nutrition can reduce the incidence of infection, and reduce both the ventilator dependency period and length of stay.

9. There is Level 1b evidence suggesting the early enteral nutrition results in a better hormonal profile of patients with TBI and may contribute to better clinical outcomes.

10. There is Level 2 evidence suggesting that initiating enteral feeding at goal rate will increase the percentage of prescribed energy and protein actually received.

11. There is Level 2 evidence that early parenteral nutrition support of closed head-injury patients appears to modify immunologic function by increasing CD4 cells, CD4-CD8 ratios, and T-lymphocyte responsiveness to Con A.

12. There is Level 1b evidence that the risk of developing pneumonia is higher among ventilated patients (stroke and head injury) fed by a naso-gastric tube compared with a gastrostomy tube.

13. There is Level 1b evidence indicating that metoclopramide is not effective as an aid to gastric emptying.

14. Based on a single RCT there is Level 1b evidence that zinc supplementation in ABI patients has a positive effect on neurological recovery as measured by the Glasgow Coma Scale. However, no significant improvement in mortality rates could be attributed to zinc supplementation.
15. Based on a single RCT, there is Level 2 evidence that high nitrogen feedings of approximately 2 g protein/kg are necessary to restore the substantial nitrogen loses that occur post ABI.

16. There is Level 2 evidence that supplementation of BCAAs in patients with ABI enhances recovery of cognitive function, without negatively effecting tyrosine and tryptophan concentration.
5.11 Reference List


Canadian Dental Association. (2009). Optimal health for frail older adults: Best practices along the continuum of care (pp. 1-26). Ottawa, ON.


swallowing (FEES) in determining the risk of aspiration in acute stroke patients. *Dysphagia*, 16(1), 1-6.


Evidence-Based Review of Moderate to Severe Acquired Brain Injury


Updated October 2014


