

11. Dysphagia

On behalf of the ERABI Research Group

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 with swallowing. Swallowing has four sequential coordinated phases which are summarized in Table 5.1 and illustrated in Figure 1.

11.1 Normal Phases of Swallowing

Q. Describe the 4 phases of normal swallowing

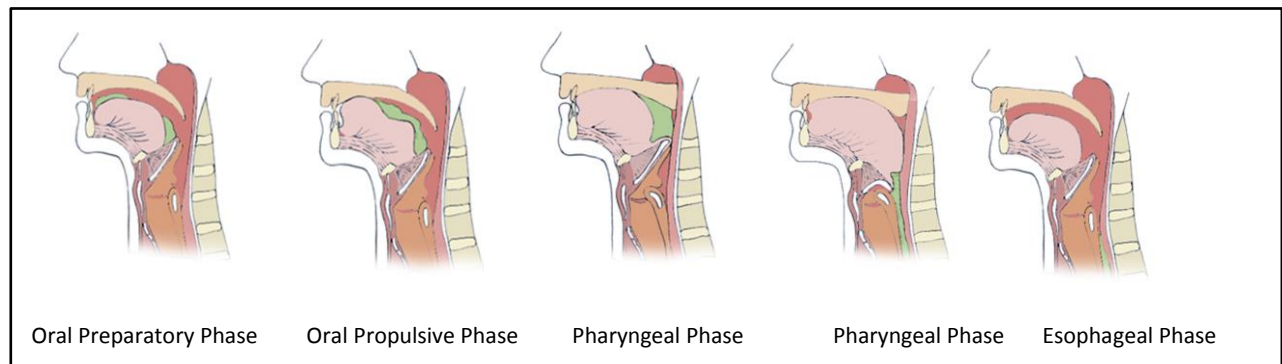
Answer

1. Oral preparatory phase
2. Oral propulsive phase
3. Pharyngeal phase
4. Esophageal phase

Table 11.1 The Four Phases of Normal Swallowing (Platt, 2001)

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

Figure 1: The phases of swallowing



11.2 Pathophysiology of Dysphagia

Q. What is the pathophysiology of dysphagia following Acquired Brain Injury (ABI)?

Answer

- Dysphagia post ABI has been attributed to pharyngeal muscular dysfunction and lack of coordination secondary to central nervous system loss of control.

11.3 Incidence and Natural History of Dysphagia Post ABI

Q. What is the incidence of dysphagia post ABI?

Answers

- Rates in the literature range between 26% and 70%.
- When specifically examining the rates at rehabilitation centres, the rates range from 26% to 42%.

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. 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; Winstein 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; Winstein 1983). Many of these rates are determined at admission; however, Winstein (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; Winstein 1983).

11.4 Aspiration Post ABI

Q. Define aspiration.

Answer

- Aspiration is defined as the entry of material into the airway below the level of the true vocal cords.

Incidence of Aspiration Post ABI

Q. What is the incidence of aspiration post ABI?

Answer

- Aspiration has been reported to occur in 25% - 71% of brain injury patients, depending on the sample surveyed.

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.

Silent Aspiration

Q. Define silent aspiration.

Answer

- Penetration of food below the level of the true vocal cords, without cough or any outward sign of difficulty (Linden & Siebens 1983).

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 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).

11.5 Assessment of Dysphagia Post ABI

Q. Describe an Approach to the Assessment of Dysphagia Post ABI.

Answers

- Screening involves a bedside clinical evaluation to determine whether the patient has dysphagia or not.
- Assessment describes the dysphagia in detail, determines the severity of the problem, and guides a management approach.
- Patients are initially kept NPO (nothing by mouth).
- Clinical assessment is initially performed and if necessary a VMBS is done.

The Bedside Clinical Examination

Q. Which bedside clinical examinations have been shown to be the most useful?

Answer

- Only two tests, the abnormal pharyngeal sensation test and the 50 ml water-swallowing test, have sufficient evidence supporting their use.

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. 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)

Water Swallowing Test

The water-swallowing test originally required a patient to swallow 3oz (90ml) of water; however, smaller amounts have also been used. 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.

Risk Factors for Dysphagia Post ABI***Q. What are the risk factors for dysphagia post ABI?******Answers***

- Increased severity of brain injury
- Increased duration of coma (Lazarus & Logemann 1987).
- Lower Glasgow Coma Score on admission (GCS 3-5; Mackay et al. 1999b).
- Increased severity of CT Scan findings (Mackay et al. 1999a).
- Increased duration of mechanical ventilation (Mackay et al. 1999a).
- Tracheostomy.
- Translaryngeal (endotracheal) intubation.
- Severe cognitive deficits.
- Physical damage to oral, pharyngeal, laryngeal and esophageal structures.
- Oral and pharyngeal sensory difficulties.

Diagnosis of Aspiration Post ABI***Q. What are the risk factors for aspiration post ABI?******Answers***

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

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. 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).

Videofluoroscopic Modified Barium Swallow (VMBS) Studies

Q. Describe the importance of VMBS studies in the diagnosis of aspiration.

Answers

- Considered to be the “gold standard” in the diagnosis of aspiration.
- Patients who aspirate over 10% of the test bolus or who have severe oral and/or pharyngeal motility problems are considered at high risk of pneumonia.
- May reveal the mechanism behind the swallowing disorder.

When aspiration is suspected, the VMBS study is considered by some to be the “gold standard” in confirming the diagnosis (Splaingard et al. 1988). A VMBS study examines the oral and pharyngeal phases of swallowing; however, the patient must have sufficient cognitive and physical skills to undergo testing (Bach et al. 1989). The subject is placed in the sitting position in a chair designed to simulate the ideal/optimal mealtime posture. Radio-opaque materials of various consistencies are tested: barium impregnated thin and thick liquids, pudding, bread and cookies are routinely used. Various aspects of oral, laryngeal and pharyngeal involvement are noted during the radiographic examination. 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.

Fiberoptic Endoscopic Evaluation of Swallowing (FEES)

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.

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).

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.

11.6 Management of Dysphagia Post ABI

Q. Describe a dysphagia management program at the time of acute care admission in an ABI patient suspected of suffering from dysphagia.

Answers

- Acutely patients should be NPO until swallowing ability has been determined.
- A trained assessor should screen all acute patients for swallowing difficulties as soon as they are able.
- A speech and language pathologist should assess all patients who fail swallowing screening and identify the appropriate course of treatment.
- VMBS is the "gold standard" for diagnosis of aspiration.
- An individual trained in low-risk feeding strategies should provide feeding assistance or supervision to patients where appropriate.
- A dietitian should assess the nutrition and hydration status of patients who fail the swallowing screening.
- Where the patient is a severe aspirator, a non-oral feeding tube is inserted.
- Where the patient is a mild to moderate aspirator treatment is determined by the findings of the VMBS. For these patients compensatory treatment techniques are used.

Low Risk Feeding Strategies

Q. Describe why low risk feeding strategies are necessary?

Answer

- 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.

Q. Describe some of these low risk strategies?**Answers**

- Calm eating environment minimal distractions.
- Patient is in an upright position with the neck slightly flexed facing midline.
- Proper oral care.
- Feed at eye level.
- Feed slowly.
- Feed using metal teaspoons (no tablespoons or plastic).
- Drink from wide mouth cup or a straw to reduce the neck extending back.
- Ensure bolus has been swallowed before offering more.
- Properly position the patient and monitor for 30 minutes after each meal.

Compensatory and Therapy Techniques**Q. Describe compensatory treatment techniques for dysphagia post ABI?****Answers**

- Postural adjustment of the head, neck and body to modify the dimensions of the pharynx and optimize the flow of the bolus.
- Sensory stimulation techniques to improve sensory input.
- Food consistency and viscosity alterations.
- Modifying the volume and rate of food and fluid presentation.
- Use of intraoral prosthetics.

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.

11.7 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.

Oral Motor Exercises (OME)

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).

Range of Motion Exercises for the Pharyngeal Structures

1. 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.

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).

3. 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.

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).

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.

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).

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).

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.

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 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).

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.

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 11.2; 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 11.2 Five Postures to Improve Swallowing Function (Logemann 2008)

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

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 – purees) and move to less restrictive diets (diced to regular foods) at a pace that has been deemed safe for that individual (Kramer et al. 2007). Asking the patient to limit the amount of food they attempt to swallow (taking smaller bites) will also help reduce difficulties with swallowing.

Passy-Muir Speaking Valve

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.

11.8 Nutritional Management

Risk Factors for Malnutrition Post ABI

Q. What are some unique risk factors for malnutrition in ABI patients?

Answers

- Hypermetabolic state.
- Hypercatabolic state associated with additional injuries.
- Decreased level of consciousness.

Ensuring patients with ABI have adequate nutrition is an important part of their medical management (Denes 2004), as it has a critical impact on the patient's recovery process and final outcome (Elovic 2000). Denes (2004) stated that rehabilitation problems associated with severely malnourished ABI patients include an increased occurrence of complications, a greater challenge in patient mobilization, an increased frequency for the need to operate on contractures and a longer length of stay in a rehabilitation unit. Despite clinicians' efforts several factors make it difficult to avoid malnutrition in patients with ABI 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 cortisol) increase takes place (Loan 1999). Deficiencies of follicle-stimulating hormones (FSH), leuteinizing hormone (LH), and growth hormone (GH) indicate alteration in the hypothalamic-pituitary feed-back mechanism that normally regulates metabolism (Loan 1999). As a result of hypermetabolism and hypercatabolism, both

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

The Incidence of Malnutrition

Q. How common is malnutrition following ABI?

Answer

- Based on a single study, in the early phase of rehabilitation, the first two months post ABI, approximately 68% of patients showed signs 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).

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).

Hypermetabolism Post-ABI

Q. Define Hypermetabolism Post ABI

Answers

- An increase in metabolic rate above that predicted using equations, which take into account age, sex, height and weight.
- Characterized by increased oxygen consumption and nitrogen excretion following injury.

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).

11.9 Routes and Timing of Non-Oral Nutritional Interventions

Routes of Nutrient Administration

Q. What would be the indications for enteral feeding? What would be the indications for parenteral feeding?

Answers

- Enteral feeding is required when the patient is severely dysphagic, an aspirator, comatose or mechanically ventilated.
- Parenteral feeding is indicated when enteral feeding is not possible; for example, where there is feeding intolerance due to gastroparesis, ileus, or increased intracranial pressure (ICP).

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.

Enhanced Enteral Nutrition***Q. What evidence is there to support enhanced enteral nutrition post ABI?******Answer***

- 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.

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).

Timing of Enteral Nutrition***Q. What are the benefits of early administration of enteral nutrition post ABI?******Answers***

- 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.

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.

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).

Timing of Parenteral Nutrition

Q. What are the benefits of early administration of parenteral nutrition post ABI?

Answer

- 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.

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.

Types of Enteral Feeding Tubes

Q. What evidence is there for one type of enteral feeding tube over another?

Answer

- 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.

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. Gastrostomies 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).

11.10 Miscellaneous Therapies

Zinc Supplementation

Q. What evidence is there for zinc supplementation in ABI?

Answer

- Based on a single RCT there is Level 1b evidence that zinc supplementation in patients with ABI 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 is an essential element for humans as it is vitally important for normal nucleic acid and protein metabolism (McClain et al. 1986). Moderate zinc deficiency has been associated with cell death. Serum hypozincemia and increased urinary zinc excretion are common following head injury and are thought to be an adaptive response to inhibit the proliferation of infective organisms. Levels of serum albumin, the major transport carrier for zinc, are also markedly depressed following brain injury and likely help to explain a portion of the reductions in serum zinc levels. Urinary excretion of zinc appears to be proportional to the severity of head injury (Levenson 2005).

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.

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).

Q. What evidence is there for nitrogen feeding post ABI?

Answer

- 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 losses that occur post ABI.

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).

Reference List

- Aviv, J. E. (2000). Prospective, randomized outcome study of endoscopy versus modified barium swallow in patients with dysphagia. *Laryngoscope*, *110*(4), 563-574.
- Bach, D. B., Pouget, S., Belle, K., Kilfoil, M., Alfieri, M., McEvoy, J., & Jackson, G. (1989). An integrated team approach to the management of patients with oropharyngeal dysphagia. *J Allied Health*, *18*(5), 459-468.
- Behrman, S. W., Kudsk, K. A., Brown, R. O., Vehe, K. L., & Wojtysiak, S. L. (1995). The effect of growth hormone on nutritional markers in enterally fed immobilized trauma patients. *J Parenter Enteral Nutr*, *19*(1), 41-46.
- Belafsky, P. C., Blumenfeld, L., LePage, A., & Nahrstedt, K. (2003). The accuracy of the modified Evan's blue dye test in predicting aspiration. *Laryngoscope*, *113*(11), 1969-1972.
- Bell, S. D. (1996). Use of Passy-Muir tracheostomy speaking valve in mechanically ventilated neurological patients. *Crit Care Nurse*, *16*(1), 63-68.
- Brady, S. L., Hildner, C. D., & Hutchins, B. F. (1999). Simultaneous videofluoroscopic swallow study and modified Evans blue dye procedure: An evaluation of blue dye visualization in cases of known aspiration. *Dysphagia*, *14*(3), 146-149.
- Brooke, M., Barbour, P., Cording, L., Tolan, C., Bhoomkar, A., McCall, G., & Johnson, S. (1989). Nutritional Status During Rehabilitation After Head Injury. *J of Neurol Rehabil*, *3*(1), 27-33.
- Bruder, N., Lassegue, D., Pelissier, D., Graziani, N., & Francois, G. (1994). Energy expenditure and withdrawal of sedation in severe head-injured patients. *Crit Care Med*, *22*(7), 1114-1119.
- Cerra, F. B., Benitez, M. R., Blackburn, G. L., Irwin, R. S., Jeejeebhoy, K., Katz, D. P., & Zaloga, G. P. (1997). Applied nutrition in ICU patients. A consensus statement of the American College of Chest Physicians. *Chest*, *111*(3), 769-778.
- Cherney, L. R., & Halper, A. S. (1996). Swallowing problems in adults with traumatic brain injury. *Semin Neurol*, *16*(4), 349-353.
- Cherney, L. R., Halper, A. (1989). Recovery of Oral Nutrition After Head Injury in Adults. *Journal of Head Trauma Rehabilitation*, *4*(4), 42-50.
- Chong, M. S., Lieu, P. K., Sitoh, Y. Y., Meng, Y. Y., & Leow, L. P. (2003). Bedside clinical methods useful as screening test for aspiration in elderly patients with recent and previous strokes. *Ann Acad Med Singapore*, *32*(6), 790-794.
- Chourdakis, M., Kraus, M. M., Tzellos, T., Sardeli, C., Pefoulidou, M., Vassilakos, D., & Kouvelas, D. (2012). Effect of early compared with delayed enteral nutrition on endocrine function in patients with traumatic brain injury: an open-labeled randomized trial. *J Parenter Enteral Nutr*, *36*(1), 108-116.
- Daniels, S. K., McAdam, C. P., Brailey, K., & Foundas, A. L. (1997). Clinical assessment of swallowing and prediction of dysphagia severity. *Am J Speech Lang Pathol*, *6*(4), 17-24.
- Denes, Z. (2004). The influence of severe malnutrition on rehabilitation in patients with severe head injury. *Disabil Rehabil*, *26*(19), 1163-1165.
- Dettelbach, M. A., Gross, R. D., Mahlmann, J., & Eibling, D. E. (1995). Effect of the Passy-Muir Valve on aspiration in patients with tracheostomy. *Head Neck*, *17*(4), 297-302.
- Donzelli, J., Brady, S., Wesling, M., & Craney, M. (2001). Simultaneous modified Evans blue dye procedure and video nasal endoscopic evaluation of the swallow. *Laryngoscope*, *111*(10), 1746-1750.
- Drake, W., O'Donoghue, S., Bartram, C., Lindsay, J., & Greenwood, R. (1997). Eating in side-lying facilitates rehabilitation in neurogenic dysphagia. *Brain Inj*, *11*(2), 137-142.

- Elovic, E. (2000). Pharmacological therapeutics in nutritional management. *J Head Trauma Rehabil*, 15(3), 962-964.
- Elpern, E. H., Borkgren Okonek, M., Bacon, M., Gerstung, C., & Skrzynski, M. (2000). Effect of the Passy-Muir tracheostomy speaking valve on pulmonary aspiration in adults. *Heart Lung*, 29(4), 287-293.
- Falcao de Arruda, I. S., & de Aguilar-Nascimento, J. E. (2004). Benefits of early enteral nutrition with glutamine and probiotics in brain injury patients. *Clin Sci (Lond)*, 106(3), 287-292.
- Field, L. H., & Weiss, C. J. (1989). Dysphagia with head injury. *Brain Inj*, 3(1), 19-26.
- French, A., & Merriman, S. (1999). Nutritional status of a brain-injured population in a long-stay rehabilitation unit: a pilot study. *J Hum Nutr Diet*, 12(1), 35-42.
- Grahm, T. W., Zadrozny, D. B., & Harrington, T. (1989). The benefits of early jejunal hyperalimentation in the head-injured patient. *Neurosurgery*, 25(5), 729-735.
- Hadley, M. N., Grahm, T. W., Harrington, T., Schiller, W. R., McDermott, M. K., & Posillico, D. B. (1986). Nutritional support and neurotrauma: a critical review of early nutrition in forty-five acute head injury patients. *Neurosurgery*, 19(3), 367-373.
- Halper, A. S., Cherney, L. R., Cichowski, K., & Zhang, M. (1999). Dysphagia after head trauma: the effect of cognitive-communicative impairments on functional outcomes. *J Head Trauma Rehabil*, 14(5), 486-496.
- Harbrecht, B. G., Moraca, R. J., Saul, M., & Courcoulas, A. P. (1998). Percutaneous endoscopic gastrostomy reduces total hospital costs in head-injured patients. *Am J Surg*, 176(4), 311-314.
- Haynes, M. (1992). Review article: Nutrition in the severely head-injured patient. *Clin Rehabil*, 6(2), 153-158.
- Henson, M. B., De Castro, J. M., Stringer, A. Y., & Johnson, C. (1993). Food intake by brain-injured humans who are in the chronic phase of recovery. *Brain Inj*, 7(2), 169-178.
- Horner, J., & Massey, E. W. (1988). Silent aspiration following stroke. *Neurology*, 38(2), 317-319.
- Krakau, K., Hansson, A., Karlsson, T., de Bousard, C. N., Tengvar, C., & Borg, J. (2007). Nutritional treatment of patients with severe traumatic brain injury during the first six months after injury. *Nutrition*, 23(4), 308-317.
- Kramer, P., Shein, D., & Napolitano, J. (2007). Rehabilitation of speech, language and swallowing disorders In J. Elbaum, & D.M. Benson (Eds.), *Acquired Brain Injury* (pp. 238-258). New York, NY: Springer.
- Langmore, S. E., Terpenning, M. S., Schork, A., Chen, Y., Murray, J. T., Lopatin, D., & Loesche, W. J. (1998). Predictors of aspiration pneumonia: how important is dysphagia? *Dysphagia*, 13(2), 69-81.
- Lazarus, C., & Logemann, J. A. (1987). Swallowing disorders in closed head trauma patients. *Arch Phys Med Rehabil*, 68(2), 79-84.
- Lazzara, G. L., Lazarus, C., & Logemann, J. A. (1986). Impact of thermal stimulation on the triggering of the swallowing reflex. *Dysphagia*, 1, 73-77.
- Leder, S. B., & Espinosa, J. F. (2002). Aspiration risk after acute stroke: comparison of clinical examination and fiberoptic endoscopic evaluation of swallowing. *Dysphagia*, 17(3), 214-218.
- Levenson, C. W. (2005). Zinc supplementation: Neuroprotective or neurotoxic? *Nutrition reviews*, 63(4), 122-125.
- Lichtman, S. W., Birnbaum, I. L., Sanfilippo, M. R., Pellicone, J. T., Damon, W. J., & King, M. L. (1995). Effect of a tracheostomy speaking valve on secretions, arterial oxygenation, and olfaction: a quantitative evaluation. *J Speech Hear Res*, 38(3), 549-555.
- Lim, S. H., Lieu, P. K., Phua, S. Y., Seshadri, R., Venketasubramanian, N., Lee, S. H., & Choo, P. W. (2001). Accuracy of bedside clinical methods compared with fiberoptic endoscopic examination of

- swallowing (FEES) in determining the risk of aspiration in acute stroke patients. *Dysphagia*, 16(1), 1-6.
- Linden, P., & Siebens, A. A. (1983). Dysphagia: predicting laryngeal penetration. *Arch Phys Med Rehabil*, 64(6), 281-284.
- Loan, T. (1999). Metabolic/nutritional alterations of traumatic brain injury. *Nutrition*, 15(10), 809-812.
- Logemann, J. A. (1983). *Evaluation and treatment of swallowing disorders*. San Diego: College-Hill Press.
- Logemann, J. A. (1989). Evaluation and treatment planning for the head-injured patient with oral intake disorders. *J Head Trauma Rehabil*, 4(4), 24-33.
- Logemann, J. A. (1991). Approaches to management of disordered swallowing. *Baillieres Clin Gastroenterol*, 5(2), 269-280.
- Logemann, J. A. (1993). The dysphagia diagnostic procedure as a treatment efficacy trial. *Clin Commun Disord*, 3(4), 1-10.
- Logemann, J. A. (1997). Role of the modified barium swallow in management of patients with dysphagia. *Otolaryngol Head Neck Surg*, 116(3), 335-338.
- Logemann, J. A. (1998). *The evaluation and treatment of swallowing disorders*. Austin Texas: Pro-Ed.
- Logemann, J. A. (1999). Behavioral management for oropharyngeal dysphagia. *Folia Phoniatr Logop*, 51(4-5), 199-212.
- Logemann, J. A. (2008). Treatment of oral and pharyngeal dysphagia. *Phys Med Rehabil Clin N Am*, 19(4), 803-816, ix.
- Mackay, L. E., Morgan, A. S., & Bernstein, B. A. (1999a). Factors affecting oral feeding with severe traumatic brain injury. *J Head Trauma Rehabil*, 14(5), 435-447.
- Mackay, L. E., Morgan, A. S., & Bernstein, B. A. (1999b). Swallowing disorders in severe brain injury: risk factors affecting return to oral intake. *Arch Phys Med Rehabil*, 80(4), 365-371.
- Manzano, J. L., Lubillo, S., Henriquez, D., Martin, J. C., Perez, M. C., & Wilson, D. J. (1993). Verbal communication of ventilator-dependent patients. *Crit Care Med*, 21(4), 512-517.
- Martino, R., Pron, G., & Diamant, N. (2000). Screening for oropharyngeal dysphagia in stroke: insufficient evidence for guidelines. *Dysphagia*, 15(1), 19-30.
- McCallum, S. L. (2003). The National Dysphagia Diet: implementation at a regional rehabilitation center and hospital system. *J Am Diet Assoc*, 103(3), 381-384.
- McClain, C. J., Twyman, D. L., Ott, L. G., Rapp, R. P., Tibbs, P. A., Norton, J. A., Young, B. (1986). Serum and urine zinc response in head-injured patients. *J Neurosurg*, 64(2), 224-230.
- Milazzo, L., Bouchard, J., & Lund, D. (1989). The swallowing process: Effects of aging and stroke. *Physical Medicine and Rehabilitation: state of the arts reviews*, 3, 489-499.
- Minard, G., Kudsk, K. A., Melton, S., Patton, J. H., & Tolley, E. A. (2000). Early versus delayed feeding with an immune-enhancing diet in patients with severe head injuries. *J Parenter Enteral Nutr*, 24(3), 145-149.
- Morgan, A. S., & Mackay, L. E. (1999). Causes and complications associated with swallowing disorders in traumatic brain injury. *J Head Trauma Rehabil*, 14(5), 454-461.
- Morgan, A., & Ward, E. (2001). Swallowing: Neuroanatomical and physiological framework. In T. D. Murdoch BE (Ed.), *Traumatic brain injury: associated speech, language, and swallowing disorders* (pp. 313-329). San Diego: Singular Publishing Group.
- Muller-Lissner, S. A., Fimmel, C. J., Will, N., Muller-Duysing, W., Heinzel, F., & Blum, A. L. (1982). Effect of gastric and transpyloric tubes on gastric emptying and duodenogastric reflux. *Gastroenterol*, 83(6), 1276-1279.
- O'Neil-Pirozzi, T. M., Liseiecki, D. J., Jack Momose, K., Connors, J. J., & Milliner, M. P. (2003). Simultaneous modified barium swallow and blue dye tests: a determination of the accuracy of blue dye test aspiration findings. *Dysphagia*, 18(1), 32-38.

- O'Neil-Pirozzi, T. M., Momose, K. J., Mello, J., Lepak, P., McCabe, M., Connors, J. J., & Lisiecki, D. J. (2003). Feasibility of swallowing interventions for tracheostomized individuals with severely disordered consciousness following traumatic brain injury. *Brain Inj*, *17*(5), 389-399.
- Ott, L., Young, B., Phillips, R., & McClain, C. (1990). Brain injury and nutrition. *Nutr Clin Pract*, *5*(2), 68-73.
- Panther, K. (2005). The Frazier free water protocol. *Perspectives on Swallowing and Swallowing Disorders (Dysphagia)*, *14*(1), 4-9.
- Passy-Muir Incorporated. (2004). Passy-Muir Clinical Inservice Outline. from http://www.passy-muir.com/pdfs/inservice_outline.pdf
- Passy, V., Baydur, A., Prentice, W., & Darnell-Neal, R. (1993). Passy-Muir tracheostomy speaking valve on ventilator-dependent patients. *Laryngoscope*, *103*(6), 653-658.
- Pepe, J. L., & Barba, C. A. (1999). The metabolic response to acute traumatic brain injury and implications for nutritional support. *J Head Trauma Rehabil*, *14*(5), 462-474.
- Platt, J. (2001). Dysphagia management for long-term care: A manual for nurses and other healthcare professionals. *Clinical and Educational Services*.
- Rasley, A., Logemann, J. A., Kahrilas, P. J., Rademaker, A. W., Pauloski, B. R., & Dodds, W. J. (1993). Prevention of barium aspiration during videofluoroscopic swallowing studies: value of change in posture. *AJR Am J Roentgenol*, *160*(5), 1005-1009.
- Sacks, G. S., Brown, R. O., Teague, D., Dickerson, R. N., Tolley, E. A., & Kudsk, K. A. (1995). Early nutrition support modifies immune function in patients sustaining severe head injury. *J Parenter Enteral Nutr*, *19*(5), 387-392.
- Schurr, M. J., Ebner, K. A., Maser, A. L., Sperling, K. B., Helgerson, R. B., & Harms, B. (1999). Formal swallowing evaluation and therapy after traumatic brain injury improves dysphagia outcomes. *J Trauma*, *46*(5), 817-821; discussion 821-813.
- Shaker, R., Easterling, C., Kern, M., Nitschke, T., Massey, B., Daniels, S., & Dikeman, K. (2002). Rehabilitation of swallowing by exercise in tube-fed patients with pharyngeal dysphagia secondary to abnormal UES opening. *Gastroenterol*, *122*(5), 1314-1321.
- Shaker, R., Kern, M., Bardan, E., Taylor, A., Stewart, E. T., Hoffmann, R. G., Bonnevier, J. (1997). Augmentation of deglutitive upper esophageal sphincter opening in the elderly by exercise. *Am J Physiol*, *272*(6 Pt 1), G1518-1522.
- Souba, W., & Wilmore, D. (1999). Diet and nutrition in the care of the patient with surgery, trauma, and sepsis. In O. J. Shils ME, Shike M, Ross AC (Ed.), *Modern nutrition in health and disease* (pp. 1589-1618). Baltimore, MD: Williams and Wilkins.
- Splaingard, M. L., Hutchins, B., Sulton, L. D., & Chaudhuri, G. (1988). Aspiration in rehabilitation patients: videofluoroscopy vs bedside clinical assessment. *Arch Phys Med Rehabil*, *69*(8), 637-640.
- Stachler, R. J., Hamlet, S. L., Choi, J., & Fleming, S. (1996). Scintigraphic quantification of aspiration reduction with the Passy-Muir valve. *Laryngoscope*, *106*(2 Pt 1), 231-234.
- Taylor, S., & Fettes, S. (1998). Enhanced enteral nutrition in head injury: effect on the efficacy of nutritional delivery, nitrogen balance, gastric residuals and risk of pneumonia. *J Hum Nutr Diet*, *11*(5), 391-401.
- Taylor, S. J., Fettes, S. B., Jewkes, C., & Nelson, R. J. (1999). Prospective, randomized, controlled trial to determine the effect of early enhanced enteral nutrition on clinical outcome in mechanically ventilated patients suffering head injury. *Crit Care Med*, *27*(11), 2525-2531.
- Terre, R., & Mearin, F. (2009). Evolution of tracheal aspiration in severe traumatic brain injury-related oropharyngeal dysphagia: 1-year longitudinal follow-up study. *Neurogastroenterol Motil*, *21*(4), 361-369.
- Tolep, K., Getch, C. L., & Criner, G. J. (1996). Swallowing dysfunction in patients receiving prolonged mechanical ventilation. *Chest*, *109*(1), 167-172.

- Twyman, D. (1997). Nutritional management of the critically ill neurologic patient. *Crit Care Clin*, 13(1), 39-49.
- Weekes, E., & Elia, M. (1996). Observations on the patterns of 24-hour energy expenditure changes in body composition and gastric emptying in head-injured patients receiving nasogastric tube feeding. *J Parenter Enteral Nutr*, 20(1), 31-37.
- Wilson, R. F., Dente, C., & Tyburski, J. G. (2001). The nutritional management of patients with head injuries. *Neurol Res*, 23(2-3), 121-128.
- Winstein, C. J. (1983). Neurogenic dysphagia. Frequency, progression, and outcome in adults following head injury. *Phys Ther*, 63(12), 1992-1997.
- Yanagawa, T., Bunn, F., Roberts, I., Wentz, R., & Pierro, A. (2000). Nutritional support for head-injured patients. *Cochrane Database Syst Rev*(2), Cd001530.
- Young, B., Ott, L., Kasarskis, E., Rapp, R., Moles, K., Dempsey, R. J., McClain, C. (1996). Zinc supplementation is associated with improved neurologic recovery rate and visceral protein levels of patients with severe closed head injury. *J Neurotrauma*, 13(1), 25-34.
- Young, B., Ott, L., Norton, J., Tibbs, P., Rapp, R., McClain, C., & Dempsey, R. (1985). Metabolic and nutritional sequelae in the non-steroid treated head injury patient. *Neurosurgery*, 17(5), 784-791.
- Young, B., Ott, L., Yingling, B., & McClain, C. (1992). Nutrition and brain injury. *J Neurotrauma*, 9 Suppl 1, S375-383.