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Note: Nancy B. Swigert was the Division 13 Coordinator at the time the content of this self-study was first published in Perspectives on Swallowing and Swallowing Disorders. For current information on ASHA’s special interest divisions, visit the division pages on the ASHA Web site (http://www.asha.org/about/membership-certification/divs/) or call the ASHA Action Center at 1-800-498-2071.
Tracheostomy and Dysphagia: A Complex Association

Rita L. Bailey
Illinois State University
Normal, IL

Tracheotomy is a surgical incision directly into the anterior aspect of the trachea for the purpose of establishing an artificial airway. A tube is placed into the surgically created opening to maintain the airway, resulting in what is typically referred to as a tracheostomy (Bissell, 2000). The tube type and size specifications vary and are determined by medical personnel according to patient factors, including size and medical needs. An artificial airway is often required for respiratory disturbances, such as primary lung disease, systemic disease with secondary lung involvement, neuromuscular disease, central nervous system depression, trauma, diseases complicated by extremes of age, mechanical obstruction, and recurrent aspiration (Bach & Ishikawa, 2000; Fornataro-Clerici & Roop, 1997b).

Several complications have been associated with the tracheostomy procedure. These include operative complications, such as subcutaneous or mediastinal emphysema, hemorrhage, respiratory complications, injury to the recurrent laryngeal nerve and/or thyroid gland, cardiac arrest, and mechanical problems related to placement of the stoma (McClelland, 1965; Meade, 1961; Stauffer & Silvestri, 1982; Stauffer, Olson, & Petty, 1981). Additional peri-operative complications include formation of granulation tissue, stenosis, tracheomalacia, tracheoinnominate-artery fistula, ventilator-associated pneumonia, and aspiration (Epstein, 2005). Although the tracheostomy procedure is far from risk free, there are several advantages associated with tracheostomy tube use versus oral or nasal intubation. These include increased comfort for patients, reduced airway resistance, easier secretion removal, decreased risk of vocal fold damage, and potential for phonation and oral nutrition (Fornataro-Clerici & Roop, 1997a).

Risk of Aspiration

While the potential for oral nutrition does offer many benefits, swallowing dysfunction has been associated with tracheostomy. An association between aspiration and tracheostomy with and without mechanical ventilation has been well documented (Abel, Ruf, & Spahn, 2004; Cameron, Reynolds, & Zuidema, 1973; Davis & Stanton, 2004; Epstein, 2005; Muz, Mathog, Rosen, Miller, & Borroto, 1987; Ross & White, 2003; Shaker et al., 1995; Stauffer & Silvestri, 1982). A scintigraphic study of tracheopulmonary aspiration concluded that tracheostomy was associated with increased risk of aspiration and pneumonia (Muz et al., 1987). Muz, Mathog, Nelson, and Jones (1989) found evidence of aspiration in 58% of patients with a diagnosis of head and neck cancer and tracheostomy compared to 28% of patients with head and neck cancer without tracheostomy. Cameron and colleagues (1973) found evidence of dye placed in the oral cavity of 61 patients with tracheostomy in the tracheal secretions of 42 of these patients. In a retrospective case-controlled study within a large rehabilitation hospital, Kirshblum, Johnson, Brown, O’Connor, and Jarosz (1999) reported that tracheostomy and mechanical ventilator dependency was one of three significant predictors of risk for dysphagia in patients with spinal cord injury. In fact, tracheostomy at admission was the strongest predictor of dysphagia in these patients.

Abraham and Wolf (2000) evaluated (a) onset times for pharyngeal phase events, laryngeal vestibule closure, and tracheostomy tube movement; (b) timelines of swallow response initiation; and (c) pharyngeal transport function in four toddler-aged patients with long term tracheostomy and compared these measurements to a single toddler-aged patient without tracheostomy. Results indicated delays in timing closure of the laryngeal vestibule in toddlers with long-term tracheostomies, which was associated with tracheal aspiration. Additionally, delayed initiation of the pharyngeal swallow response was observed across toddlers with tracheostomy at a frequency of 45% with associated laryngeal penetration. The authors concluded that
this investigation provided preliminary evidence to support the concept that long-term tracheostomy in toddler-aged study participants negatively affected their swallowing physiology.

**Causal Factors**

Although the association between tracheostomy tube presence and aspiration status has been reported for many years, the strength of this relationship has been questioned. Leder, Joe, Ross, Coelho, and Mendes (2005) evaluated 22 postoperative head and neck cancer patients with fiberoptic endoscopic evaluation of swallowing (FEES). These investigators performed FEES under three conditions to determine evidence of aspiration: (1) tracheostomy tube present, (2) tracheostomy tube removed and tracheostoma covered with gauze sponge, and (3) tracheostomy tube removed and tracheostoma left open and uncovered. These authors found no immediate effect on aspiration status in early, postsurgical, head-and-neck cancer patients under these three experimental conditions. They suggested that presence of tracheotomy or tracheostomy tube does not increase incidence of aspiration and that decannulation does not result in improved swallowing. Leder and colleagues concluded that dysphagia and aspiration that occur in patients with tracheostomy results from critical illnesses that necessitate a tracheostomy in the first place. The interaction between oropharyngeal dysfunction and respiratory impairment has been well documented (Davis & Stanton, 2004; His, Strauss, Treole, Stuart, & Boutilier, 2003; Martin, Logemann, Shaker, & Dodds, 1994; Morton, Minford, Ellis, & Pinnington, 2002). It is less clear whether an underlying respiratory dysfunction requiring tracheostomy or the presence of a tracheostomy underlies swallowing impairments in patients with tracheostomy.

**Pressure Differences**

Logemann (1998) described the upper aerodigestive tract as a set of tubes and valves. The tubes are the oral cavity (horizontal tube) and the pharynx (vertical tube). Within these tubes, there are six valves which serve to direct food and apply pressure to propel the bolus. They are the lips, oral portion of the tongue, velopharyngeal region, larynx, tongue base and pharyngeal wall, and the cricopharyngeal region. The purpose of these valves is to apply pressure to direct food safely through the oral and pharyngeal cavities. Given that swallowing is a pressure driven event (Eibling & Gross, 1996; McConnel, 1988; McConnel, Cerenko, & Mendelsohn, 1988; Perlman, Schultz, & VanDaele, 1993), the inability to build up adequate pressure to propel the bolus may have an aversive effect on swallow physiology. Therefore, the leak in the system caused by an open tracheostomy tube may distort the pressure driving the bolus, which could divert the bolus from the normal pathway of deglutition and increase the risk of aspiration.

The ability to properly maintain or even build pressure at the larynx appears to be affected by tracheostomy. It has been suggested that a drop in pressure at the midpoint of deglutition assists closure of the larynx by increasing the pressure gradient between the hypopharynx and subglottal space (Shin, Maeyama, Morikawa, & Umezaki, 1988). The leak in the previously closed system caused by the open tracheostomy tube distorts the interrelationship of pressures, decreasing the coordination and/or degree of closure of the larynx with swallowing.

Eibling and Gross (1996) suggested that dysfunction in swallowing in persons with tracheostomy may be due to decreased subglottic air pressure and glottic airflow that occurs with an open subglottic system. They theorized that restoration of a closed subglottic system by decannulation or one-way speaking valve would decrease dysphagia in patients with tracheostomy. These researchers measured subglottic air pressure and airflow through tracheostomy during swallowing. They found a minimal rise in pressure and significant expiratory airflow during swallowing with tracheostomy tube open. When using a one-way speaking valve, subglottal pressure was effectively restored and expiratory airflow ceased. Each of the 11 participants in this investigation were evaluated via videofluoroscopy with and without a one-way speaking valve attached to the tracheostomy tube. In every case, use of the one-way speaking valve resulted in a significant decrease or elimination of
aspiration. Eibling and Gross concluded that these findings were due to the restoration of subglottic pressure.

Gross, Atwood, Grayhack, and Shaiman (2003) evaluated the effects of lung volumes on pharyngeal swallowing physiology in 28 healthy participants. They theorized that pressurized air during swallowing plays a role in neuroregulation of swallowing function by stimulating subglottic mechanoreceptors. The authors suggested that when subglottic pressure is altered as in tracheostomy, neuroregulation of pharyngeal swallowing physiology is likewise altered. Each participant in the investigation by Gross and colleagues (2003) swallowed three pudding boluses at three randomized lung volumes: total lung capacity, functional residual capacity, and residual volume. Results indicated that pharyngeal activity duration for swallows produced at residual volume was significantly longer than those at the other lung volumes tested. The researchers summarized that these results tended to support their hypothesis that the respiratory system may have a regulatory function related to swallowing and that “positive subglottic air pressure is important to swallow integrity” (p. 2211).

**Airflow Differences**

The loss of expiratory airflow through the upper airway for normal respiration has been linked to increased pooling of secretions within the larynx and pharynx (Siebens, Tippet, Kirby, & French, 1993). Secretions of individuals with dysphagia without tracheostomy are often swept out of the larynx with normal expiration. Siebens, Tippet, Kirby, and French (1993) outlined two case studies of patients with tracheostomy and dysphagia. Swallowing function improved and laryngeal penetration was eliminated or minimized in both patients with the use of a one-way speaking valve and restored expiratory airflow through the upper airway. Similarly, a study by Lichtman and colleagues (1995) found decreases in secretions and improvements in olfaction with the restoration of expiratory airflow through the upper airway with the use of one-way speaking valves.

**Laryngeal Elevation**

The hyomandibular complex functions to effectively elevate and anteriorly rotate the larynx during swallowing. Mechanical tethering of the larynx due to tracheostomy leading to decreased laryngeal elevation has long been cited as a contributor to swallowing problems in the tracheostomized population (Bonanno, 1971; Cameron et al., 1973; Ding & Logemann, 2005; Nash, 1988). “The tracheostomy tube, particularly with the cuff inflated, anchors the larynx in place thereby reducing laryngeal excursion during the swallow” (Fornataro-Clerici & Roop, 1997b, p. 117).

Upper esophageal sphincter (UES) opening is an active mechanical event rather than simply a consequence of cricopharyngeal relaxation (Jacob, Kahrilas, Logemann, Shah, & Ha, 1989). The opening of the UES is an event that occurs with laryngeal elevation and has been associated with anterior movement of the larynx. This action, in conjunction with the force of pressures created during swallowing which aid advancement of the bolus, serves to assist opening of the UES. Because of the relationship between anterior and superior elevation of the larynx with UES opening, it is probable that decreased UES opening may be related to decreased laryngeal excursion in patients with tracheostomy. Unfortunately, there have been no well-controlled studies to systematically investigate the relationship between laryngeal tethering in tracheostomy and swallowing impairment.

**Tube and Cuff Issues**

The cuff of a tracheostomy tube is an internal balloon that surrounds the outer cannula or body of the tracheostomy tube. It can be inflated or deflated externally. The primary function of cuffs is to seal the trachea for delivery of air into the lungs with mechanical ventilation. Cuffs are to prevent the air from leaking out of the tracheostomy site, so that the preset volume of air delivered by mechanical ventilator is received into the lungs. Though it has been believed that an inflated cuff limits the amount of aspiration, evidence suggests otherwise (Suiter, McCullough, & Powell, 2003). Secretions and/or food collect atop the cuff only to be aspirated with cuff deflation. Increased pooling of these
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secretions may also lead to leakage past the cuff with a patient’s body movements or with breathing due to the movement of the trachea (Betts, 1965).

There are several complications and hazards that may occur in tracheostomized patients due to inflation of tracheostomy tube cuffs. These include difficulties associated with overinflation, such as partial or total occlusion of the airway, damage to tracheal mucosa, and difficulties associated with extended cuff use such as tracheal stenosis, granuloma formation, tracheal erosion, tracheoesophageal fistula, tracheomalacia, and tracheal dilatation (Mason, 1993; Stauffer & Silvestri, 1982). Each of these factors may negatively affect swallowing function.

Betts (1965) was one of the first to suggest that distention caused by the tracheostomy tube against the esophagus can obstruct the esophagus, causing liquids to overflow the esophageal opening and fall into the trachea. He also recognized that inflated tracheostomy cuffs may not prevent aspiration, reporting that the cuffs were not “watertight.” Aspiration of liquids around cuffed tracheostomy tubes has been well documented (Bone, Davis, Zuidema, & Cameron, 1974; Elpern, Jacobs, & Bone, 1987; Nash, 1988; Pavlin, VanNimwegan, & Hornbein, 1975; Ross & White, 2003). Aspiration of food has also occurred with cuff inflation (Pinkus, 1973). It is clear that cuff inflation does not eliminate patients’ risk of aspiration.

The anterior aspect of the trachea contains 16 to 20 C-shaped cartilages. Connecting the cartilage posteriorly is the trachealis muscle. The combination of muscle and cartilage facilitates strength, patency, and the ability to change diameter. Tracheal lumen is not static during respiration; tracheal dilation occurs during inspiration, and tracheal constriction occurs during expiration. The amount of air inserted into a standard air-filled cuff, however, is static. Therefore, cuff to tracheal wall approximation and resultant pressure changes within each respiratory cycle. Aspiration around tracheal cuffs may be due to the leak caused by tracheal dilation during inspiration. It has also been speculated that secretions may collect in folds that form in a cuff that is not fully inflated (Elpern, Jacobs, & Bone, 1987; Elpern, Scott, Petro, & Ries, 1994).

Laryngeal Sensitivity

Protective function of the larynx may be viewed neurophysiologically by examination of the glottic closure reflex. This reflex produces protective laryngeal closure during swallowing. This protection is the result of the following events

1. Adduction of the vocal cords associated with the horizontal approximation of the arytenoid cartilages;
2. Vertical approximation of the arytenoids to the base of the epiglottis;
3. Laryngeal ascent; and

Laryngeal sensitivity and related glottic closure function appear to be affected by tracheostomy. The reflexive closure of the true vocal folds occurs primarily as a result of the contraction of the intrinsic laryngeal muscles. Primary reflex closure is produced by rapid contraction of the thyroarytenoid muscle in response to superior laryngeal nerve stimulation (Ikari & Sasaki, 1980). Buckwalter and Sasaki (1984) separated the effect of tracheostomy on laryngeal function into two categories:

1. The mechanical positioning of the larynx controlled by the extrinsic muscles of the larynx and
2. The refined neurophysiologic regulation of the intrinsic muscles.

Using an animal model, Sasaki and Buckwalter (1984) demonstrated that in dogs with prolonged tracheostomy the threshold of the adductor reflex produced by electricostimulation of the superior laryngeal nerve nearly doubled. They also reported that repetitive superior laryngeal nerve stimulation produced marked attenuation of the adductor reflex, which was reflected in a weakened closure response after long-term tracheostomy. These authors postulated that such changes in the behavior of the medullary adductor motoneurons indicated their susceptibility to surgical modifications in lower respiratory function. They hypothesized that these changes may explain the onset of aspiration due to a weakened, ill-coordinated closure response resulting from long-term tracheostomy in the absence of known laryngotracheal surgical injury. Poorly coordinated laryngeal
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closure may lead to airway compromise. “Cessation of breathing or swallowing apnea and airway closure must occur so that food/liquid may pass from the oral cavity, through the pharynx, and into the esophagus without threatening entrance into the trachea and lungs” (Hiss et al., 2003, p. 293).

When laryngeal sensitivity is normal, aspiration of food or liquids typically produces a cough response. This response can help clear aspirated material out of the airway and into the pharynx or oral cavity to be expectorated or swallowed. Moreover, it often serves to alert caregivers to the possibility of swallowing dysfunction. Decreased laryngeal sensitivity accompanied by decreased ability to build up subglottic pressure in patients with a tracheostomy may lead to a less effective or absent cough response, which may further compromise patients’ ability to protect the airway. It has been reported that an increased incidence of silent aspiration occurs in individuals with tracheostomy (Davis & Stanton, 2004; Elpern et al., 1994).

Summary

The cause of dysphagia is often complex. Because of the interrelatedness between respiration and swallowing, this is especially true in patients with severe respiratory impairment requiring tracheostomy. A review of the literature related to tracheostomy presents a complex picture of increased risk of dysphagia. Several possible causes for this association have been suggested, including loss of normal pressure and airflow relationships, decreased laryngeal sensitivity, decreased or absent cough response, mechanical factors or complications related to the tracheostomy tube or cuff, complications associated with tracheotomy procedure, and the underlying primary respiratory dysfunction requiring tracheostomy. More research is needed in this area to help speech-language pathologists evaluate and provide appropriate treatments for patients with tracheostomy and dysphagia.

Rita L. Bailey is a speech-language pathologist and Board Recognized Specialist in Swallowing and Swallowing Disorders. She is an assistant professor in the Department of Speech Pathology and Audiology at Illinois State University where she teaches coursework in adult and pediatric dysphagia, voice, neuropathology, and evaluation and management of communication and swallowing in tracheostomized and ventilator dependent patients. Her primary research interests include pediatric dysphagia, AAC, and voice.

References


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Use of Blue Dye and Glucose Oxidase Reagent Strips for Detection of Pulmonary Aspiration: Efficacy & Safety Update

Susan Brady
Marianjoy Rehabilitation Hospital
Wheaton, IL

The efficacy of using of blue dye and glucose oxidase reagent strips to detect pulmonary aspiration of enteral feedings has been called into question. Recent safety issues have also been raised about using blue dye in critically ill patients. Because of these concerns, many speech-language pathologists (SLPs) are faced with the challenge of whether or not to use blue dye for trial feedings with patients with a tracheotomy or during the fiberoptic endoscopic examination of the swallow (FEES). This article will review recent literature on the use of blue dye and oxidase reagent strips to detect pulmonary aspiration.

Types of Blue Dyes

There are different types of blue dye used in a variety of medical procedures as a clinical marker to detect abnormalities, such as tumors, cellular membrane permeability, blood flow, and pulmonary aspiration. Forms of blue dye that have been used in medical procedures include the Evans blue dye, Methylene blue dye, Isosulfan blue dye, FD&C Blue No. 1, and FD&C Blue No. 2. According to the Food and Drug Administration (FDA, 1993), FD&C Blue No. 1 is the most common type of blue dye used to dye enteral feedings in order to detect for pulmonary aspiration.

The FDA regulates FD&C Blue No. 1, and its common name is Brilliant Blue. The hue is bright blue and is commonly used in beverages, dairy products, powders, jellies, confections, condiments, icing, syrups, and extracts. The dye was FDA approved after initial experiments in animals showed it to be relatively non-toxic, as less than 5% of the FD&C Blue No. 1 is absorbed systemically with the majority of the dye being excreted in the stool (Gaur, Sorg, & Shukla, 2003; Maloney et al., 2002). The FDA (1982) estimated the maximum daily amount of FD&C Blue No. 1 acceptable for daily human intake is 12.0-milligrams/kilogram of body weight. This means that an individual who weighs 120-lb (54 kilograms) would be permitted a maximum 648 milligrams per day (ASHA, 2005).

Efficacy of Blue Dye

Enteral Feeding

Use of blue dye with enteral feedings to detect pulmonary aspiration was very popular in the 1990s. A survey conducted by Methany, Aud, and Wunderlich (1999) found 86% of intensive care unit nurses reported routinely using blue dye with enteral feedings. It was assumed that using blue dye with enteral feedings had a high sensitivity rate for aspiration with relatively few or no risks (Maloney et al., 2002). Potts, Zaroukian, Guerrero, and Baker (1993) first investigated the efficacy of dying enteral feedings blue as a means to detect pulmonary aspiration. They found that inspecting tracheal secretions for blue discoloration failed to detect most episodes of known aspiration of enteral feedings. Methany and colleagues (2002) conducted an animal model study using rabbits, and results showed a low sensitivity rate of 46.3% for detection of aspiration using blue dye following forced small-volume pulmonary aspiration of a mixture of human gastric juice and enteral formula that had been dyed with FD&C Blue No. 1.

Oral Feedings in Patients With a Tracheotomy and FEES

Using blue dye to detect aspiration in patients with a tracheotomy was first described by Cameron, Reynolds, and Zuidema (1973). They described using four drops of 1% solution of Evans blue dye on tongues of patients with a tracheotomy to document incidence of aspiration of their oropharyngeal secretions. The modified blue food swallow test used today with patients with a tracheotomy is based upon the original Evans blue dye test. Food coloring (FD&C Blue No. 1) is mixed with food and liquid and given to the patient to swallow. The modified blue food swallow test is considered positive for aspiration when blue dye/tinged secretions
are suctioned through the tracheotomy tube.

Thompson-Henry and Braddock (1995) initially called into question the efficacy of the blue food test for detection of aspiration in patients with a tracheotomy as they reported five cases where it had failed to detect aspiration. Brady, Hildner, and Hutchins (1999) were the first to report conducting simultaneous videofluoroscopic swallow studies (VFSS) with the blue food test. They found that in cases of known aspiration as documented by the VFSS, the blue food test was only 50% accurate in the detection of aspiration. Donzelli, Brady, Wesling, and Craney (2001) conducted a follow-up study with simultaneous fiberoptic endoscopic exam of the swallow (FEES) and the blue food test. Again, they found that in cases of known aspiration as documented by FEES, the blue food test was only 50% accurate in detection of aspiration. Peruzzi, Logemann, Currie, and Moen (2001) also conducted simultaneous VFSS and blue food test and found a sensitivity rate for the blue food test of only 38% when compared to the VFSS. Belafsky, Blumenfeld, LePage, and Kristen (2003) reported a higher sensitivity of 82% for the blue food test for the detection of aspiration as compared to the FEES. However, in that study, the blue food test and the FEES were completed at separate times. O’Neil-Pirozzi, Lisiecki, Momose, Connors, and Milliner (2003) replicated previous simultaneous studies and found a sensitivity rate of 79.3% for detection of aspiration using the blue dye test when compared to the VFSS. Many investigators have reported the blue food test should best be viewed as only a screening tool to detect aspiration in patients with a tracheotomy tube (Belafsky et al., 2003; Brady et al.1999; Donzelli, Brady, and Wesling, 2004; Donzelli et al., 2001; Peruzzi et al., 2001).

Food coloring has also been used during FEES procedures for many years under the assumption that it enhances the visualization of food and liquid to assist with detection of aspiration. A recent study by Leder, Acton, Lisitano, and Murray (2005) sought to determine intra- and inter-rater reliability in detecting the critical feature of pharyngeal dysphagia and aspiration using either blue dyed or non-blue dyed foods. They concluded that the use of blue dye during FEES could be discontinued.

### Adverse Events

As of September 2003, the FDA reported that they were aware of 20 documented cases identified in either the scientific literature or reported to the FDA regarding adverse events associated with using FD&C Blue No. 1 in tube feedings (see Table 1 on p. 11). These adverse events ranged in severity from discoloration of skin and body fluids to death. While at this time the FDA has not been able to establish a clear causal relationship between the reported life-threatening patient outcomes and the use of FD&C Blue No. 1, given the seriousness of the potential complications, they felt that health care professionals should be notified of these reports. In more than 75% of the reported cases, the patients who experienced an adverse event had a previous history of sepsis (with an increased likelihood of altered gastrointestinal permeability) before or during the systemic absorption of FD&C Blue No. 1. The FDA further reported that patients who may be at risk for increased gastrointestinal permeability for absorbing FD&C Blue No. 1 include those with sepsis, burns, shock, multiple trauma, surgical intervention, renal failure, inflammatory bowel disease, or celiac sprue disease (Acheson, 2003).

Given the fact that the patients who expired were critically ill, it would be difficult to attribute their deaths solely to the FD&C Blue No. 1, although it is conceivable that systemic absorption of FD&C Blue No. 1 may have played a major contributing role in their clinical deterioration (Gaur et al., 2003). Currently, there are no data regarding the extent of systemic absorption and safety of FD&C Blue No. 1 in patients who have increased gastrointestinal permeability (Acheson, 2003; Gaur et al., 2003). It has been reported that FD&C Blue No. 1 may interfere with the action of the adenosine triphosphate (ATP)/adenosine diphosphate (ADP) trans-locator situated in the inner mitochon-
The inhibitory effect of the FD&C Blue No. 1 on the translocator in the mitochondrial membrane may be responsible for refractory acidosis noted in the death of some of the patients (Gaur et al., 2003). ATP is essential for cellular functioning and the subsequent mitochondrial dysfunction may be devastating to the overall functioning of an organism (Clay, Behnia, & Brown, 2001). Deprivation of ATP may also lead to alternative metabolic pathways that may result in the accumulation of metabolic byproducts, such as lactate, which can also be harmful to an organism (Clay et al., 2001).

Another potential concern with the use of blue dye is the possibility of cross contamination with bacterial colonization from multiuse non-sterile bottles (File, Tan, Thomson, Stephens, & Thompson, 1995). As a result of this, FD&C Blue No. 1 became available in single use sterile vials. However, following reports of the potential adverse side effects of FD&C Blue No. 1 with enteral feedings, many manufacturers discontinued production of single use sterile vials.

Some authors have recommended that use of FD&C Blue No. 1 be discontinued with enteral feedings for the detection of aspiration and that focus instead should be on prevention of aspiration (Maloney et al., 2002; McClave et al., 2002). Some specific suggestions for prevention of aspiration of enteral feedings include

1. Confirm tube placement with X-ray,
2. Adjust feeding concentrations and rate based upon gastric residual volumes,
3. Use gastric motility agents in select patients to increase gastric emptying,
4. Elevate patient’s head of bed to at least 45 degrees, and
5. Placement of the feeding tube beyond the pylorus may lead to less aspiration as compared with gastric positioning (Maloney et al., 2002).

Safety With Oral Feedings

Some institutions have banned the use of blue dye altogether for enteral as well as oral feedings, whereas others have limited using blue food coloring just for swallowing evaluations. Adverse effects reported in the literature to date regarding use of blue dye have been with critically ill patients using enteral feedings. There have been no adverse reports published regarding using foods dyed blue with non-critically ill patients during swallowing evaluations in patients with a tracheotomy, during the FEES procedure (ASHA, 2005), or associated with general use (Acheson, 2003). The amount of FD&C Blue No. 1 used during a swallow evaluation or during a FEES is usually several drops that approximates 1 milligram (ASHA, 2005) and

Table 1. Reported Adverse Events in the Literature

<table>
<thead>
<tr>
<th>Author(s)/Year</th>
<th>Age (years)</th>
<th>Outcome</th>
<th>Publication Type</th>
</tr>
</thead>
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<tr>
<td>Davis et al. (1991)</td>
<td>70</td>
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<td>Abstract</td>
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<tr>
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<td>75</td>
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<td>56</td>
<td>Green Urine</td>
<td>Journal</td>
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<td>Zillich et al. (2000)</td>
<td>11</td>
<td>Skin Discoloration</td>
<td>Journal</td>
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<td>Died</td>
<td>Journal</td>
</tr>
<tr>
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<td>84</td>
<td>Died</td>
<td>Abstract</td>
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<td>Gaur et al. (2003)</td>
<td>56</td>
<td>Died</td>
<td>Journal</td>
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<tr>
<td>Alsolaiman &amp; Howard (2003)</td>
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<td>Blue Nail Discoloration</td>
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<td>57</td>
<td>Died</td>
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this quantity is well below acceptable daily intake values. Some clinicians choose to use a green food coloring instead of the FD&C Blue No. 1 during trial feedings in patients with a tracheotomy or during FEES. Green food coloring mainly used is FD&C Green No. 3, and its common name is Fast Green. The hue is sea green and is commonly used in beverages, puddings, ice cream, sherbets, cherries, confections, baked goods, and dairy products (Gilman, 2003). Although the FDA has cautioned that other blue dyes such as methylene blue and FD&C Blue No. 2 may have similar if not greater toxicity than FD&C Blue No. 1 and should not be used as an appropriate replacement (Acheson, 2003), it did not specifically mention FD&C Green No. 3 in the warning. Because both FD&C Blue No. 1 and Green No. 3 have a similar chemical make-up (they are petroleum-derived triphenylmethanes, meaning they have three aromatic rings attached to a central carbon atom), it is possible that they would present with similar adverse effects with some patients. Additionally, there has been one case report of an allergic reaction (intense eosinophilia) following use of green food dye with enteral feedings (Bell & Fishman, 1990).

**Glucose Oxidase Reagent Strips**

Glucose oxidase reagent strips were originally designed to evaluate for glucose in blood or urine. The rationale behind using glucose oxidase test strips to detect pulmonary aspiration was that enteral feeding formulas have a high concentration of glucose. If glucose was found to be present in the tracheobronchial secretions, it could then be assumed the patient was aspirating the enteral feedings.

The literature is mixed on the efficacy of using this technique to detect pulmonary aspiration of enteral feedings. The first report of using glucose oxidase reagent strips to detect pulmonary aspiration of enteral feedings was completed by Winterbauer, Durning, Barron, and McFadden (1981). Twenty critically ill patients receiving enteral feedings were examined, and aspiration was detected by glucose oxidase reagent strips in 38% of the samples. St. John, Lefrak, Ridoff, Ridoff, and Bohlmann (1985) reported that using glucose oxidase reagent strips was an effective method to detect aspiration in their sample of 18 critically ill patients. Potts and colleagues (1993) compared blue dye visualization with glucose oxidase reagent strip method and found that glucose oxidase testing was more effective in identifying aspiration of enteral feedings. A follow-up study by Montejo-Gonzalez and colleagues (1994) concurred with the Potts and colleagues (1993) finding that the inspection of blue tracheal sections for detection of pulmonary aspiration of enteral feedings was inferior to the use of the glucose oxidase reagent strip method. More recent studies have advocated adding additional glucose to feeding formula in order to increase the sensitivity of glucose oxidase reagent strips for detection of aspiration of enteral feedings (Hussain, Roy, Young, 2003; Young, 2001).

A potential problem reported with using glucose oxidase reagent strips is that glucose may not be an appropriate marker of aspiration for enteral feedings. Elpern and colleagues (1986) found similar glucose patterns in the tracheobronchial secretions of patients who were enterally fed and non-enterally fed. Kinsey, Murray, Swensen, and Miles (1994) also found similar glucose patterns for patients who were enterally fed, but without evidence of aspiration and non-enterally fed patients. In that study, both patient groups had a high glucose concentration in their tracheal secretions. The authors concluded that the concentration of glucose in tracheal secretions may be partially determined by ambient extracellular glucose concentrations and that measurement of glucose in tracheal secretions is useful for the detection of aspiration of tube feedings. More recently, Meert, Daphtary, and Metheny (2002) found elevated glucose concentrations in tracheobronchial secretions can occur by mechanisms other than aspiration of enteral feeding formula. They suggested that pepsin may be a more specific marker for aspiration than glucose.

Additional reported problems associated with the use of the glucose oxidase reagent strip method include the fact that specific guidelines for testing other bodily fluids, such as tracheobronchial secretions, have not been established for this off-label
use (Metheny & Clouse, 1997). Another limiting factor is that blood contains glucose; any presence of blood in the tracheobronchial secretion sample has the potential to result in a false positive reading for aspiration (Metheny & Clouse, 1997). Different types of enteral feeding formulas have varying concentrations of glucose; the relationship between quantitative estimates of glucose content in the tracheobronchial secretions and the clinical significance of aspiration would need to be established for each specific formula (Metheny & Clouse, 1997). A survey by Metheny and colleagues (1999) found that only 14% of intensive care unit nurses reported using glucose strips to detect aspiration of enteral feedings, indicating that this technique is not widely practiced.

Conclusion

As a result of the debate on the clinical utility of both blue dye and glucose oxidase reagent strips for the detection of pulmonary aspiration of enteral feedings, a consensus statement was developed by the North American Summit on aspiration in critically ill patients (McClave et al., 2002). It recommended that both blue food coloring and glucose oxidase reagent strip method be discontinued as clinical markers for the detection of aspiration of enteral feedings (McClave et al.). Additionally, the clinical value of using of blue food coloring during trial feedings in patients with a tracheotomy and during FEES has also been questioned by recent research. Following adverse reports in the literature and caution from the FDA, use of blue dye with enteral feedings has been abandoned at many institutions. At this time, the FDA has not come out with a specific warning against using blue food coloring during swallowing evaluations. For those clinicians who choose to use food coloring during swallowing evaluations, some possible options to consider include:

1. Use blue-dyed foods and liquids only with non-critically ill patients who are not at risk for increased gastrointestinal permeability and
2. In order to avoid cross contamination from a multi-use bottle of blue dye, use only commercially available single-serving foods that are already prepared blue (i.e., blue yogurt, blue jello, and blue sports drinks).

For those clinicians who choose not to use food coloring, it is recommended that foods are used that are highly reflective (i.e., the food used is brighter than the tissue it is resting on such as white milk and yellow pudding) during the swallowing procedure in order to enhance visualization of the bolus (Leder et al., 2005). It is ultimately up to the individual clinician to work with his or her institution to develop guidelines for the safe usage of food coloring during swallowing evaluations.

Susan Brady is the research coordinator for the Rose McSweeney Voice and Swallowing Center at Marianjoy Rehabilitation Hospital, Wheaton, IL (sbrady@marianjoy.org). The Dr. Ralph and Marian Falk Medical Research Trust provides support for her research activities.

References


Dysphagia in the Trach/Vent Population


Dysphagia in the Trach/Vent Population
Do tracheostomy tubes cause dysphagia? Estimates of the number of individuals with tracheostomy and concomitant oropharyngeal dysphagia have been reported to be as high as 87% (Pannuzio, 1996). Whether there is a direct causal relationship between tracheostomy and dysphagia remains unclear, however, because results in the literature are equivocal. For further discussion of this topic, please see Bailey, this issue. In addition, many patients with tracheostomies have other medical factors, such as chronic obstructive pulmonary disease, that could predispose them to difficulty swallowing.

Regardless of whether tracheostomy tubes adversely affect swallowing, the fact remains that many individuals with tracheostomy tubes do aspirate. A number of options, including cuff deflation, tracheostomy tube occlusion, and one-way speaking valve placement, have been introduced to reduce or eliminate the risk of aspiration in this patient population.

Cuff Deflation and Swallowing

Some researchers (Betts, 1965; Mehta, 1972; Tippett & Siebens, 1991) have suggested that the presence of inflated tracheostomy tube cuff adversely affects swallowing either by tethering the larynx and reducing hyolaryngeal excursion and airway closure during the swallow or by impinging on the tracheoesophageal wall with air pressure and impeding the passage of food or liquid through the esophagus. Tippett and Siebens examined the effects of cuff deflation on swallowing in five individuals with tracheostomy tubes who were ventilator-dependent. They found that 3 of 5 participants were able to safely swallow when their cuffs were deflated and their ventilator settings were adjusted to facilitate swallowing. Because of the additional adjustments in ventilator settings, it remains unclear if cuff deflation alone had any significant effect on swallow status.

Suiter, McCullough, and Powell (2003) examined the effects of cuff deflation on swallow function in 14 individuals who were not on mechanical ventilation. Participants completed a videofluoroscopic swallow study (VFSS) with and without the tracheostomy cuff inflated. All participants aspirated thin liquids during the cuff-inflated condition. Swallows were analyzed for seven swallow duration measures, extent of hyolaryngeal excursion, oropharyngeal residue, and penetration-aspiration, using an 8-point scale (Rosenbek, Robbins, Roecker, Coyle, & Wood, 1996). Pharyngeal transit duration ($p = .036$) and duration of hyoid maximum anterior excursion ($p = .049$) were significantly longer when the cuff was deflated, and duration of cricopharyngeal opening was significantly shorter when the cuff was deflated ($p = .005$). Mean maximum hyoid anterior movement was significantly greater during the cuff deflated condition ($p = .014$). However, these changes did not appear to affect overall swallow safety, as oropharyngeal residue and penetration-aspiration were not significantly affected by cuff deflation.

Ding and Logemann (2005) completed a retrospective study with 623 participants who completed VFSS under one condition only: either with or without the tracheostomy cuff inflated. Participants were grouped according to four primary medical diagnoses: (a) neuromuscular disorders, (b) head and neck cancer, (c) respiratory disease, and (d) general medical diagnoses. Swallows were analyzed for the presence or absence of the following physiological events: delayed initiation of the oral phase, decreased lingual strength, slowed oral transit, decreased mastication, delayed initiation of the pharyngeal swallow, decreased base of tongue retraction, decreased laryngeal elevation, decreased laryngeal closure, aspiration before, during, or after the swallow, and silent aspiration. Results indicated a higher incidence of aspiration in participants who swallowed with their cuffs inflated, with the incidence of silent aspiration being significantly greater in those who completed VFSS with inflated cuffs inflated.
cuffs ($p > .001$). In addition, the incidence of reduced laryngeal elevation was significantly greater for those participants who completed VFSS with their tracheotomy cuffs inflated ($p > .001$). Because this was a retrospective study and participants completed the VFSS under only one condition, it is difficult to determine if noted differences in swallow physiology between the two participant groups were actually due to the presence or absence of an inflated tracheostomy cuff.

**Tube Occlusion and Swallowing**

Muz, Mathog, Nelson, and Jones (1989) completed scintigraphy in 7 participants with head and neck cancer and tracheostomy when the tracheostomy tube was open and when the tube was occluded by an obturator. One participant did not aspirate under either condition; 2 aspirated under the tracheostomy tube open condition only; and 4 participants aspirated under both conditions, but aspirated significantly less when the tracheostomy tube was occluded. Overall, the incidence and severity of aspiration during the tracheostomy tube open condition was significantly greater than during the tracheostomy occluded condition.

Muz, Hamlet, Mathog, and Farris (1994) used scintigraphy to examine swallow function in 18 patients with head and neck cancer and tracheostomy. Swallowing was examined under two conditions: 1) occluded tracheostomy tube, and 2) open tracheostomy tube. Results indicated a significant reduction in the percentage of aspirated material during the tracheostomy occluded condition when compared to the open tracheostomy condition.

Logemann, Pauloski, and Coleangelo (1998) examined the effects of digital occlusion of the tracheostomy tube in eight patients with head and neck cancer. Four of 7 participants aspirated thin liquids when their tracheostomy tube was unoccluded. Aspiration was eliminated for two of these participants when their tracheostomy tube was digitally occluded. One participant aspirated thin liquid and paste consistencies with the tracheostomy tube open but did not aspirate either consistency when the tracheostomy tube was occluded. Two participants had no change in aspiration status between the two conditions or an increase in aspiration when the tracheostomy tube was occluded. The authors further examined physiological effects of tracheostomy tube occlusion and found the following changes when the tracheostomy tube was occluded: reduced duration of tongue base to posterior pharyngeal wall contact, increased laryngeal elevation, increased laryngeal and hyoid elevation at the time of cricopharyngeal relaxation, and delayed anterior movement of the posterior pharyngeal wall in relation to onset of cricopharyngeal opening.

Leder, Ross, Burrell, and Sasaki (1998) found very different results. They completed VFSS with 16 patients with head and neck cancer and tracheostomy when their tracheostomy tubes were occluded and then when the tracheostomy tube was not occluded. Ten participants aspirated thin liquids and pureed material under both conditions. Two participants aspirated thin liquids (but not pureed material) under both conditions. Four participants did not aspirate under either condition. Thus, for 100% of participants, tracheostomy tube occlusion status had no effect on aspiration.

**Speaking Valves and Swallowing**

Patients with tracheostomy tubes are sometimes able to tolerate one-way speaking valve placement. Speaking valve placement offers several advantages over digital (finger) occlusion, including increased sanitation (i.e., there is a risk of contamination when a tracheostomy tube is digitally occluded); less conscious effort for the patient (i.e., the patient does not have to coordinate digital occlusion with respiration); and reduced respiratory load when compared to complete tracheostomy occlusion with a tracheostomy cap. A one-way, bias-closed speaking valve remains closed during exhalation allowing air to flow upward through the upper respiratory system. The valve opens during inhalation, allowing the patient to inhale through the tracheostomy tube.

The main purpose of speaking valve placement is to allow the individual to phonate. However, a number of additional purported benefits of valve placement have been reported, including decreased oral and nasal secretions, increased food intake, and increased energy levels (Lichtmann
et al., 1995; Manzano et al., 1993; Passy, Bay-
dur, Prentice, & Darnell-Neal, 1993). In addition,
speaking valve placement may facilitate weaning
from mechanical ventilation (Frey, 1991).

Several studies have indicated that placement
of a one-way speaking valve also helps eliminate
or reduce aspiration in patients with tracheos-
tomy. Placement of a one-way speaking valve
may resolve several of the potential factors related
to tracheostomy that may adversely affect swal-
lowing. First, speaking valve placement requires
that an individual’s tracheostomy cuff be deflated.
This would reduce the potential for tethering of
the larynx, which a number of researchers (Betts,
1965; Mehta, 1972; Tippett & Siebens, 1991) have
suggested occurs in the presence of an inflated
tracheostomy cuff. Second, speaking valve place-
ment allows air to flow through the upper airway,
including the vocal folds. This may restore laryn-
geal sensation and airway clearance. Finally, valve
placement reportedly restores subglottal air pres-
sure (Eibling & Gross, 1996; Gross, Mahlmann, &
Grayhack, 2003). The role of subglottal air pressure
in swallowing is not fully understood. How-
ever, Eibling & Gross (1996) have suggested that
the primary mechanism affecting swallow func-
tion in patients with open tracheostomy tubes is a
reduction in subglottal pressure. The following is a
review of the literature containing examinations of
the effects of speaking valve placement on swallow
function.

Dettelbach, Gross, Mahlmann, and Eibling
(1995) examined 11 individuals with tracheostomy.
Patients completed a VFSS with and without a one-
way valve (Passy-Muir, Inc., Irvine, CA). Results
indicated that all patients exhibited a significant re-
duction in the amount of aspiration when the valve
was in place. Aspiration was completely eliminated
for several participants.

Stachler, Hamlet, Choi, and Fleming (1996)
completed scintigraphic quantification of aspiration
in 11 patients who were either pre- or post-treat-
ment for head and neck cancer. Swallow studies
were completed with and without a one-way speak-
ing valve in place. Scintigraphy was completed
in conjunction with a VFSS. Although one-way
speaking valve placement did not eliminate aspira-
tion for any of the patients, it did significantly re-
duce the amount of aspiration. They found a mean
amount of aspirate of 2.60% with the tracheostomy
tube open and a mean of 1.17% for the speaking
valve condition.

Elpern, Okonek, Bacon, Gerstung, and
Skrzynski (2000) completed VFSS with and with-
out a speaking valve in place in 15 patients with
tracheostomy tubes. Participants were given three
boluses of thin liquid under each condition (valve
off and valve on). During the valve off condition,
7 participants aspirated thin liquids during at least
one presentation. Aspiration was eliminated in 5
of these participants when the speaking valve was
placed.

Gross, Mahlmann, and Grayhack (2003)
completed VFSS with 4 patients with tracheostomy
tubes under two conditions: open tracheostomy
tube or speaking valve (Passy-Muir, Inc., Irvine,
CA). Conditions were alternated in an ABAB or
BABA design, with “A” designated as open tra-
cheostomy tube and “B” designated as speaking
valve in place. Results indicated that bolus transit
times and pharyngeal activity duration times were
reduced for all 4 participants when the speaking
valve was placed. Scores on an 8-point penetra-
tion-aspiration scale (Rosenbek et al., 1996) were
reduced (improved) for 3 of 4 participants when
the valve was placed.

Suiter and colleagues (2003) examined the
effects of one-way speaking valve (Passy-Muir,
Inc., Irvine, CA) placement on swallow physi-
ology. Eighteen patients with tracheostomy were
examined using VFSS. Fourteen patients had
cuffed tracheostomy tubes and completed VFSS
under three conditions: cuff inflated, cuff deflated,
and speaking valve in place. Four participants had
cuffless tracheostomy tubes and completed VFSS
under two conditions: cuffless and speaking valve
in place. Each participant was given thin liquid and
pureed boluses to swallow. Swallows were ana-
lyzed for the presence of penetration or aspiration,
the severity of penetration-aspiration based on an
8-point scale (Rosenbek et al., 1996), seven swal-
low duration measures, hyolaryngeal excursion,
and amount of oropharyngeal residue. Results for
the cuff inflated/speaking valve comparison indi-
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cated that valve placement significantly reduced (improved) scores on the penetration-aspiration scale \((p = .001)\). Results for the cuff deflated/cuff-fless-speaking valve comparison indicated that valve placement significantly reduced scores on the penetration aspiration scale for the liquid bolus \((p = .001)\). No significant changes in swallow duration measures or hyolaryngeal excursion were noted when the valve was in place. One-way valve placement actually increased the amount of residue on the tongue base, on the posterior pharyngeal wall, and at the cricopharyngeus. Thus, the reason for reduction in aspiration remains unclear.

Despite a large body of evidence suggesting favorable effects of speaking valve placement on swallowing, there are confounding reports. Leder (1999) completed fiberoptic endoscopic evaluation of swallowing (FEES) with 20 patients who had tracheostomies under two conditions: tracheostomy tube open and with a one-way speaking valve in place. Results indicated that speaking valve placement had no effect on aspiration status. All subjects who aspirated without the valve in place also aspirated with the valve in place. Subjects who presented with no aspiration with the valve removed also did not aspirate with the valve in place.

The specific effects of one-way speaking valve placement on swallow physiology have not been determined. Some believe that the valve may help increase subglottal pressure, which is diminished when the tracheostomy tube is open. Gross, Dettelbach, Zajac, and Eibling (1994) measured subglottal air pressure with the tracheostomy tube open and with a speaking valve in place. Results indicated a ten-fold increase in subglottal pressure during swallowing with the speaking valve in place compared to subglottal pressure with the tracheostomy tube open. These authors have suggested that a reduction in subglottal pressure is the main mechanism responsible for the high incidence of aspiration in patients with tracheostomy (Eibling & Gross, 1996).

It is possible that the speaking valve placement restores laryngeal and pharyngeal sensation, because it allows for the flow of air through the upper airway. Improved sensation should lead to improved swallow safety. The effects of speaking valve placement on laryngeal and pharyngeal sensation need further study.

Overall, most reports in the literature indicate that the speaking valve placement improves swallow safety. Research is needed to further elucidate the specific effects of speaking valve placement on swallow function. It should also be noted that most, if not all, of the studies investigating the effects of speaking valve placement on swallow physiology have examined swallowing with the Passy-Muir Tracheostomy Speaking Valve (Passy-Muir, Inc., Irvine, CA). There are a number of other manufacturers of speaking valves (e.g., Portex, Montgomery), and the effect of these valves on swallowing bears study. Finally, most studies of speaking valve effects on swallowing have included very low numbers of participants. Further studies with larger numbers of participants are needed.

**Recommendations**

Caution should be used when deciding to feed a patient with a speaking valve in place, as valve placement may increase oral and pharyngeal residue (Suiter et al., 2003). Clinicians who complete instrumental swallow examinations with tracheostomized patients should include several presentations with a one-way speaking valve in place before making any decisions regarding the use of the valve as a means for reducing aspiration.

In some cases, patients may not be able to tolerate valve placement for a period of time sufficient to complete a meal or the patient may not wish to eat with the speaking valve in place. In such instances, it is advisable to have the patient complete the swallow evaluation under the same conditions in which he or she would eat normally. In other words, if the tracheostomy cuff is inflated at all times, the patient should complete the evaluation with the cuff inflated. Our research (Suiter et al., 2003) does not support the notion held by many physicians that an inflated cuff prevents aspiration. In our sample of 18 individuals we saw for an initial swallow study, 14 aspirated thin liquids with their tracheostomy cuffs inflated. It should be noted that, if food or liquid falls as far as the tracheostomy cuff, the material is in the airway and the patient has aspirated. It is possible that an inflated
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cuff may prevent material from spilling farther into the trachea or lungs. However, tracheostomy cuffs often do not form a complete seal, and material can seep around the cuff and enter the lower airway. In addition, our research does not support the idea of deflating the cuff as a means of preventing aspiration. In our sample, cuff deflation eliminated aspiration of thin liquids for only 2 of 14 participants.

Debra M. Suiter is an assistant professor at the University of Memphis in Memphis, TN where she teaches courses in dysphagia, motor speech disorders in children, and neurogenic speech-language disorders. Her research interests include dysphagia diagnosis and treatment, neurogenic speech disorders, and tracheostomy and ventilator dependence. Her national presentations and peer-reviewed publications have been in the areas of dysphagia diagnosis and treatment and issues related to tracheostomy. She may be reached at dsuiter@memphis.edu.

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An estimated 4,861 tracheotomies are performed yearly on pediatric patients in the United States (Lewis, Carron, Perkins, Sie, & Feudtner, 2003). Over half are performed on children between the ages of birth and 11 months (Carron, Derkay, Strope, Nosonchuk, & Darrow, 2000; Kenna, Reilly, & Stool, 1987; Lewis et al., 2003; Wetmore, Marsh, Thompson, & Tom, 1999). The majority of the current population of children with tracheostomies are 2 to 3 years of age, although there is a tendency for children cannulated for prolonged ventilation, the primary indicator for tracheostomy today, to be younger with a mean age of 1.4 years (Carron et al.; Hadfield, Lloyd-Faulconbridge, Almeyda, Albert, & Bailey, 2003; Pereira, MacGregor, McDuffie, & Mitchell, 2003; Wetmore et al.). Duration of cannulation tends to be greater than 24 months (Carron et al.; Wetmore et al.). However, children with craniofacial anomalies cannulated for upper airway obstruction and those cannulated secondary to trauma are more likely to be decannulated in less than 24 months, whereas children with neurological impairments and tracheostomies typically remain cannulated for an average of 46 months (Carron et al.).

"Trach Effect" on Swallowing

According to national demographics, the most common ages at which tracheostomies are placed in children include the years critical to the acquisition and development of language, speech, and oral feeding skills. A small corpus of anecdotal and descriptive studies is available that supports a “trach effect” on language, motor speech, and phonology in pediatric patients with long-term tracheostomies placed during the period of newborn through 13 months (Hill & Singer, 1990; Kamen & Watson, 1991; Kaslon, Grabo, & Ruben, 1978; Kaslon & Stein, 1985; Kertoy, Guest, Quart, & Lieh-Lai, 1999; Simon, Fowler, & Handler, 1983; Simon & McGowan, 1989; Singer, Kercsmar, Legris, Orlofski, Hill, & Doershuk, 1989; Tucker, Rusnov, & Cohen, 1982).

Few investigators have recognized that children with tracheostomies have problems with oral ingestion. Even fewer have investigated the effects of long-term cannulation on swallowing physiology and feeding development in infants and young children. The paucity of clinical research in this field of study is understandable given the difficulties inherent in studying human subjects within the pediatric-age range and controlling for confounding variables, such as the underlying medical diagnosis and, closely associated, indicator for tracheostomy. The lack of normative data for pharyngeal stage swallowing physiology in young, pediatric patients further exacerbates the problem. Prescott and Vanlierde (1989) reported 15 (5%) of 293 patients with tracheostomy, ages newborn to 12 years, had laryngeal incompetence when feeding was resumed after tracheostomy. These 15 patients had etiologies of laryngotracheobronchitis with and without herpetic ulceration of the laryngeal inlet, supraglottitis, caustic ingestion, laryngomalacia, and cleft larynx. Although laryngeal incompetence was not defined and swallowing deficits were not detailed, the underlying medical diagnoses implicated both structural and neurophysiological factors affecting swallowing physiology. Arvedson and Brodsky (1992) found that 14 (48%) of 29 patients with tracheostomy, ages one month to 17 years, who were referred for speech and language evaluations during an acute inpatient stay, had swallowing problems. The swallowing deficits of these 14 patients were not delineated; however, it is likely that many had underlying neurophysiological factors affecting swallowing physiology given the reported high incidence of central nervous system involvement in the subject group. Rosingh and Peek (1999) reported that 31 (91%) of 34 patients with tracheostomy, ages 37 weeks to 12 months, who were followed prospec-
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tively had swallowing disorders. Here again, actual swallowing deficits were not described, but the authors reported not being able to attribute all of their subjects’ swallowing disorders to underlying anatomic or neurological disorders.

In 2000, clinical investigators offered evidence of a “trach effect” on pediatric feeding and swallowing based on instrumental measures rather than on clinical measures alone. Willging (2000) utilized fiberoptic endoscopic examination of swallowing (FEES) to assess feeding abilities in 255 patients with a median age of 2.5 (range: one week to 51 years) prior to their airway reconstruction surgery. All had structural abnormalities of the upper aerodigestive tract, with 222 (87%) having one or more other underlying medical diagnoses. Of the 255 subjects, 135 (53%) had tracheostomies. Willging found a higher incidence of enteral feeding in the patient group with tracheostomies than in the patient group without tracheostomies. Unfortunately, between-group differences in swallowing physiology and in feeding development were not presented.

Abraham and Wolf (2000) utilized videofluoroscopic studies of swallowing (VFSS) to investigate the effects of long-term tracheostomy on swallowing physiology in a select group of four toddlers aged 1;2 to 2;9. The participants had functional cognitive and motor skills without anomalous upper airways. Swallowing deficits secondary to their primary medical diagnosis and indicator for tracheostomy were ruled out. A normal-developing patient aged 1;2 with no tracheostomy served as a toddler model for purposes of comparison. All 5 subjects were oral only feeders on bottle feeds of thin liquids, spoon feeds of purees, soft chews, and finger foods. Comparative analyses revealed differences in structural movements and timing of pharyngeal stage events that offered insight into a possible “trach effect” in young children with long-term tracheostomies. The toddlers with tracheostomies had no confirmed superior excursion of the epiglottis and arytenoid associated with the swallowing response. They displayed slowing of supraglottic airway closure for timely bolus swallows of liquid and puree. Specifically, the toddlers with tracheostomy showed a prolonged time line to close the laryngeal vestibule once the arytenoids began their anterior excursion. There were also differences in timing of supraglottic airway closure and pharyngoesophageal (PE) segment opening. Closure of the laryngeal vestibule occurred after PE segment opening in the toddlers with tracheostomies, whereas closure occurred before or within the same time frame as PE segment opening in the toddler with no tracheostomy. Subsequent additions to the original cohort who met criteria for inclusion (N = 10) also showed increased time line to closure of the laryngeal vestibule when compared with children without tracheostomies (Abraham, unpublished raw data). Of interest was an individual aged 2;2 who had confirmed superior excursion of the epiglottis and the arytenoid associated with the swallow response, yet still displayed slowing of laryngeal vestibule closure similar to the original cohort. These findings suggest that movement of the supraglottic structures during the act of bolus swallowing is slower and tends to be more restrictive in young children with long-term tracheostomies.

Translation to Clinical Practice

Inability to palpate laryngeal movement or severely restricted movement of the larynx associated with bolus ingestion on clinical examination of an infant or young child with tracheostomy is a sign of a swallowing disorder that warrants instrumental examination. Specific deficits to rule out during VFSS include slowing of laryngeal vestibule closure, reduced laryngeal excursion, and airway contamination resultant of these deficits.

“Trach Effect” on the Airways

A “trach effect” on the airways is readily observable in the secretions and secretion management of young pediatric patients with tracheostomy. All infants and young children with open tracheostomy tubes have secretion issues. A notable increase in secretions with concomitant decrease in the ability to manage secretions is typical of tracheostomized infants and young children. Management of secretions in the upper airway as well as in the lower airways is critical to maintaining upper airway patency and pulmonary health. The upper airway mechanisms that humidify, warm,
and filter inspired air are bypassed when a tracheostomy is in place. In contrast to nasal breathing, the air that flows at the tracheostomy level is dry, cold, and unfiltered and leads to increased viscosity of mucous and other complications, such as inflammation of the upper airways. Suctioning is needed because of decreased intrathoracic pressures and loss of effort closure by the larynx in the open tube mode (Lumb, 2000; A. Narvaez, personal communication, September 1, 2005). Frequent suctioning irritates the lower airways and increases secretion production (Mason & Meehan, 1993). A “wet trach” with mild, intermittent accumulation of clear, nonpurulent tracheal secretions and no laryngeal secretion accumulation is an acceptable secretion baseline for an infant or a young child with a tracheostomy. Chronic laryngeal and/or tracheal secretions with recurrent need for suctioning in the home 10 or more times a day, or copious secretions throughout the upper airway, is an abnormal secretion baseline. Situations in which infants and young children have “dry trachs”—that is, no audible tracheal or laryngeal secretions over time—can lead to mucous plugs that can occlude the tube and restrict respiration. There are some infants and young children with tracheostomies—and with and without craniofacial anomalies and neurologic sequelas—who present with a significant volume of oral secretions and concomitant reduction in oral secretion management. Oral pooling in young patients with tracheostomy who have open tubes can be totally, or in part, caused by cannulation. We studied 50 patients aged 2 months to 4;9 (M = 22 months; Mdn = 19 months) with long-term tracheostomies and found that all 50 presented with secretion management issues on their initial visit to our program. Of this group, 98% (n = 49) had reduced secretion management at the level of the trachea, 56% (n = 8) had problems with oral secretion management, and 40% (n = 20) showed reduced secretion management at the level of the larynx (Abraham, unpublished raw data).

**Translation to Clinical Practice**

Any change in laryngeal and/or tracheal secretions associated with oral feeds is a remarkable finding on clinical examination of an infant or child with tracheostomy. Although it is important to evaluate all textures and utensils in use, directed observation of a full feed from a bottle should take precedence. It is best accomplished using the child’s formula, rather than juice or water. Any secretion build-up or accumulation at the level of the larynx and/or trachea during or after oral ingestion is an indication of a swallowing disorder. Instrumental evaluation is required to determine the specific swallowing deficits. Management decisions range from determining the feasibility of continuing oral only feeds to modifications to current oral feeds. Options depend on the patient’s swallowing deficits, medical course, and current medical status, in particular, his/her airway, nutrition, and respiration. Aside from decannulation, the most effective treatment for the adverse changes to secretions and their management secondary to tracheostomy in infants and young children is placement of a one-way speaking valve, by Passy-Muir, Inc. (Abraham, 2003; Waldowski, 2002). Of the 49 infants and children with tracheostomy who had reduced secretion management described above, 49% (n = 24) were able to tolerate one-way speaking valve placement. Of this group, 39% (n = 19) tolerated full-time valve wear time, and 10% (n = 5) tolerated part-time valve wear time. Part-time status was secondary to airway and respiratory factors. All 24 patients showed significant improvement in secretion management at the levels of the oral cavity, larynx, and/or trachea. Patients who tolerated wearing a speaking valve throughout the entire day with removal only for sleep, that is, the full time valve wear time patient group, demonstrated laryngotracheal secretion management within normal limits within an average time frame of 2 weeks (Abraham, unpublished raw data).

**“Trach Effect” on Airway Protective Responses**

A “trach effect” on airway protective responses in infants and young children with tracheostomies can be readily observed in the reflexive cough. Because of the trend toward pediatric tracheostomy for long-term airway management and away from tracheostomy for short-term management (Wetmore et al., 1999), the potential for a “trach effect” on airway protective responses is...
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heightened. The reflexive cough to clear laryngeal and/or tracheal secretions can be very delayed or absent in pediatric patients with tracheostomy. Some children with tracheostomies cough only in association with cannula suctioning or require deep suctioning to elicit a cough. Others simply have no cough with a cannula in situ. In the 50 patients aged 2 months to 4;9 with long-term tracheostomies whom we followed prospectively, 90% displayed problems with airway protection responses on initial visit. Specifically, in the presence of audible, wet tracheal secretions, 44% (n = 22) did not elicit a reflexive cough to clear, 36% (n = 18) had a delayed cough to clear, and 18% (n = 9) coughed only when suctioned (Abraham, unpublished raw data).

Translation to Clinical Practice

Any aberrant reflexive cough response on clinical examination of tracheostomized infants and young children, whether it be a delayed or an absent cough in the presence of audible laryngotracheal secretions or a cough elicited only by suctioning, warrants therapeutic intervention. Instrumental evaluation is needed to rule out airway contamination. Airway Protection Techniques (APTs) proposed by Kagel (1996) and modified for neurodevelopmental age should be initiated early in the treatment process, because they are effective in eliciting a cough response with a post-cough swallow to clear laryngotracheal secretions in young children with tracheostomies (Abraham, 1997). According to Kagel, the “Airway Protection Technique should always be preceded by a swallow and followed by a swallow” (p. 17). A primary modification to the Kagel APTs for training young children with tracheostomy is exclusion of the swallow preceding the APT. APT facilitators for children with tracheostomies include offering single swallows of water or pairing “occlude–release” with the word “cough” in the presence of audible laryngeal and/or tracheal secretions. Treatment effectiveness and carryover of modified APTs are optimized when the child tolerates consistent placement of a one-way speaking valve and effort closure of the larynx is restored. Modified APTs using the throat clear require audibility of laryngeal frication and more advanced neurodevelopment than modified APTs using the cough response (Abraham, 2005; G. Fries, personal communication, September 11, 2005).

VFSS Special Considerations

Issues of patient compliance are commonplace during VFSS with any young pediatric patients. The presence of a feeding disorder of refusal and/or selectivity can further compromise compliance during VFSS. Issues encountered when studying swallowing in infants and young children with tracheostomy under fluoroscopy include those typical of any young pediatric patient as well as variables unique to this population.

In depth videofluoroscopic analysis of swallowing physiology in infants and young children with tracheostomies requires visualization of structures in the highest magnification mode of the fluororadiography system. Anatomic markers that should be within the fluoroscopic field include the nasal and nasopharyngeal passages superiorly, the lips anteriorly, the cervical spine posteriorly, and the tracheostomy tube inferiorly. In general, the edges of the pediatric and neonatal cannula are more easily visualized under fluoroscopy than are the edges of the hub of the tracheostomy tube. Having even a portion of the superior aspect of the cannula within the fluoroscopic field provides an important marker for analysis. Unfortunately, there are young children in whom size, positioning, and/or angling of upper airway structures coupled with positioning of tracheostomy tube in the trachea preclude visualization of the cannula and all key anatomic markers within the fluoroscopic field in the highest magnification mode. When magnification is decreased to facilitate inclusion of key anatomic markers, analysis of structural movements, their timing, as well as visualization of trace aspirants can be compromised. Furthermore, the neck flange of the tracheostomy tube can obscure visualization of laryngeal structures.

Another variable unique to infants and young children with tracheostomies is the need to prevent aspiration into the tracheostomy tube from external sources during the VFSS procedure. There can be spillage of barium from the oral cavity secondary to a feeding disorder and/or a swallowing deficit
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as well as accidental spillage from the dispensing utensil itself. Of primary concern is the spillage of contrast material from the mouth, chin, or cheeks inferior to the hub of the tracheostomy tube, because it can easily and rapidly enter the cannula and be aspirated directly into the trachea. Precautionary measures must be in place should external spillage occur during the VFSS. An Argyle De Lee Suction Catheter with Mucus Trap (Tyco Healthcare Group LP, Mansfield, MA) may be kept in the pocket of the clinician’s lead apron as a safety net that allows for immediate suctioning of spillage of contrast material. This suction catheter requires no set up and is faster than a suction machine in times of urgent need. Another safety net to prevent aspiration from external spillage into the tracheostomy tube is the use of a heat moisture exchanger (HME) placed on the hub of the pediatric patient’s tracheostomy tube. The Hygroscopic Condenser Humidifier™ Neonatal 5704 (HCH; Vital Signs, Inc., Totowa, NJ) can be tolerated by most young children with tracheostomy, including those who cannot tolerate other types of HMEs. An HME should not be substituted for a one-way valve. If open and closed tracheostomy tube trials under fluoroscopy are being accomplished in an infant or a young child, the HCH may be a necessary precaution in the open tracheostomy mode.

Another variable unique to infants and young children with tracheostomies that can adversely affect the fluoroscopic study is external spillage of contrast material onto the tracheostomy ties. Any spillage from the mouth, face, or utensil can quickly drain inferiorly onto the patient’s tracheostomy ties. Contrast material on the tracheostomy ties (some of which are a half-inch or more in width) can obscure critical views of swallowing physiology, because of the positioning of the ties around the neck. Changing soiled tracheostomy ties on infants and young children cannot be easily or readily accomplished. Furthermore, young patients with tracheostomies may become very upset when their tracheostomy ties are changed. In sum, external spillage of contrast material during fluoroscopic swallowing studies with infants and young children with tracheostomies can result in serious consequences to the patient, obscure fluoroscopic images for in depth analysis, and preclude continuation of the procedure. Precautionary measures are warranted for this specialty population.

Concluding Remarks

Although few in number, studies to date indicate that many infants and young children with tracheostomies have swallowing disorders. The question is then posed as to the etiology of their swallowing disorders. Are they due to the underlying medical diagnosis, the indicator for tracheostomy, or the tracheostomy itself? Tracheostomy in infants and young children causes significant, adverse changes to secretions, secretion management, and airway protective responses. Given the close association of swallowing with these variables, a “trach effect” on swallowing is possible. The available data base, albeit scant, does support a “trach effect” on swallowing physiology in young children in their developmental years. The need for additional studies with replication is apparent. There is also a need for normative swallowing data for this age group. The need for quality clinical management of infants and young children with tracheostomy is equally important. This population as a whole tends to be a medically fragile, “sick” population. The physiological consequences of tracheostomy are implicated in the recurrent illnesses of these children and negatively affect their health-related quality of life. The interactive relationship of the physiologically-based variables of swallowing, secretions, and airway protective responses, in the context of pediatric tracheostomy necessitates their inclusion in the management plan.

Suzanne Abraham is an associate professor in the Department of Otolaryngology at the Albert Einstein College of Medicine in New York City. She is a member of the Otolaryngology Faculty Practice and on staff of the Montefiore Medical Center and the Children’s Hospital at Montefiore in the Bronx, NY.
References


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Food for Thought

Does What the Patient Thinks Really Matter?

Rosemary Martino
University of Toronto
Toronto, Ontario

Most of us received our clinical training according to the biomedical model. That is, we have been taught to think of the physical body as separate and distinct from the psyche. Hence, we believe that targeting the patient’s specific physical dysfunction is enough to successfully treat a physical impairment. Let’s take the example of a patient with acute stroke who is aspirating during the swallow. We would all agree that a likely successful compensatory strategy would be to first trial a chin tuck posture along with, depending on the cognitive capacity of the patient, a supraglottic swallow. These strategies may even be successful in diverting the bolus away from the airway during our videofluoroscopic testing.

But then what? How do we know that the patient is going to follow through and consistently comply with these recommended strategies? How do we know whether the patient buys into the need for these strategies? How do we know whether the patient is so overwhelmed with his or her new swallowing problem that he or she might (at least temporarily) be unable to comprehend what has happened to the swallow let alone now learn and incorporate all the new steps required to keep him or her swallow safe? How about the pleasure of eating and drinking? Do we even realize how much pleasure is taken away from the patient when the swallow is disrupted in this way? After all, for this patient, the simple task of taking a sip of water has now been completely redefined.

As human beings, and maybe even past patients, we can appreciate that the biomedical model does not completely define health or, for that matter, poor health. We know there is value in addressing the psychosocial issues related to healing and recovery. But how do we do this with our patients, and exactly what psychosocial issues do we address? Is there enough evidence to help direct us in this area? No! Right now there is a limited amount of evidence about what our patients with dysphagia know, feel, care about, or even want in relation to their swallowing impairment.

To date, there are only five published studies addressing how patients with dysphagia perceive their swallowing problems. The following is a review of these studies and their related findings:

Tibbling and Gustafsson (1991) studied the extent to which swallowing difficulty in elderly individuals was accompanied by other symptoms and/or a reduction in quality of life. The authors sent a questionnaire to 2,480 subjects and received 796 responses. Questions pertained to physical symptoms related to dysphagia, including heart burn, chest pain, regurgitation, and psychosocial impact of dysphagia, including anxiety and isolation at mealtimes. Subjects were identified as having symptoms of dysphagia if they responded “yes” to questions of whether subjects experienced a sensation of food sticking in the chest or throat during meals. Of the 796 respondents, 62 (32 women, 30 men) indicated that they were experiencing symptoms of dysphagia. Based on their reported symptoms, subjects were designated as having hypopharyngeal dysphagia (N = 10), esophageal dysphagia (N = 26), or both types of dysphagia (N = 26). Results of the questionnaire indicated that 50% of subjects experienced anxiety during mealtimes as a consequence of having dysphagia. All of the subjects with hypopharyngeal dysphagia indicated a desire to eat alone. None of the subjects with hypopharyngeal dysphagia reported experiencing anxiety during meals as a result of their dysphagia. Eight subjects (13%), all of whom experienced symptoms consistent with esophageal phase dysphagia, indicated that they preferred to eat alone. None of the subjects with hypopharyngeal dysphagia indicated a desire to eat alone.

Gustafsson and Theorell (1995) examined how students with dysphagia manage everyday eating situations from a physical, psychological, and social standpoint. Students with dysphagia attending a secondary school were identified from pa-
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Patient-reported symptoms (N = 87). They completed a series of two questionnaires and one phone interview. Questions pertained to swallowing difficulties, social support, eating desires and habits, and the students’ perceptions about their swallowing abilities. Students who stated that their dysphagia affected their lifestyle (N = 9) were labeled “maladapted” and compared to the remaining “adapted” students (N = 78). Results indicated that students in the “maladapted” group were more likely to experience anxiety during meals, be more negatively affected by eating environment (i.e., eating alone, type of food, time for meal), and less likely to cope with their swallowing difficulty.

Jacobsson, Axelsson, Osterlind, and Norberg (2000) compared eating experiences of 30 patients with stroke and 15 healthy older individuals. Participants completed a “test-meal” during which they were interviewed and asked about their experience of eating that meal. In addition, participants completed oral function testing. Of the inpatients, 17 patients had clinical symptoms of dysphagia based upon results of a feeding observation. One of the healthy older individuals also demonstrated difficulty swallowing during the test meal. Common themes in the patients with dysphagia subsequent to stroke included fear of choking, shame about appearance, humiliating dependency in eating, and threats to hope.

Ekberg, Hamdy, Woisard, Wuttge-Hannig, and Ortega (2002) examined the extent to which swallowing difficulty in patients was accompanied by other symptoms and/or a reduction in quality of life. The authors completed a large-scale multinational repeat administration of the survey by Tibbing and Gustafsson (1991) to patients with dysphagia resulting from a variety of etiologies (N = 360) and from across four countries: United Kingdom, Spain, Germany, and France. In addition to dysphagia, the majority of subjects (67%) had serious medical conditions, including Parkinson’s disease, Alzheimer’s disease, and multiple sclerosis. Forty percent of the subjects had a confirmed diagnosis of dysphagia. Of those, 32% had received treatment for their swallowing problems. Fifty-five percent of patients reported that their swallowing difficulty affected their eating habits, either by requiring a change in diet consistency or increased viscosity of liquids they consumed. Only 45% of participants indicated that eating was pleasurable. Thirty-six percent of participants reported that they avoided eating with others because of their dysphagia. Thirty-seven percent reported feeling embarrassed at mealtimes because of their swallowing problems, and 41% reported anxiety or panic during mealtimes.

McHorney and colleagues (2000) developed a patient-based scale measuring quality of life in adult outpatients with oropharyngeal dysphagia. Initially, 13 focus groups with a total of 52 patients with dysphagia were held in two sites in the United States. These focus groups were held in an effort to gain an appreciation of the patient’s perspective regarding dysphagia and its impact on daily life. From these focus groups, a total of 19 common themes were derived, including fear, fatigue, self image, psychological distress, social functioning, role functioning, and eating desire. This research has been advanced, and two new validated scales have been developed; one measures quality of life (SWAL-QOL) and the other patient satisfaction (SWAL-CARE).

From only a handful of studies, of which only one has sound methodology, there is at least emerging evidence that patients with swallowing difficulties experience psychological issues. There still remains a need to address the level of psychological issues within this patient group. We need to know how aspects of the dysphagia and other personal or environmental characteristics can affect its presence and severity. The study by McHorney and colleagues gives us a tool by which we as clinicians can measure quality-of-life issues in the adult outpatient. This is a large advancement in our clinical armament, allowing us, for the first time, to track changes in the quality of life of our patients with dysphagia. In so doing, we will be able to determine which treatments are more effective than others along this aspect of care.

In our own research lab, we are conducting studies comparing the perceptions of patients to that of their clinicians and caregivers. Our preliminary findings have been reported elsewhere (Martino & Diamant, 2005; Martino, Soucie, & Kaplin,
2003). We know from other literature with inpatients with arthritis that their perception of pain differs greatly from that of their clinicians (Cremeans-Smith et al., 2003; Fair, 2003). Disparities are even found in healthier patients with arthritis attending primary outpatient clinics (Sherbourne, Sturm, & Wells, 1999). The outcomes that matter most to these patients related to mental and social health, but their clinicians focused treatment decisions on physical health according to the biomedical model. Other research with different disorders has evaluated the benefit of interventions that address both the psychosocial and biomedical issues. These combined treatment approaches have hastened and even ameliorated recovery in patients with cancer (Cunningham, Phillips, Lockwood, Hedley, & Edmonds, 2000), cardiac (Carney, Freedland, Veith, & Jaffe, 1999), and gastrointestinal (Maunder, 1998) diseases. The time has come for us to take note of these findings. As researchers, we need to focus more extensively on the psychological issues related to swallowing. As clinicians, we need place more value to psychosocial symptoms in the design and implementation of our interventions.

Rosemary Martino is an assistant professor in the Graduate Department of Speech-Language Pathology at the University of Toronto. Her research and teaching focuses on swallowing impairment and its impact on patients.

References