Assessment of infants and children with dysphagia (swallowing problems) and feeding disorders involves significantly more considerations than a clinical observation of a feeding. In addition to the status of feeding in the child, considerations include health status, broad environment, parent-child interactions, and parental concerns. Interdisciplinary team approaches allow for coordinated global assessment and management decisions. Underlying etiologies or diagnoses must be delineated to every extent possible because treatment will vary according to history and current status in light of all factors that are often interrelated in complex ways. A holistic approach to evaluation is stressed with a primary goal for every child to receive adequate nutrition and hydration without health complications and with no stress to child or to caregiver. Instrumental swallow examinations that aid in defining physiological swallowing status are needed for some children. Successful oral feeding must be measured in quality of meal time experiences with best possible oral sensorimotor skills and safe swallowing while not jeopardizing a child's functional health status or the parent-child relationship.

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Key Words: infant; child; swallowing; feeding; assessment; evaluation

INTRODUCTION

Comprehensive assessment of infants and children with dysphagia and feeding disorders involves considerations of the broad environment, parent-child interactions, parental concerns, and health status of the child. All of those factors must be taken into account by professionals in order to make optimal management decisions for every child to assure that nutrition and hydration needs are met for best possible oral sensorimotor skills and safety of swallowing in isolation.

Professionals involved in assessment and management of infants and children with swallowing and feeding problems must have adequate knowledge and skills about associated health conditions and specific feeding/swallowing issues. Improper diagnoses and management decisions increase risk for poor nutrition and health outcomes. In contrast, thorough problem solving and interdisciplinary management can enhance the lives of children and their caregivers. Children and families are better served by an interdisciplinary team than by a single discipline in isolation [Arvedson et al., 2002].

INTERDISCIPLINARY FEEDING/SWALLOWING TEAM APPROACH

An interdisciplinary approach allows for coordinated consultation with focus on the whole child (and caregivers) who may have multiple interrelated health and developmental issues. Individuals involved in the problem solving have opportunities to provide patient care and case coordination that is difficult to obtain when professionals function independently. Of course, not all disciplines are needed for all children, and as children change over time, primary team players may change as well. These kinds of teams demonstrate several important characteristics that include (1) a shared group philosophy related to diagnostic approaches and management protocols, (2) team leadership with organization for evaluation and sharing information, (3) collegial interaction among varied specialists, and (4) time commitment for the labor intensive nature of this kind of work [Brodsky and Arvedson, 2002,a].

Interdisciplinary teams may be in medical settings or in school-based settings [ASHA, 2007]. School-based team members work closely with medical team colleagues so that findings from all evaluations or assessments can be incorporated into appropriate coordinated recommendations. Physician input is of utmost importance in the development of management plans and for monitoring the health status of children. Treatment options vary by history, physical examination, findings during clinical feeding evaluations, and instrumental swallowing evaluations. To set the stage for evaluating infants and young children with feeding and swallowing disorders, a few operational definitions are in order.

Operational Definitions

• Feeding disorders: Problems in a broad range of eating activities that may or may not be accompanied by a
difficulty with swallowing food and liquid. Feeding disorders may be characterized by food refusal, disruptive mealtime behavior, rigid food preferences, less than optimal growth, and failure to master self-feeding skills expected for developmental levels.

- **Swallowing disorders (dysphagia):** Problems in one or more phases of the swallow that include (1) oral phase: (a) bolus formation (from time food or liquid enters the mouth until it begins to move over the tongue in the oral cavity), and (b) oral (transit of bolus posteriorly over the tongue ending with initiation (trigger) of the pharyngeal swallow); (2) initiation of the swallow (under voluntary neural control); (3) pharyngeal phase (involuntary neural control) from the initiation of the swallow to end when the bolus moves through the cricopharyngeal juncture into the esophagus; and (4) esophageal phase (begins with opening of the upper esophageal sphincter through the lower esophageal sphincter). Particular concern relates to timing and coordination deficits that may result in aspiration.

- **Aspiration:** Passage of any material (e.g., food, liquid, saliva) below the level of the true vocal folds into the trachea.

- **Silent aspiration:** No cough, choke, or other signs of problems when food or liquid enters the trachea.

**INCIDENCE AND PREVALENCE OF FEEDING/SWALLOWING DISORDERS**

Feeding-related concerns are among the most common issues in preschool children who are brought to primary health care professionals by parents. Given the range of diagnostic labels applied to these disorders by varied specialists, it is not surprising that incidence figures vary considerably [Casey, 1999; Chatoor, 2002]. Some children with feeding disorders have no swallowing related concerns. The broader context of family and society should be addressed as a preliminary step in the assessment prior to focusing on children's skills and safety for oral feeding.

Incidence of feeding disorders is estimated to be 25–45% of typically developing children and up to 80% of children with developmental disabilities [Linscheid et al., 2003]. The incidence of dysphagia (swallowing disorders) is unknown, although it seems clear that the incidence of swallowing dysfunction is increasing [Burklow et al., 1998; Hawdon et al., 2000; Marlow, 2001; Newman et al., 2001; Ancel et al., 2006]. Improved survival rates of children with history of prematurity (birth at <37 weeks gestation), low birth weight, and complex medical conditions provide at least a partial explanation for the increasing incidence of swallowing disorders [Martin et al., 2005; Hamilton et al., 2007]. Preterm births (<37 weeks gestation) accounted for 12.7% of 4.14 million births in the United States in 2004–2005, which represents an increase of 20% since 1990 [Hamilton et al., 2007]. The survival rate of preterm infants delivered at <1,000 g (extremely low birth weight) increased from 65 to 90% from 1987 to 2000. The survival rate of micropreemies (<600 g) increased from 30 to 55% in that same time period. Incidence of cerebral palsy (CP) is higher in infants born between 24 and 26 weeks (20%) than those delivered at 32 weeks gestation (4%) [Ancel et al., 2006].

Children with a wide range of disabilities who are seen by feeding and swallowing specialists frequently are classified as failure to thrive (slow weight gain). Children who are slow to gain weight are at particular risk for both feeding problems (60%) and developmental delays (55%) [Raynor and Rudolf, 1996; Wright and Birks, 2000]. Children with CP are at high risk for feeding and swallowing problems. Prevalence of feeding problems is less in children with hemiplegia and diplegia (25–30%) compared with children who have spastic quadriplegia or extrapyramidal CP (50–75%) [Stallings et al., 1993a,b; Dahl et al., 1996; Reilly et al., 1996]. Ongoing growth analysis and developmental assessments are important components of the process in identification of infants at high risk for feeding and swallowing disorders.

**FEEDING AND FEEDING DISORDERS IN THE CONTEXT OF FAMILY AND SOCIETY:**

CASE FOR A RELATIONAL DISORDER BETWEEN PARENT AND CHILD

A child with signs of a feeding disorder more prominent than a swallowing disorder will be served better with the family in the context of a multiaxial diagnosis rather than an initial focus on the child's status and needs [American Psychiatric Association (APA), 2000]. This kind of diagnosis includes the child (with medical, developmental, and behavioral characteristics), the parent, the parent–child relationship, and the social and nutritional context of feeding [Davies et al., 2006]. Davies et al. [2006] proposed diagnostic criteria for a “Feeding Disorder Between Parent and Child” that spans a range of interactions, attitudes, and expectations that are not meant to be mutually exclusive or hierarchical. These criteria include:
WHO NEEDS A FEEDING/SWALLOWING EVALUATION?

Physicians, nurses, and other professionals who do not carry out comprehensive clinical feeding and swallowing assessments may find the following questions helpful to determine whether a child has signs of a feeding or swallowing problem that should be followed up by a specialist(s). This list of questions provides some examples and is not intended to be inclusive. The answers to these questions do not define the problem, but they can help identify infants and children in need of a comprehensive evaluation and they may also provide useful information in the history part of an assessment [e.g., Arvedson and Rogers, 1993, 1997]:

- How long does it take to feed the child? If parents report more than about 25–30 min on a regular basis, there might be a serious problem. Prolonged feeding duration for infants and children of all ages is a primary marker of feeding problems and points to a need for further investigation.
- Is the child totally dependent on others for feeding? Does the child do some assisted feeding or some independent feeding? Children who are not feeding independently, but should be on the basis of age and overall developmental skills, typically present with significant neurodevelopmental [e.g., CP]. These children frequently show a high probability for silent aspiration with oral feeding [Rogers et al., 1994]. Although there are exceptions, children who maintain upright position with good head control and hand-to-mouth skills for self-feeding usually have better coordination for safe swallowing.
- Does the child refuse food? Food refusals can occur for a variety of reasons that include, but are not limited to, physiologic based problems [e.g., airway or gastrointestinal (GI) factors], oral sensorimotor deficits, or disordered parent–child interactions. Refusals occur in multiple ways. Some children clamp their mouths shut and turn the head away when a spoon approaches their mouth; others hit at the spoon or the feeder’s arm; still others may spit food out; and in some instances, children may vomit purposefully.
- Are mealtimes stressful? Meal times may be stressful for a variety of reasons. Regardless of the reasons, follow-up investigations are needed. Parents may say, “I dread every meal. We take turns feeding our child because it is so stressful.” Forced feeding can result when parents get stressed with children who are difficult to feed. Forced feeding then leads to additional complications that may include inadequate weight gain, increased food refusals, and in severe cases, global behavior maladaptations.
- Has the child slowed or stopped gaining weight in the previous 2–3 months? Particularly in the first 2 years of life, steady and appropriate weight gain is expected and critical for brain development along with overall growth. Lack of weight gain in a young child is like a weight loss in older children or adults.
- Are there any signs of respiratory distress? For example, a child may become increasingly "congested" as a meal progresses. There may be a gurgly voice quality. Rapid or "catch up" (panting) breathing may be seen in an infant taking a nipple feeding. Respiratory issues can be related to aspiration with oral feedings in some instances.
- Does the child vomit regularly? When? Under what circumstances does the vomiting occur? Can parents estimate the volume per event? Vomiting tends to be a negative experience for most children. However, some children with neurologic impairment and gastrointestinal reflux (GER) may not vomit at all [Wilson et al., 2006].
- Does the child get irritable or become lethargic during mealtimes? Irritability may signal GI discomfort, airway problems, or behavioral issues. Lethargy or sleepiness may result from fatigue, sedating medications (e.g., anticonvulsants, muscle relaxants), or recurrent seizures.

ASSESSMENT PROCESS:
INFANTS AND CHILDREN WITH FEEDING AND SWALLOWING DISORDERS

Assessment of infants and young children with signs and symptoms of feeding and/or swallowing disorders is likely to encompass multiple dimensions that include, but may not be limited to: (a) review of family, medical, developmental, and feeding history; (b) physical ex-
Table 1. Assessments of Infant Oral Sensorimotor Function for Feeding

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bottle/breast feeding: Neonatal Oral Motor Assessment Scale (NOMAS)</td>
<td>Checklists of behaviors in categories of normal, disorganized, and dysfunctional tongue and jaw movement</td>
</tr>
<tr>
<td>Systematic Assessment of the Infant at the Breast (SAIB) [Association of Women’s Health, Obstetric, and Neonatal Nurses, 1990]</td>
<td>Observations related to alignment, areolar grasp, areolar compression, and audible swallowing</td>
</tr>
<tr>
<td>Preterm Infant Breast-feeding Behavior Scale (PIBBS) [Nyyyst et al., 1996]</td>
<td>Diary by mother: rooting, amount of breast in mouth, latching, sucking, sucking bursts, swallowing, state, letdown, and time</td>
</tr>
<tr>
<td>Breastfeeding evaluation [Tobin, 1996]—for term infant</td>
<td>Purpose: identify when a mother would benefit from lactation support. List of expectations for feedings</td>
</tr>
<tr>
<td>Bottle feeding: Feeding flow sheet [Vandenberg, 1990]</td>
<td>Observations for state, respiratory rate, heart rate, nipple, form of nutrition, position, coordination, support quantity, and duration changes over time</td>
</tr>
<tr>
<td>Infant feeding evaluation [Swigert, 1998]</td>
<td>Not standardized evaluation: means of documenting a variety of observations, including infant responses to attempted interventions. Devised for birth to 4 months, components for preterm or ill infant not specified</td>
</tr>
</tbody>
</table>

Review of Family, Medical, Developmental, and Feeding History

The clinical evaluation of infants and children begins with a review of family, medical, developmental, and feeding history as the first step in addressing feeding and swallowing problems. History is typically obtained from medical charts, medical and educational professionals, parents, and other caregivers. Prenatal, birth, and neonatal history can yield possible clues to etiologies of feeding and swallowing problems [Arvedson et al., 2002, pp 324–330]. Knowledgeable professionals consider various categories for diagnostic conditions that may underlie feeding and swallowing issues. Disorders and abnormalities of swallowing and feeding are categorized in various ways [e.g., Rogers et al., 2002; Link and Rudolph, 2003]:

- disorders affecting hunger/appetite, food-seeking behaviors, and ingestion;
- anatomic and physiological abnormalities of the oropharynx, larynx, and trachea (congenital and/or acquired);
- anatomic and physiological abnormalities of esophagus;
- respiratory tract disorders that affect sucking–swallowing–breathing coordination;
- central nervous system and neuromuscular disorders;
- cardiovascular (congenital heart disease, congestive heart failure);
- inflammatory disorders and mucosal infections that may cause dysphagia;
- miscellaneous disorders that may affect feeding and swallowing, e.g., Prader-Willi syndrome, hypothyroidism, some craniofacial anomalies, xerostomia, allergies, and lipid and lipoprotein metabolism disorders.

Clinical Feeding and Swallowing Assessment

The oral sensorimotor and feeding assessment typically consists of a physical examination (prefeeding assessment), oral structure and function examination, and feeding observation. Assessments for breast-feeding and bottle feeding of neonates and young infants have not been standardized, but a few assessments provide systematic observations of infant feeding (e.g., Table 1). Multiple scales and check lists, although not standardized, enable clinicians to systematize observations of children [e.g., Arvedson et al., 2002, pp 324–329; Kenny et al., 1989; Jelm, 1990; Coster et al., 1998; Koontz-Lowman and Lane, 1999; Reilly et al., 2000]. Instrumental swallowing assessments may be recommended as the next step in a comprehensive evaluation of feeding and swallowing.

Physical Examination (Prefeeding Assessment)

Regardless of age and feeding expectations, the observer notes “at rest” posture and position, with the realization that underlying tone and strength are particularly important factors in consideration of oral feeding safety. Prefeeding observations are made to note deviations from normal expectations and include [Arvedson and Rogers, 1993]:

- child and parent interactions;
- posture, position, and movement patterns (head, neck and trunk focus);
- respiratory patterns (e.g., breathing rate, effort, nose/mouth);
- overall responsiveness, temperament, affect;
- alertness and ability to sustain attention to tasks;
- response to sensory stimulation to include tactile, visual, auditory, smell;
- self-regulation and self-calming abilities.

Oral Structure and Function Assessment

Thorough examination of oral structures and function must be made before introducing liquid to an infant: observations are made regarding symmetry or asymmetry of facial features, lip and jaw position, palate shape and height, tongue position in the oral cavity and movement patterns, oral reflexes and nonnutritive sucking (NNS) in young infants, and laryngeal function as noted by voice quality. For example, breathy voice makes one suspicious of possible unilateral vocal fold paralysis/paresis. Weak or uncoordinated NNS would indicate lack of readiness for nipple feeding sufficient to meet nutrition needs. Drooling after the age of 5 years suggests a need for a comprehensive work-up [Brodsky and Arvedson, 2002,c]. Detailed descriptions of facili-
tating oral feeding in preterm infants in the NICU can be found in other sources [e.g., McCain, 2003; Rogers and Arvedson, 2005; Delaney and Arvedson, 2008]. Intraoral inspection may be held until after the feeding observation with children who may be wary about someone getting “in their face.” It is helpful to have children in their typical state for meal times in order to get the most useful observation of eating and drinking.

Feeding Observation

Newborn infants: Cardiorespiratory status must be stable. A calm alert state is desirable for anticipation of feeding with minimal stress to the infant. NNS is assessed, even though adequate NNS is not sufficient to predict adequacy of oral feeding abilities. If an infant does not demonstrate rhythmic and strong NNS, it is not likely that she will be ready to suck, swallow, and coordinate breathing to take enough breast milk or formula to meet nutrition and hydration needs. An infant who is anticipated to be an oral feeder should be observed for at least 15–20 min. Efficient feeding is accomplished in 15–20 min or maximum 30 min for most typical infants. Length of feeding times among preterm infants fed according to their cues and tolerance range from 10 to 30 min with none fed longer than 30 min [McCain, 2003]. Some infants may take a few minutes to “warm up.” If the feeding observation is stopped after 5 min, an erroneous impression might be made. On the other hand, an infant may start out well, become disorganized, and show signs of fatigue as the feeding progresses. This pattern is not uncommon in infants with cardiac abnormalities or neurogenic dysphagia. Management decisions would not likely be made in the infant’s best interests if the infant is observed for only the first few minutes of an oral feeding.

Older infants and children: The feeding observation is made with a familiar feeder holding an infant as typically as would be done at home, or with a child in a high chair or other seating system. These observations are attempts to simulate as closely as possible the regular feeding environment and routine as carried out at home. Observations are made about the parent and child interactions around feeding. The child is observed for specific aspects of oral sensorimotor function that can be related to function of cranial nerves V, VII, IX, X, and XII with a few examples in Table 2. Inferences are made regarding time to produce swallows and whether a child appears to make multiple swallows to clear a single bolus. Textures may be varied, usually starting with a texture or consistency that is familiar to the child and then offering a food that may be more difficult, according to parents. Other attributes of food and liquid that can be varied include taste and temperature. It is of interest that children who have not experienced typical development of oral feeding in the first year of life often require additional time to accept textured food and to make developmentally appropriate gains. They often prefer sour and tart flavors over bland food. They also may prefer finger foods that they handle independently, rather than have someone else spoon feed them. Children have shown that they are more likely to have feeding difficulties when lumps are introduced at or after 10 months of age than when lumps are introduced earlier than 10 months [e.g., Northstone et al., 2001]. Age estimates relate to critical and sensory periods that appear pertinent to readiness to accept new textures [e.g., Illingworth and Lister, 1964]. Children are likely to be ready for chewable food even when they have not mastered all gradations of pureed textures [Gisel, 1991; Green et al., 1997]. Expectations for chewing skills are made in relation to normal development, which reemphasizes the need for all feeding and swallowing specialists to know normal development exceedingly well. A child’s failure to close lips around a spoon, reduced tongue action to form a bolus, and delay in trigger or initiation of a pharyngeal swallow all may be indications of cranial nerve deficits. Observations provide information related to possible oral sensory versus oral motor disorders. Many children have both types, but may show a preponderance of one over the other (Table 3).

A fundamental question that must be answered by the end of the clinical feeding assessment is: Can this child eat and drink safely strictly orally? If the answer is “yes,” modifications may include, but are not limited to:

- posture and position alterations;
- taste, texture, and temperature changes of food or liquid;
- broader based sensory and motor interventions;
- scheduling of meal and snack times to facilitate hunger;
- structure and routines at meal times to improve parent–child interactions as well as behavioral responses of the child.

If the answer is “no” or if there are signs of concern regarding safety of swallowing that may include risks for aspiration, follow-up instrumental evaluation is warranted. One can only make inferences regarding pharyngeal and upper esophageal phases of swallowing by clinic examination/observation regardless of the experience, knowledge, and astuteness of a specific clinician.

OTHER CONSIDERATIONS

In addition to the clinical evaluation of feeding and swallowing, the clinician should focus on somatic growth patterns, neurodevelopmental status, orofacial structures, cardiopulmonary and other GI function.

Somatic Growth

Thorough nutrition assessment is critical with various methods available. Advances in nutrition assessment can be found in several recent excellent reviews [e.g., Kirby and Noel, 2007]. No single

Table 2. Examples of Observations That May Relate to Cranial Nerve (CN) Function During Feeding Assessment of Transitional Feeders or Older Children

<table>
<thead>
<tr>
<th>CN</th>
<th>Stimulus</th>
<th>Typical Response</th>
<th>Deficit Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>Food on tongue</td>
<td>Mastication</td>
<td>Bolus not formed</td>
</tr>
<tr>
<td>VII</td>
<td>Sucking</td>
<td>Lip pursing to latch on nipple</td>
<td>Lip seal not attained</td>
</tr>
<tr>
<td>Food on lower lip</td>
<td>Lip closure</td>
<td>Limited or no lip movement</td>
<td></td>
</tr>
<tr>
<td>IX,X</td>
<td>Smile</td>
<td>Lip retraction</td>
<td>Lack of retraction or asymmetry</td>
</tr>
<tr>
<td>Food in posterior oral cavity</td>
<td>Swallow initiated</td>
<td>Delayed initiation of pharyngeal swallow</td>
<td></td>
</tr>
<tr>
<td>Tongue</td>
<td>Tongue lacking elevation and with protruding</td>
<td>thinning; excessive thrusting; atrophy</td>
<td></td>
</tr>
</tbody>
</table>

Source: Adapted from Arvedson et al. [2002].
Table 3. Attributes of Children with Primarily Oral Sensory vs. Primarily Oral Motor Disorders

<table>
<thead>
<tr>
<th>Primary Motor Disorder</th>
<th>Primary Sensory Disorder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inefficient sucking and swallowing at breast or bottle</td>
<td>Nipple confusion from breast- to bottle-feeding</td>
</tr>
<tr>
<td>Taste differentiation noted with liquids in bottle</td>
<td>Lack of taste differentiation of liquids in bottle despite intact sucking</td>
</tr>
<tr>
<td>Inefficiency or incoordination with all textures</td>
<td>Efficiency with liquids better than with solid foods</td>
</tr>
<tr>
<td>Food swallowed whole when given mixed textures</td>
<td>Sorts out food of different textures, e.g., fruit piece in yoghurt</td>
</tr>
<tr>
<td>Difficulty manipulating bolus of food on tongue; loss of food out mouth or pocketed in cheeks</td>
<td>Food held under tongue or in cheek to avoid swallowing</td>
</tr>
<tr>
<td>Vomiting—not texture specific</td>
<td>Vomiting—certain textures</td>
</tr>
<tr>
<td>Gagging noted after food moves through oral cavity</td>
<td>Gagging noted when food approaches or touches lip or tongue</td>
</tr>
<tr>
<td>Gagging with liquid or solid after swallow initiated or triggered</td>
<td>Gagging prominent with solids; normal swallow with liquids</td>
</tr>
<tr>
<td>Tolerance of others’ fingers in mouth</td>
<td>Tolerance of one’s own fingers in mouth, but not others</td>
</tr>
<tr>
<td>Acceptance of teething toys, but not able to bite them or maintain them in the mouth</td>
<td>No mouthing of toys</td>
</tr>
<tr>
<td>No problems with toothbrushing</td>
<td>Refusal of toothbrushing</td>
</tr>
</tbody>
</table>

Source: Palmer and Heyman [1993]. Adapted from Arvedson et al. [2002], p 296.

measure fulfills all requirements for assessing nutrition status in infants and young children. Multiple measures may be needed. All children deserve adequate nourishment so that they can grow and develop fully to meet their potential in all functional domains.

Neurodevelopmental Examination

Each child’s neurodevelopmental status must be determined as feeding and swallowing intervention plans need to be tailored to a child’s developmental levels of function, not to chronicologic age. Methods of evaluation and scales can be incorporated for cognitive and language levels, with healthcare providers being aware of strengths and weaknesses of various measures [Rossman et al., 1994; Macias et al., 1998; Voigt et al., 2003; Vincet et al., 2005]. Sensory and motor skills need to be evaluated with differentiation of primarily oral sensory deficits versus primarily oral motor deficits [Palmer and Heyman, 1993] (Table 3). Most children tend to demonstrate some aspects of both sensory and motor deficits, although it is not unusual for children to have a strong tendency to one or the other. Additional resources for these areas of assessment include the works of Blanche et al. [1995], Case-Smith and Humphrey [2000], and Morris and Klein [2000]. Risk factors in the development of behavioral food refusal and maintenance of maladaptive feeding behaviors after periods of illness include communicative disorders and mental retardation. A thorough neurological history and examination is essential in identifying and treating the vast range of nervous system disorders and neuromuscular diseases that are associated with feeding and swallowing disorders.

Upper Airway and Orofacial Examination

Alterations of orofacial structures are common with some congenital syndromes and craniofacial anomalies. Nasopharyngeal obstruction can occur with choanal atresia or stenosis, nasal polyps, or foreign bodies and often disrupt infant nipple feeding at the breast or bottle. Open mouth posture may be an indication of limitations in nasal breathing, hypotonia, or some combination of factors. With midline defects such as cleft palate, food and liquid may get into the nasopharynx. In some instances, liquid or food may come out the nose. Tonsil and adenoid hypertrophy may result in partial airway obstruction with mouth breathing and snoring. In some instances, solid food may get caught in palatine or lingual tonsils and can interfere with swallowing. Improvement has been noted following tonsillectomy in a small sample of children with neurological impairment [Conley et al., 1996]. Mandibular hypoplasia with retracted tongue posture can interfere with resting respiration that may become more problematic with oral feeding, as in Pierre Robin sequence.

Asymmetry of facial features may be a sign of a unilateral stroke or some other neurological insult. Knowledge of syndromes and anomalies is basic to consideration of impact on swallowing and feeding for both short- and long-term prognoses.

Cardiopulmonary Examination

Airway stability is a prerequisite for successful oral feeding. The cardiopulmonary examination may reveal signs of dysphagia and possible chronic aspiration. The complexity of patients at risk for aspiration makes it difficult to sort out the various factors that contribute to aspiration in children. This area is one where interdisciplinary evaluation is mandatory [Brodsky and Arvedson, 2002]. Numerous diagnostic conditions and comorbidities associated with dysphagia and respiratory consequences arise from the pulmonary and neurological systems, genetic conditions, and others that include congenital heart disease, immunodeficiencies, and trauma. Additional examples can be found in the work of Lefton-Greif and McGrath-Morrow [2007]. Infants may exhibit signs of apnea and bradycardia with swallowing dysfunction [e.g., Guilleminault et al., 1984; Loughlin and Lefton-Greif, 1994]. A child who requires assistance for feeding and is neurologically impaired is at high risk for silent aspiration with oral feeding [Arvedson et al., 1994; Rogers et al., 1994a,b]. Children with intractable seizures and treated with vagal nerve stimulation may be at increased risk for aspiration with no observable response [Lundgren et al., 1998]. Other signs include recurrent pneumonia, undernutrition (failure to thrive), and radiographic signs of chronic lung injury [Bauer et al., 1993]. Children with tracheostomy vary significantly in their degree of swallowing difficulties. The degree of difficulty is likely related more to the underlying reasons for the tracheostomy than to the presence of the tracheostomy tube itself [Arvedson and Brodsky, 1992] and duration of the tracheostomy tube in toddlers [Abraham and Wolf, 2000]. It is important to sort out chronic (at least 4 weeks in duration) respiratory manifestations of dysfunctional swallowing from episodic events that are temporally related to feedings [e.g., Matsuse et al., 1998; Thach, 2005].

The type and extent of respiratory presentations and effects can vary by multiple interacting factors that include age, presence of comorbidities, frequency of aspiration, and type of aspi-
The primary unanswered question prompts continued need for research: How much aspiration of what for how long can be tolerated by an individual before chronic lung disease is an issue? A variety of procedures can be used for delineating respiratory status and whether swallowing dysfunction is an underlying cause or whether the pulmonary dysfunction may underlie the dysphagia. Criteria for specific tests and descriptions of procedures can be found elsewhere. Again a team approach is stressed with professionals communicating across specialties and with parents.

GI Examination
GER, the passage of gastric contents into the esophagus, is common in normal infants with a frequency of regurgitation as high as 67% at 4 months of age [Nelson et al., 1997]. The etiology in infants is primarily anatomic and a function of a liquid diet, low esophageal capacitance, minimal length of subdiaphragmatic esophagus, and supine positioning [Kirby and Noel, 2007]. This benign infantile GER seldom results in esophagitis or airway irritation since the regurgitated breast milk or formula is nonacidic. However, infants and children with GERD (GERD) may present with signs that result from pain, airway irritation, or feeding disorder. The North American Society for Pediatric Gastroenterology, Hepatology, and Nutrition (NASPGHAN) [Rudolph et al., 2001] has published guidelines for evaluation and management of GERD. Eosinophilic esophagitis (EE or EoE), an inflammatory disease of the esophagus, may mimic the signs of GERD [Noel and Tipnis, 2006]. EE is often associated with food allergy and atopy [Noel et al., 2004], and unrelated to acid exposure. Diagnosis requires endoscopy and is made by histologic confirmation of mucosal changes [Gupta et al., 1997; Lim et al., 2004]. Treatments involve dietary changes and medications [Markowitz et al., 2003; Konkoff et al., 2006]. Overall, adequate management of GI tract disorders that may also include motility problems along with the conditions described above is an important underpinning for potential of successful oral feeding in those children who have safe swallowing. To interpret findings of infants’ and children’s oral feeding during a clinical feeding assessment, knowledge regarding all related interactive systems aids in decision making regarding management of feeding and swallowing problems.

INSTRUMENTAL EVALUATION OF SWALLOWING
Imaging studies that allow for visualization of some aspects of oral, pharyngeal, and upper esophageal phases of swallowing include: Videofluoroscopic swallow study (VFSS), fiberoptic endoscopic evaluation of swallowing (FEES), FEES with sensory testing (FEES-ST), and ultrasonography (US). Although US is not used routinely in most clinical settings, it is a valuable research tool that provides useful data while visualizing aspects of the oral and pharyngeal phases of swallowing. A brief discussion of US, FEES/FEES-ST, and VFSS follows.

Ultrasonography
US uses reflected sound as an imaging tool, which has been applied to visualize temporal relationships between movement patterns of oral and pharyngeal structures in fetal swallowing [Petrikovsky et al., 1996; Miller et al., 2003, 2006; Grassi et al., 2005], premature infants [Miller and Kang, 2007], young infants [Bosma et al., 1990], and in older children and adults [e.g., Shawker et al., 1984; Fanucci et al., 1994; Yang et al., 1997].

Fiberoptic Endoscopic Evaluation of Swallowing with Sensory Testing
The flexible (fiberoptic) endoscopic examination of swallowing allows for visualization of events occurring immediately before and immediately after the pharyngeal swallow. It was developed as an adjunct to VFSS and clinical examination of swallowing function in adults. It can be performed safely in persons of all ages including premature infants [Willging, 1995; Willging et al., 1996; Willging and Thompson, 2005]. The sensory testing component uses an air pulse stimulus of mechanoreceptors within the larynx (FEES-ST). Cooperation can be obtained in nearly all children. No cases of laryngospasm or respiratory compromise have been encountered [Willging and Thompson, 2005]. FEES may be an adjunct to VFSS in some instances [Bastian, 1991]. Technology advances in recent years make it feasible to integrate FEES with VFSS with the same patient.

FEES-ST is carried out best by a pediatric otolaryngologist and speech-language pathologist working as a team. The flexible endoscopic tube is passed transnasally, which allows for visualization of nasal, pharyngeal, and laryngeal structures (including true and false vocal folds). Tonsils and any other mass can be seen readily. Secretions may be seen in pharyngeal recesses or in the laryngeal vestibule. When a child swallows, a “white out” occurs as the epiglottis tilts upon initiation (trigger) of the pharyngeal swallow. The area comes into view immediately after the initiation of the swallow, allowing for visualization of any residue in valleculae, pyriform sinuses, posterior pharyngeal wall, laryngeal vestibule, and at times it may be possible to see aspirated material below the level of the true vocal folds. However, the inability to visualize the entire dynamic swallowing sequence is a drawback of this evaluation. Advantages include: no radiation exposure, position of patient is flexible, observation of structures, sensory component, can be repeated frequently, and it is readily available in most medical settings.

Videofluoroscopic Swallow Study
The VFSS is the primary instrumental examination to provide dynamic imaging of oral, pharyngeal, and upper esophageal phases of swallowing. The lateral view is standard. The anteroposterior view is used in some instances, particularly when asymmetry is noted and for view of palatine tonsils. The esophagus is scanned only for transit of a bolus. If a comprehensive examination of esophageal structure and function is needed, an esophagogram or in some instances an upper GI study is completed.

For purposes of the radiographic examination of swallowing, it must be remembered that this examination captures only a brief window in time and it does not simulate a real meal. The primary purpose is to define the pharyngeal phase of swallowing, not just to determine whether a child aspirates [Arvedson and Lefton-Greif, 1998]. Oral tongue propulsion of boluses into the pharynx has an impact on pharyngeal function. This examination provides structural and functional findings that can be related to varied swallowing disorders (Table 4). When aspiration is observed, the clinician must note whether the aspiration occurred before, during, or after swallows and on what texture(s) or consistencies. The findings must be related to possible swallowing problems or disorders, since management decisions are based on the problems that are identified. Details regarding criteria for referral for VFSS, preparation of infants and children, pro-
versus tube feeding, adjustments of text-contribute to the current status of each obtained across multiple dimensions that integrated with information from his-

Findings should be interpreted and considered can be found in other sources [e.g., Arvedson and Lefton-Greif, 1998; Arvedson and Brodsky, 2002, Brodsky and Arvedson, 2002,b]. Findings should be interpreted and integrated with information from history, other diagnostic tests, and data obtained across multiple dimensions that contribute to the current status of each child and family. Decisions about oral versus tube feeding, adjustments of textures/consistencies, and sensorimotor intervention must take into account underlying medical and developmental factors, nutrition status, and parent–child interactions in addition to specific oral sensorimotor and swallowing deficits.

**SUMMARY**

Evaluation of infants and children with dysphagia and feeding problems involves a multifactorial approach. Children with complex swallowing and feeding problems with their families are served best through an interdisciplinary team approach with considerations to include the WHO identification of the ICF as a potential framework for coding functional status and for standardizing language to describe health and health-related domains. Consideration of feeding problems in young children as a parent–child relational disorder provides a basis for incorporating those concepts into a comprehensive management plan. Evaluation has been discussed in a holistic framework that has the potential to facilitate the best possible safety and function of feeding for all children whether it be with a goal for total oral feeding or a goal that includes supplemental tube feedings to assure that nutrition and hydration needs are met, while facilitating oral feeding in ways that will not jeopardize a child’s health. Every child deserves to receive adequate nutrition and hydration without stress to child or to caregiver. Successful oral feeding must be measured in quality of meal time experiences with best possible skills while not jeopardizing a child’s functional health status or the parent–child relationship.

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**REFERENCES**


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**Table 4. Selected Videofluoroscopic Swallow Study Findings and Common Swallow Disorders**

<table>
<thead>
<tr>
<th>Radiographic Finding (Sign)</th>
<th>Possible Common Swallowing Disorder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bolus formation</td>
<td>closure − lip tension or tone − buccal tension or tone − tongue thrust − tongue control − jaw and tongue control − suck strength/coordination</td>
</tr>
<tr>
<td>Oral transit</td>
<td>Apraxia of swallow − Tongue thrust − lip tone − tongue control − tongue movement/strength − tongue movement/strength − tongue strength − high/narrow palate − tongue coordination, disorganized anteroposterior movement</td>
</tr>
<tr>
<td>Pharyngeal phase initiation (trigger)</td>
<td>If brief, no delay in pharyngeal initiation − Delayed pharyngeal initiation − Tonsil blocking bolus transit, delayed pharyngeal initiation − Delayed pharyngeal phase initiation</td>
</tr>
<tr>
<td>Nasopharyngeal backflow/reflux</td>
<td>Velopharyngeal closure − UES opening − Incoordination − pharyngeal contraction</td>
</tr>
<tr>
<td>Penetration to underside of superior part of epiglottis</td>
<td>Closure of airway entrance − tongue base retraction − pharyngeal contractions − UES anteroposterior (AP) opening diameter</td>
</tr>
<tr>
<td>Penetration into airway entrance and/or pharynx</td>
<td>Delayed pharyngeal swallowing initiation</td>
</tr>
<tr>
<td>Residue after swallows in valleculae</td>
<td>Unilateral vocal fold paralysis, incoordination</td>
</tr>
<tr>
<td>Residue in pyriform sinuses</td>
<td>Reduced pharyngeal pressure − tongue base retraction − pharyngeal contractions − UES AP opening</td>
</tr>
<tr>
<td>Aspiration before swallow</td>
<td>UES prominence − UES AP opening diameter, reduced pharyngeal pressures may contribute − Structural abnormality or UES AP opening diameter</td>
</tr>
<tr>
<td>Aspiration during swallow</td>
<td>Esophageal dysmotility; structural abnormality</td>
</tr>
<tr>
<td>Aspiration after swallow</td>
<td>Esophageal dysmotility; structural abnormality</td>
</tr>
<tr>
<td>Residue cleared with next swallow</td>
<td></td>
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<tr>
<td>Residue not cleared after swallow</td>
<td></td>
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<tr>
<td>Upper esophageal phase</td>
<td></td>
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<tr>
<td>Slow bolus passage through UES</td>
<td></td>
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<tr>
<td>Residual on/in UES</td>
<td></td>
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<tr>
<td>Retrograde bolus movement from esophagus to pharynx</td>
<td></td>
</tr>
<tr>
<td>Retrograde bolus movement from lower esophagus to upper esophagus</td>
<td></td>
</tr>
</tbody>
</table>

Adapted from Arvedson and Lefton-Greif [1998], p 253.


