Cough and Aspiration of Food and Liquids Due to Oral-Pharyngeal Dysphagia

ACCP Evidence-Based Clinical Practice Guidelines

Carol A. Smith Hammond, PhD; and Larry B. Goldstein, MD

Background: **Cough may be an indicator of aspiration due to oral-pharyngeal dysphagia.**
Methods: **Relevant literature was identified by searching the Communication Sciences and Disorders Dome, the Cumulative Index to Nursing and Allied Health Literature, the Educational Resource Information Center, Health & Psychosocial Instruments, the American Psychological Association, and the National Library of Medicine databases from 1965 to 2004 using the terms "deglutition," "aspiration," and "cough."**
Results: **Aspiration was observed on radiologic evaluation in over one third of acute stroke patients and in > 40% of patients undergoing cervical spine surgery. Cough while eating may indicate aspiration, but aspiration may be clinically silent. Subjective patient and caregiver reports of cough while eating are useful in identifying patients who are at risk for aspiration. Objective measures of voluntary cough and tussigenic challenges to inhaled irritants are under investigation to determine their capacity to predict the risk for aspiration and subsequent pneumonia. The treatment of dysphagic patients by a multidisciplinary team, including early evaluation by a speech-language pathologist, is associated with improved outcomes. Effective clinical interventions such as the use of compensatory swallowing strategies and the alteration of food consistencies can be based on the results of instrumental swallowing studies. The efficacy of swallowing exercises and electrical muscle stimulation is under study. Surgical interventions may be considered in selected patients, but studies proving efficacy are generally lacking.**
Conclusions: **Patients who are at risk for aspiration can be identified, and appropriate interventions can reduce its associated morbidity.** ***(CHEST 2006; 129:154S–168S)***

Key words: aspiration; deglutition; reflexive cough; silent aspiration; speech-language pathologist; voluntary cough

Abbreviations: ACE = angiotensin-converting enzyme; CI = confidence interval; FEES = fiberoptic endoscopic evaluation of swallowing; OR = odds ratio; RC = reflexive cough; SLP = speech-language pathologist; VC = voluntary cough; VSE = videofluoroscopic swallow evaluation

Oral-pharyngeal dysphagia (*ie*, abnormal swallowing) may result in several complications including dehydration, malnutrition, bronchospasm, and airway obstruction, as well as aspiration pneumonia and chronic chest infection (Table 1).[1–3] The condition may have secondary consequences such as social isolation and depression. Cough is an important potential indicator of aspiration due to oral-pharyngeal dysphagia.[2] This section will discuss the settings in which cough should prompt the consideration of a diagnosis of oral-pharyngeal dysphagia with aspiration and review dysphagia diagnosis and management. Prototypical diseases are stressed in the text focusing on neurologic and surgical conditions as other conditions have been less well-studied. Relevant literature was identified by searching the Communication Sciences and Disorders Dome, Cumulative

Correspondence to: Carol A. Smith Hammond, PhD, Durham VAMC, 508 Fulton St, No. 126, Durham, NC 27705; e-mail: smith390@mc.duke.edu

Table 1—*Medical Diagnoses and Conditions Associated With Aspiration and Silent Aspiration on VSE*

Diagnoses and Conditions	Description
Neurologic impairment	Cerebrovascular disease*
	Head trauma, closed head injured*
	Cervical spinal injury*
	Anoxia*
	Seizure disorder*
	Vocal fold paralysis*
	Degenerative disease (inclusion body myositis)
	Multiple sclerosis
	Parkinson disease*
	Amyotrophic lateral sclerosis*
	Huntington disease
	Brain and brain-stem tumors
	Myasthenia gravis
	Guillain-Barre syndrome
	Progressive supranuclear palsy
	Dementia, altered mental status
	Alzheimer disease*
Surgery related	Head and neck cancer; postradiation effects*
	Anterior or posterior cervical spine surgery*
	Surgery-related muscular or neurogenic injury
	Vocal fold paralysis*
	Brain surgery*
	Coronary artery bypass grafting*
	Cervical spinal* (anterior and posterior approach)
	Esophagogastrectomy*
Infectious	Botulism toxin, anticholinergics, possible drug related
	Diptheria
	Lyme disease
	Altered immune response: HIV, leukemia
	Candida
	Mucositis (herpes, cytolomegalovirus)
	Syphilis
Structural	Osteophytes, diffuse idiopathic skeletal hypertrophy
	Diffuse idiopathic skeletal hyperostosis
	Cricopharyngeal bar
	Oropharyngeal tumors, glossectomy,* poor dentition, periodontal disease
	Congenital abnormalities of nasal, oral, and laryngeal cavities,† cleft palate
	Tracheoesophageal fistula
Endocrine disease	Diabetes, thyroid disorders
Cardiac conditions	
GI problems	Zenker diverticulum
	Esophageal dysphagia
	Laryngopharyngeal reflux*
	Globus
Pulmonary	Pneumonia
	Bronchitis*
	COPD
Tracheotomy	
Intubation	> 48 h*
	Ventilated patients*
Medication side effects	Chemotherapy
	Sedatives*
	Neuroleptics*
	Antipsychotics

*Diagnostic groups reported to have a high risk for aspiration and silent aspiration.
†See Derkay and Schechter[7] for a review of pediatric disorders.

Index to Nursing and Allied Health Literature, Educational Resource Information Center, Health & Psychosocial Instruments, The American Psychological Association, and the National Library of Medicine databases from 1965 to 2004 using the terms "deglutition," "aspiration," and "cough."

Normal Swallow

Normal swallowing requires the coordinated activity of the muscles of the mouth, pharynx, larynx, and esophagus, which are innervated by the central and peripheral nervous systems. Respiration and swallowing are coordinated systems that share some common anatomy and physiology. Swallowing is generally divided into phases (Fig 1) that are modified during normal development[4] due to anatomic and physiologic maturation. Swallowing in the infant consists of the suck reflex followed by oral-pharyngeal and esophageal phases that eventually mature into four phases (oral preparatory, oral propulsive, pharyngeal, and esophageal). The newborn infant is able to breathe and swallow simultaneously, an ability that is lost with maturity. The more superior location of the larynx and the shorter pharyngeal length in infancy contribute to reduced laryngeal elevation during the swallow in infants compared to adults. During postnatal development, the pharynx lengthens and enlarges, the larynx lowers, and the mandible and the hyoid descend.[5] The more superior location of the larynx and the shorter pharyngeal length in infancy contribute to reduced laryngeal elevation compared to mature swallowing. For the first 3 months of life, the tongue acts as a piston within a cylinder to facilitate sucking on a nipple. The ability to form a bolus of solid food is developed as the oral pharyngeal structures mature. The tongue, lips, and mandible perform the independent functions of biting (achieved at approximately 7 months of age) and then chewing (which develops at approximately 10 to 12 months of age). As reflected by electromyography findings, children achieve an adult pattern of muscle activation during the oral and pharyngeal phases of swallowing by ages 5 to 8 years of age.[4]

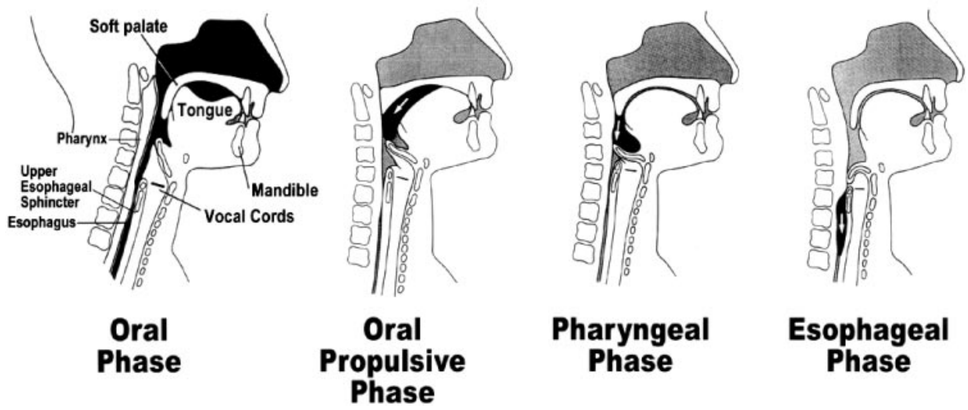

FIGURE 1. Schematic of anatomic structures and physiologic function of the normal swallow. During the oral preparatory phase, food and saliva are masticated to form a bolus. The soft palate lifts to close off the nasopharynx as the tongue slides the bolus along the hard palate. The bolus is then propelled under positive pressure into the pharynx. The duration of the pharyngeal phase is 1 to 2 s and involves a rapid sequence of events that protect the airway. The hyoid bone and larynx move upward and forward, the vocal folds move to the midline, and the epiglottis folds over the arytenoid cartilages. The tongue pushes backward and downward into the pharynx to provide positive pressure to propel the bolus. The pharyngeal walls then move inward with a progressive wave of contraction providing continuing pressure to move the bolus through the upper esophageal sphincter into the esophagus. The bolus traverses through the pyriform sinuses, which are hypopharyngeal spaces formed by the lateral pharyngeal wall and the larynx. During the esophageal phase, the upper esophageal sphincter is opened and the bolus passes into the proximal esophagus. The upper esophageal sphincter closes after passage of the bolus to prevent swallowed material from reentering the larynx. The bolus moves by a pressure wave through the esophagus.

Developmental changes in the laryngochemo reflex also occur. Cough (one of a variety of laryngeal chemoreflexes) is elicited when hypochloremic or strongly acidic solutions contact the epithelium surrounding the entrance to the laryngeal airway. In adult animal models, the introduction of acid or water into the larynx causes coughing and swallowing, whereas the introduction of a saline solution does not elicit a cough. During the fetal or newborn periods, water in the larynx does not result in a cough; rather, it results in apnea and increased swallowing frequency.[4]

Dysphagia (Abnormal Swallow), Penetration, and Aspiration

Dysphagia is defined as abnormal swallowing due to impaired coordination, obstruction, or weakness affecting swallowing biomechanics. The terms *penetration* and *aspiration* are used to describe different degrees of abnormal airway protection that are associated with eating and drinking. Penetration occurs when material enters the laryngeal area to the level of the true vocal folds; aspiration occurs when material moves below the true vocal folds and enters the trachea.

The most dangerous time of life for fatal aspiration pneumonia is during the brief period just before and immediately after birth. Neonatal aspiration syndromes are reported in 4% of all live births and are associated with significant morbidity and mortality.[6,7] The significant mortality rate in newborns and infants may be due to the subtle signs of aspiration (*ie*, apnea and increased swallowing frequency) and the lack of cough during aspiration at this stage of development.

Aspiration pneumonia is the most common form of hospital-acquired pneumonia among adults and occurs in 4 to 8 of every 1,000 patients who are admitted to hospitals in the United States. Mortality rates ranging from 20 to 65% have been reported for aspiration pneumonia.[8]

Several conditions may increase the incidence of dysphagia, aspiration, and pneumonia. Three studies of consecutive patients who were admitted to the hospital for acute stroke found a significant portion of material aspirated on videofluoroscopic swallow evaluation (VSE), a moving picture radiograph of the oral-pharyngeal area during swallow of solid food and liquids. In these studies, aspiration was found in 37%,[9] 38%,[10] and 22% of patients.[11] The importance of identifying aspiration was underscored by the results of a retrospective review[1] of stroke patients (n = 378), which found an association between aspiration on VSE and pneumonia. Cervical spinal surgery can also increase aspiration risk.[12] For example, in one study[12] of 83 consecutive patients who had undergone preoperative and postoperative VSE evaluation, 42% of patients undergoing anterior cervical operations, 20% of those undergoing posterior cervical procedures, but none of those undergoing lumbar surgery aspirated after the procedure. Elderly residents of long-term care facilities are also at increased aspiration risk.[13] Multivariate analysis revealed that difficulty swallowing food (odds ratio [OR], 2.0; 95% confidence interval [CI], 1.2 to 3.3) and sedative medication (OR, 8.3; 95% CI, 1.4 to 50) were the most important risk factors leading to pneumonia.[13] Vergis et al[14] identified witnessed aspiration and sedative medications as the most important risk factors for pneumonia in a long-term care facility. Another study[15] of nursing home residents reported that bed-bound patients, reduced activity levels, reliance on others for feeding, and oral care were associated with aspiration pneumonia. Two independent predictors of pneumonia, as determined by multiple logistic regression analysis, were being fed by gastric tube (OR, 3.03; $p = 0.05$) and a requirement for total assistance for oral care (OR, 2.8; $p = 0.03$). For patients not requiring tube feedings, the likelihood of pneumonia was increased among those who were dependent for feeding (OR, 19.98; $p = 0.0001$), were currently smoking (OR, 4.13; $p = 0.02$), or were receiving more than eight medications (OR, 1.15; $p = 0.02$).[15] Coughing in patients with abnormal oral pharyngeal swallowing suggests that aspiration has occurred, it is important to appreciate that aspiration can occur without coughing.[2]

Silent Aspiration

The term *silent aspiration* refers to the occurrence of aspiration before, during, or after swallowing in the absence of cough. Patients with penetration into the laryngeal area during swallow on VSE can have a fourfold increased risk of pneumonia ($p < 0.008$) compared to healthy control subjects. Those with more profound tracheobronchial aspiration had a total 10-fold increased risk of aspiration ($p < 0.0001$), and those with silent tracheobronchial aspiration had a 13-fold increased risk for developing pneumonia ($p < 0.0001$).[8]

Both male gender and age > 65 years are independently associated with silent aspiration ($p = 0.017$ and $p = 0.003$, respectively). Neurologically impaired individuals, those with GI problems, and those with unknown medical diagnoses were also more likely to silently aspirate (62%, 60%, and 64% respectively).[16] Other medical conditions in which a high portion of patients have silent aspiration are indicated with by an asterisk in Table 1.

Evaluation of Cough Suspected to be Associated With Dysphagia

Cough and History of Aspiration

Upper airway laryngeal motor functions are important components of both cough and swallowing. Involuntary or reflexive cough (RC) in response to the presence of liquids or solid food in the laryngeal area protects against tracheobronchial aspiration. The term *voluntary cough* (VC) refers to a cough that is produced on command and is not related to eating or drinking. Table 2 lists the sensitivity, specificity, and, when reported, the positive and negative predictive values of both RC and VC as indicators of aspiration on VSE (the "gold standard").

The initial evaluation of patients with cough

Table 2—*Validity Measures for Cough Associated With Aspiration**

Cough Parameter and Study Identifier	Study/Year	Study Population/ Patients, No.	SENS, %	SPEC, %	PPV, %	NPV, %
RC after food or liquid						
History of RC with eating/drinking	Mari et al[18]/1997	Mixed neurologically impaired/93	74	74	71	77
Patient report of RC during eating/drinking	Rosenbek et al[9]/2004	Acute CVA/60	38	79	43	64
Family report of RC during eating/drinking	Rosenbek et al[9]/2004	Acute CVA/60	14	80	44	41
RC	Rosenbek et al[9]/2004	Acute CVA/60	68	82	68	97
RC	Smith Hammond et al[36]/2001	Acute CVA/96	55	83	62	78
RC or throat clear	Logemann et al[19]/1999	Mixed diagnoses/200	78	58	69	NR
RC	Daniels et al[10]/1998	Acute stroke/55	57.1	85.3	NR	NR
RC or wet voice	Rosenbek et al[9]/2004	Acute CVA/60	86	50	39	91
RC or wet/hoarse voice	Mari et al[18]/1997	Mixed neurologically impaired/93	50	91	84	74
Subjective assessment of VC						
VC weak subjective assessment	Rosenbek et al[9]/2004	Acute CVA/60[13]	70	45	45	68
VC wet/gurgly subjective assessment	Rosenbek et al[9]/2004	Acute CVA/60[13]	55	68	59	73
Subjective VOCO	Daniels et al[10]/1998	Acute stroke/55	47.6	94.1	NR	96

*SENS = sensitivity; SPEC = specificity; PPV = positive predictive value; NPV = negative predictive value; NR = not reported; RC = reflexive cough; CVA = cough variant asthma; VC = voluntary cough.

should first focus on the identification of any developmental problems, existing conditions, surgical procedures, and medications that have been associated with oral-pharyngeal dysphagia and aspiration on VSE or fiberoptic endoscopic evaluation of swallowing (FEES) [Table 1]. In addition to these conditions, dysphagia and aspiration may underlie unexplained dehydration, malnutrition, and unintentional weight loss. A combination of conditions listed in Table 3 has been associated with oral-pharyngeal dysphagia and aspiration with a sensitivity of 91% and a specificity of 47%.[17]

The patient, their family members, and caregivers should be questioned regarding the patient's swallowing problems. Subjective reports by the patient or caregiver of coughing while eating and drinking or a medical history of coughing related to feeding predicts an increased risk of aspiration (Table 2). One study[18] focused on a group of selected neurologically impaired patients (n = 93; mean [SD] age, 59.8 ± 16 years; range, 18 to 80 years) who had been admitted to a rehabilitation clinic over an 18-month period. The patients had a variety of conditions including stroke, brain injury, Parkinson disease, multiple sclerosis, amyotrophic lateral sclerosis, myotonic muscular dystrophy, and other neurodegenerative diseases. Subjective reports by patients of difficulty in swallowing liquids or solids, "currently or in the past," had a sensitivity of 88%, a specificity of 30%, a positive predictive value of 52%, and a negative predictive value of 75% for aspiration on VSE (the "gold standard").[18]

Recommendations

1. In patients with cough, a medical history particularly directed at identifying conditions increasing the likelihood of oral-pharyngeal dysphagia and aspiration, as indicated in Table 1, should be obtained. Patients with high-risk conditions should be referred for an oral-pharyngeal swallowing evaluation. Level of evidence, low; benefit, substantial; grade of recommendation, B

2a. Patients with cough and their caregivers should be questioned regarding perceived swallowing problems, including an association of cough while eating or drinking and a fear of choking while eating and drinking. If a patient with cough reports swallowing problems, further evaluation for oral-pharyngeal dysphagia is indicated. Level of evidence, low; benefit, substantial; grade of recommendation, B

2b. Further evaluation, including a chest radiograph and a nutritional assessment, should be considered in patients with cough or conditions associated with aspiration. Level of evidence, low; benefit, substantial; grade of recommendation, B

3. Patients with oral-pharyngeal dysphagia

Table 3—*Contraindications for VSE and FEES and Clinical Signs of Dysphagia**

Contraindications and Clinical Signs	Description
Contraindications for VSE or FEES	Lethargy
	Absent swallow response on command
	Abnormal upper airway sounds
	Inability to manage oral pharyngeal secretions (need for frequent oral/pharyngeal suctioning)
	Respiratory rate > 35 breaths/min
Clinical identifiers that predict need for swallow evaluation	Need for oral pharyngeal suctioning
	Malnutrition
	Unintentional weight loss
	Moderate or severe compromise
	Moderate or severe nutritional problem (per dietitian assessment)
	Feeding tube in place
	Abnormal chest x-ray results
	Patchy opacity
	Lower lobe infiltrate
	Air space disease
	Aspiration
	Dysarthria
	Dysphonia
	Weak voluntary cough
	Reflexive cough or wet voice after water bolus
	Dysphonia after water bolus
	Drooling from mouth
	Nasal regurgitation after water bolus

*VSE = videofluoroscopic swallow evaluation; FEES = fiberoptic endoscopic evaluation.

and cough should be referred, ideally to a speech-language pathologist (SLP), for an oral-pharyngeal swallow evaluation. Level of evidence, low; benefit, substantial; grade of recommendation, B

4. Patients with cough related to pneumonia and bronchitis who have received medical diagnoses and conditions associated with aspiration (Table 1) should be referred, ideally to a SLP, for an oral-pharyngeal swallow evaluation. Level of evidence, low; benefit, substantial; grade of recommendation, B

Physical Examination and Oral Pharyngeal Dysphagia

Patients with unexplained cough should have a thorough evaluation for potential underlying medical conditions beginning with general medical and neurologic examinations. To swallow safely, patients must be alert, awake, and able to accept food and liquids into the mouth. Extremely lethargic patients or those experiencing inconsistent levels of alertness are at increased aspiration risk.[14]

Recommendation

5. Patients with a reduced level of consciousness are at high risk for aspiration and should not be fed orally until the level of consciousness has improved. Level of evidence, low; benefit, substantial; grade of recommendation, B

For alert patients, the ability to eat and drink should be evaluated, including observation of the patient's response to drinking water and performing a VC. Observation of the patient drinking water (a 3-oz volume) has been validated in a number of patient groups[9,10,18,19] as a means of detecting dysphagia and aspiration (Table 2). The sensitivity for RC after water swallows alone further improves in the presence of other signs, (*eg*, wet voice, throat clear, or hoarse voice [Table 2]). *Wet voice* is a descriptive term for the gurgling sound produced on phonation of a prolonged "ee." A throat clear is produced by approximation of the vocal folds, which may be audible as "ahem." A hoarse voice quality or an inability to produce sound (dysphonia) after swallowing water has also been associated with aspiration. Patients with dysphagia often also exhibit dysarthria, which is characterized by slowed or slurred speech, resulting in reduced intelligibility.

Recommendation

6. Alert patients with cough who are in high-risk groups for aspiration (Table 1) should be observed drinking small amounts of water (3 oz). If the patient coughs or shows clinical signs that are associated with aspiration (Tables 2, 3), the patient should be referred for a detailed swallowing evaluation, preferably to a SLP. Level of evidence, low; benefit, substantial; grade of recommendation, B

VC is elicited by asking the patient to cough with as much force as possible. An abnormal VC has been described as being either "weak"[9,10] or as "wet/gurgly."[9] In one study[20] of 57 patients with bilateral strokes evaluated with VSE, the majority of aspirators (21 of 25 patients; 84%) were identified by subjective evaluation to have a weak or absent VC. However, subjective evaluations of abnormalities of VC can be unreliable (Table 2).

In a study[21] of selected patients ($n = 30$) with acute middle cerebral artery distribution stroke, the inability to cough on command (*ie*, VC), or absent or discoordinated phases of cough as determined by subjective assessment was labeled as "cough apraxia." Patients with left middle cerebral artery infarctions were more likely ($p < 0.001$) to have cough apraxia compared to those with right middle cerebral artery infarctions. However, no instrumental studies (*eg*, VSE or FEES) were performed, and aspiration pneumonia did not develop in any patients.[21] Therefore, the clinical significance of cough apraxia remains uncertain.

Recommendation

7. In patients with cough, the value of the subjective assessment of VC as the sole predictor of aspiration is uncertain because of poor reliability and an unclear association with evaluation. Level of evidence, low; benefit, conflicting; grade of evidence, I

Cough Response to Tussigenic Challenges

Reduction in laryngeal sensation has been described in the elderly,[22] in stroke patients,[23] in patients after undergoing heart-lung transplant,[24] and in patients with laryngopharyngeal reflux.[25] Tussigenic challenge assesses the RC response to increasing concentrations of irritants. The threshold of concentration of citric acid to elicit the cough reflex does not appear to change with age in healthy subjects.[26] Impaired cough reflex sensitivity in response to tussigenic challenges is associated with the development of pneumonia in the elderly; however, this has not as been associated with aspiration on VSE or FEES.[27]

Patients with laryngeal sensory system damage might be expected to have decreased sensitivity to inhaled irritants and, thus, to require increased concentrations to elicit a cough response. A reduction or absence of the RC response might place patients at increased aspiration risk. Consistent with this hypothesis, heart-lung transplant patients were found to have a significant decrease in the frequency of cough stimulated by the inhalation of distilled water compared to control subjects (0.5 vs 12.1, respectively; $p < 0.001$).[24] The mean cough reflex sensitivity to inhaled citric acid in patients with advanced Parkinson disease (46.7 ± 49.3 g/L) was significantly lower than that for control subjects (14.5 ± 16.6 g/L; $p < 0.01$) and patients with early disease (11.2 ± 14.8 g/L, $p < 0.005$). There was no difference between control subjects and those with early disease.[28] In contrast, another study[29] failed to find an increased cough threshold to the inhalation of nebulized distilled water in patients with Parkinson disease compared to age-matched control subjects. In a later study,[30] this same group found no difference between laryngectomized patients and age-matched control subjects for the threshold of nebulized distilled water required to elicit RC. The cough response to inhaled irritants has also been studied as a predictor of pneumonia with varying results. Cough sensitivity to the inhalation of capsaicin was evaluated in selected adult patients with a variety of neurologic impairments (n = 28) and was grouped by swallowing ability. Patients were categorized as dysphagic on the basis of swallowing speed (in milliliters per second) judged by the palpation of the cervical area during swallow without the use of instrumental swallowing evaluations (*eg*, VSE or FEES) to determine the presence or absence of dysphagia or aspiration. The cough threshold was not significantly different between those with normal and abnormal swallowing.[31] Therefore, there is variation among studies in the usefulness of a tussigenic challenge in assessing RC related to aspiration.

Several studies have evaluated the relationship between cough sensitivity to inhaled irritants and the risk of pneumonia. Cough sensitivity to capsaicin was measured in a small consecutive group of patients (n = 7) with recurrent pneumonia (two to six episodes each), all of whom had chest radiographic findings that were consistent with aspiration.[32] The concentration of capsaicin needed to induce five RCs was higher ($p < 0.0001$) in pneumonia patients compared to age-matched and gender-matched control subjects (mean, 2.37 mol/L [95% CI, 1.84 to 2.9 mol/L] vs 1.2 mol/L [95% CI, 1.11 to 1.47]; $p < 0.0001$), implying that patients with recurrent pneumonia had reduced sensitivity to foreign material in the laryngeal area.[32] The incidence of pneumonia was also studied in a cohort[33] of consecutive nursing home patients who had been admitted after stroke (n = 143). The subjects were > 65 years of age and were grouped according to the following classifications: oral feeding without dysphagia (n = 43); oral feeding with dysphagia (n = 48); nasogastric tube feeding with dysphagia (n = 52); or nasogastric tube and bedridden (n = 14).[33] The swallowing reflex was assessed as the latency of the response to swallow after the injection of 1 mL of water into the pharynx through a nasal catheter. The cough threshold to citric acid aerosols was defined as the concentration at which the patient coughed five times. Abnormal responses were defined as a swallow response longer than 5 s and a cough threshold to citric acid concentrations of > 1.35 (log mg/mL). The incidence of pneumonia (24 of 143 patients) was higher in patients with oral feeding (19 of 35 patients) than in those with tube feeding (54.3% vs 13.2%, respectively; $p < 0.001$). Bedridden patients with tube feeding had a swallowing latency of > 20 s, no patient coughed at the highest concentration of citric acid and the incidence of pneumonia in this group was 64.3%.[33] However, it is not clear how much the assessment of RC added to the patient's known clinical aspiration risk factors.

Pneumonia rates were compared between patients assessed by an SLP in an acute rehabilitation hospital with the use of a cough reflex test and by an SLP assessment without use of the cough reflex test.[34] The cough reflex test used a 20% solution of prescription-grade l-tartaric acid, which was dissolved in 2 mL of sterile normal saline solution. The solution was placed in a nebulizer and was inhaled as a microaerosol. In the hospital using the cough reflex test, 1.25% of stroke patients (n = 400) developed pneumonia compared to 13.2% of stroke patients in the institution that did not use the cough reflex test (n = 204). However, conclusions are limited because the patients were not randomized and no data were provided to assess the comparability of the groups or their treatments.

Cough reflex sensitivity to citric acid was also measured in elderly nursing home patients who were randomly assigned to receive intensive oral care (n = 30) and usual oral care (n = 29). Cough reflex sensitivity after 30 days of intensive oral care was significantly higher than at baseline ($p < 0.01$) and was comparable to that in the control group ($p < 0.05$).[35] The implications of this observation for patient care are uncertain.

Recommendation

8. The assessment of the RC response to inhaled irritants as a predictor of aspiration risk and subsequent pneumonia is not recom-

mended due to a lack of adequate supportive studies. Level of evidence, low; benefit, conflicting; grade of evidence, I

Aerodynamic Measures of Cough

Objective aerodynamic measures of VC were studied in a group of selected patients (n = 43) who had been admitted to the hospital with acute hemorrhagic or ischemic stroke.[36] Based on the results of VSE or FEES (the "gold standard"), patients were categorized into three groups: (1) mild aspirators (n = 17), if aspiration was observed for thin liquids and Ensure (Abbott; Abbott Park, IL) only; (2) severe aspirators (n = 11), if there was aspiration of all liquid consistencies (thin liquids, Ensure, and thickened liquids); and (3) nonaspirators (n = 15). There were 15 age-matched and gender-matched control subjects with no history of stroke or dysphagia. The Canadian Neurologic Stroke Scale was used to determine stroke severity.[37] There was no difference between groups for age, gender, or the presence of pulmonary disease. All VC measures were abnormal in stroke patients compared to control subjects (each $p < 0.05$) [Fig 2]. Univariate analysis showed that VC peak flow of the inspiration phase, sound pressure level, peak flow of the expulsive phase, expulsive phase rise time, and VC volume acceleration (peak flow expulsive phase/expulsive phase rise time) were significantly different in nonaspirators compared to both severe and mild aspirators (Fig 2). Multivariate

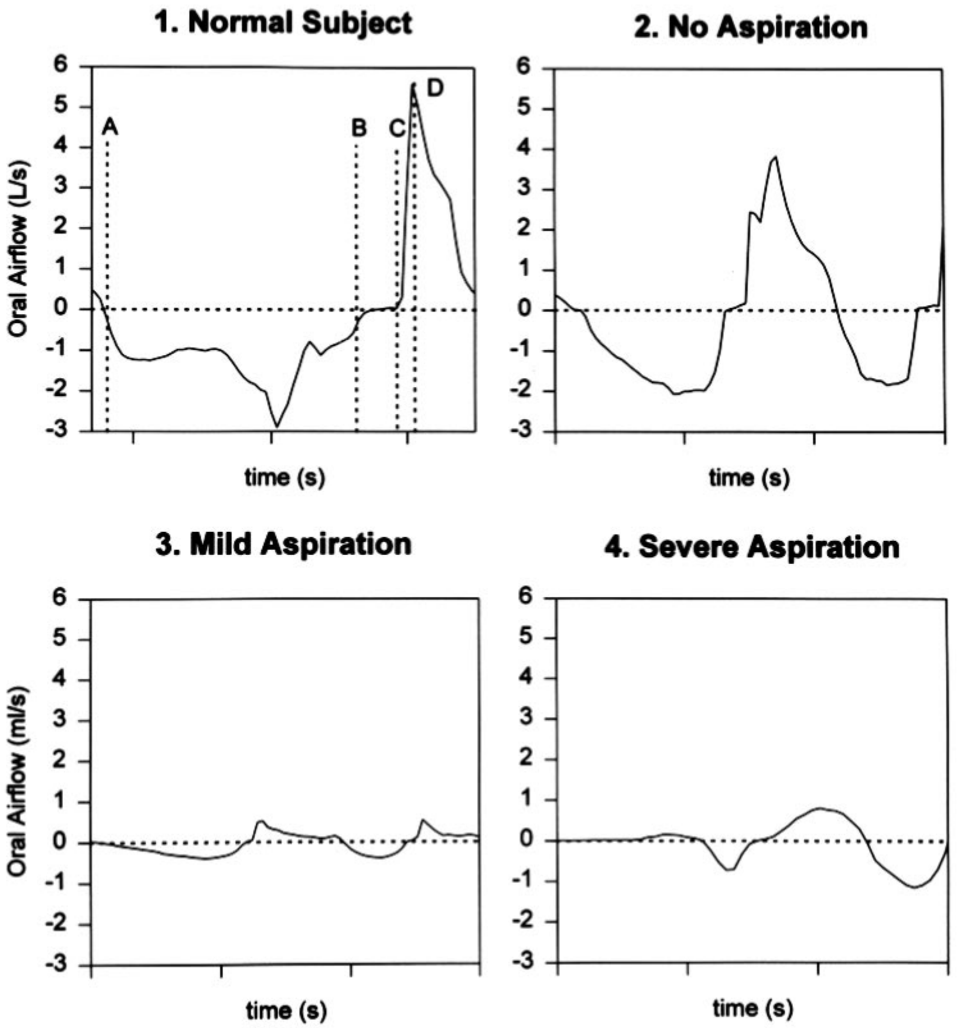

FIGURE 2. Examples of airflow records from healthy subjects (*top left*, *1*) and stroke subjects (*top right*, *2*, *bottom left*, *3*, and *bottom right*, *4*) during VC. Zero airflow is depicted as a horizontal dotted line. All phases of VC are illustrated as follows: inspiration phase, A to B; compression phase, B to C; expulsion phase rise time, C to D. Control subjects were significantly different from stroke patients as a group for all cough measures ($p < 0.001$). Note the increased expulsion phase rise time in aspirators (*bottom left*, *3*, and *bottom right*, *4*) compared to stroke patients who did not aspirate (*top right*, *2*).

logistic regression revealed that only expulsive phase rise time values during cough independently correlated with aspiration status ($p < 0.001$), with no additional contribution by stroke severity or other VC variables. Respiratory function, VC expulsive phase peak flow, and sensitivity to inhaled citric acid were also compared between patients with early-stage and late-stage Parkinson disease and age-matched control subjects.[28] No differences were found for age, height, FVC, and FEV_1. The mean peak expulsive phase flow for VC was weaker both in patients with early-stage Parkinson disease (230 ± 74 L/min; $p < 0.005$) and in those with advanced-stage disease (186 ± 60 L/min) compared to control subjects (316 ± 70 L/min; $p < 0.0001$), but not between the groups of patients with Parkinson disease.[28]

Aerodynamic measures of VC have also been studied[38] in patients with motor neuron disease (n = 53). Cough spikes are transient increases in expiratory flow above the maximal expiratory flow-volume curve. In this study,[38] patients with cough spikes were significantly more likely to be alive 18 months after undergoing baseline tests ($p < 0.05$). Two thirds of the survivors (12 of 18 survivors) had cough spikes compared to 34% of those who died.[38]

Recommendation

9. In acute stroke patients, the expulsive phase rise time of VC may predict aspiration. The use of this test has not been validated in other patient groups, and further studies comparing the accuracy of objective measures of VC to the clinical swallow evaluation to identify aspiration risk are needed. Level of evidence, low; benefit, small; grade of recommendation, C

The Roles of SLP, VSE, and FEES

The American Speech Language and Hearing Association position statement[39] includes oral-pharyngeal dysphagia in the scope of practice for the SLP, and provides guidelines for the knowledge and skills needed by the SLP for the evaluation and treatment of swallowing disorders.[40] The evaluation by the SLP includes a clinical swallowing ("bedside") examination as well as the use of dynamic imaging techniques during the oral and pharyngeal phases of swallow (*ie*, VSE or FEES. In some medical centers, occupational therapists may also be trained in dysphagia management. The US Agency for Healthcare Research and Quality[41] reported that the implementation of programs to screen acute stroke patients for aspiration and dysphagia, and to refer patients with apparent problems to dysphagia specialists for evaluation and treatment resulted in a dramatic reduction in the rate of aspiration pneumonia.

Typically, the clinical swallow evaluation relies on the clinician's subjective judgments, while the VSE and FEES provide direct visualization of the anatomy and physiology of swallowing during deglutition. The VSE is a motion picture radiograph of the bone, cartilage, and soft tissue swallowing structures visualized as the food and liquid mixed with barium passes through all stages of the swallow. The patient is observed in the lateral and anterior-posterior positions.[5] FEES can be performed at the bedside or in a clinic area and involves the transnasal passage of a flexible nasopharyngoscope to provide direct observation of the pharynx and larynx before and after the swallow.[42] The addition of an instrumented swallow evaluation (VSE or FEES) would only need to result in a reduction in the rate of pneumonia by 10% (absolute difference, approximately 0.8%) to fully offset the expense of the tests (based on Medicare reimbursement rates at the time of the report). At least this much improvement is reasonable to expect, considering the rate of detection of silent aspiration not expected on the clinical swallow evaluation.[41]

One very important advantage of imaging swallow studies is their use not only for diagnosis, but to determine which therapeutic technique will eliminate aspiration during oral eating and drinking. Staffing limitations, economic constraints, and the lack of availability of VSE or FEES often place the clinician in a position of dependence on the clinical swallow evaluation alone.

Recommendation

10. Patients with dysphagia should undergo VSE or FEES evaluation of swallow to identify appropriate treatment (reviewed below). Level of evidence, low; benefit, substantial; grade of recommendation, B

Treatment

General Management of Patients With Oral-Pharyngeal Dysphagia

The goal of treatment of patients with cough due to oral-pharyngeal dysphagia is to eliminate the penetration of food and liquids into the laryngeal area and their aspiration below the level of the true vocal folds. The guideline of the American Gastroenterological Association on oral pharyngeal dysphagia management[43] recommends a multidisciplinary approach due to the complexity of the disorder, and noted the need to design and test therapy on an individual-patient basis. The adoption of a stroke clinical practice analysis program[44] led to a more uniform, evidence-based treatment of acute stroke patients at one facility in which aspiration pneumonia was the leading cause of stroke-related morbidity and mortality. A proactive team consisting of a neurologist, a nurse, occupational, physical, and speech therapists, a pharmacist, a dietitian, and a discharge planner were responsible for stroke patient care including assessment by an SLP within 24 h of hospital admission. The program resulted in a significant decrease in the rate of aspiration pneumonia from 6.4 to 0% ($p = 0.03$), an overall decrease in unadjusted costs from $7,111 to $6,246 ($p = 0.001$), and an associated trend for decrease in the stroke mortality rate from 11 to 4.6% ($p = 0.063$).[45]

Recommendation

11. Patients with dysphagia should be managed by organized multidisciplinary teams that may include a physician, a nurse, an SLP, a dietitian, and physical and occupational therapists. Level of evidence, low; benefit, substantial; grade of recommendation, B

Compensatory Maneuvers

The goals of dysphagia therapy focus on the reduction of aspiration, improved swallowing ability in order to optimize nutritional status, and quality of life. Techniques have been developed to improve the opening of the upper esophageal sphincter, to increase pharyngeal clearance, and to minimize aspiration. These compensatory maneuvers can be used if the patient's cognitive status is appropriate for training. The effect of maneuvers on aspiration was studied[46] in consecutive patients who had been referred for dysphagia management ($n = 165$) with a variety of diagnoses. When aspiration occurred, the patient was instructed to perform one of the following postures: to chin-down, chin-up, head-rotated, head-tilted, or lying down. With the use of postural maneuvers, aspiration was eliminated during the VSE in 127 of the patients (77%).[46]

Recommendation

12. In patients with dysphagia, VSE or FEES can be useful for determining compensatory strategies enabling patients with dysphagia to safely swallow. Level of evidence, low; benefit, substantial; grade of recommendation, B

Dietary Modification

Specific recommendations for liquid consistency can also be made based on the results of the VSE or FEES. The administration of solid foods and liquids commonly available to the patient should be administered during VSE or FEES to determine which consistencies of these substances can be swallowed without risk for aspiration. Studies in adults and children have shown a dramatic reduction in the aspiration of thickened liquids compared to thin liquids. In patients with acute stroke ($n = 745$) who had been referred for VSE in which liquids (*ie*, thin, nectar thick, and ultra-honey-thick) under two methods of delivery (spoon and cup drinks) were administered, aspiration was more common with use of the cup vs use of the spoon ($p < 0.001$), was more frequent for thin liquids (*eg*, soda and coffee) than for nectar-thick liquids, and were more frequent for thick liquids than for ultra-honey-thick liquids ($p < 0.001$).[47] Another recent study[48] of adult patients found a reduction in airway protection with straw drinking in older healthy subjects compared to young healthy subjects, indicating a need to include straw drinking, which is a commonly used method for the delivery of liquids in the elderly, during instrumental evaluations. In infants with bronchiolitis, dramatic reductions in the occurrence of aspiration were observed on VSE for thick liquids compared to thin liquids.[49]

Recommendation

13. In patients with dysphagia, dietary recommendations should be prescribed when indicated, and can be refined by testing with foods and liquids simulating those in a normal diet during the VSE or FEES. Level of evidence, low; benefit, substantial; grade of recommendation, B

Swallowing Exercises

Physiologic exercise programs to strengthen the swallowing musculature are under investigation. Some exercises are augmented with electromyographic biofeedback and electrical stimulation of the swallowing musculature. The exercise of Shaker et al[50] is designed to strengthen the cervical musculature. Patients are asked to perform sustained and repetitive head lifts three times daily while in the supine position.[50] Consecutive outpatients ($n = 27$) with a variety of medical diagnoses and a median age of 72 years (age range, 62 to 89 years) exhibited pharyngeal phase dysphagia on VSE characterized by abnormal upper esophageal sphincter relaxation.[51] All patients exhibited severe dysphagia and were tube-fed prior to treatment, 18 patients were fed by gastrostomy, and 9 patients were fed by jejunostomy tubes. A VSE was performed before and after 6 weeks of therapy in all subjects. Initially, seven patients were randomized to a sham exercise group and later crossed over to the Shaker et al[50] exercise group. There was no change in swallow function and biomechanics after the sham exercise; however, all 27 patients showed a significant improvement in upper esophageal sphincter opening, anterior laryngeal excursion ($p < 0.01$), as well as the resolution of aspiration after the swallow. All patients were restored to receiving oral nutrition after treatment; 25 of 27 patients (93%) returned to a regular or soft mechanical diet, and 2 patients required thickened liquids with soft solid foods.[51] The Masako technique refers to a tongue hold between the teeth or lips paired with a dry swallow.[52] Ten healthy adult men increased the anterior bulge of the posterior pharyngeal wall, which demonstrated the importance of the contact of the base of the tongue to the pharyngeal wall and thus the potential effect on vallecular (*ie*, the space formed by the base of the tongue and the epiglottis) clearance. Muscle training augmented with electromyographic biofeedback has been studied[53] in aspirating patients at least 10 months following brainstem stroke (n = 7) and in patients who have undergone resection for brainstem tumors (n = 3). Improvements leading to a change in diet occurred after 1 week of muscle training with biofeedback in 9 of the 10 patients.

Electrical stimulation of the submandibular and hyolaryngeal muscles during swallow with aspiration[54,55] and stimulation of the recurrent laryngeal nerve via an implanted electrode around the recurrent laryngeal nerve represent new approaches to treatment for patients with severe dysphagia. The results of preliminary investigations are promising; however, further studies are needed.

Recommendation

14. For patients with muscular weakness during swallowing, muscle strength training, with or without electromyographic biofeedback, and electrical stimulation treatment of the swallowing musculature are promising techniques but cannot be recommended at this time until further work in larger populations is performed. Level of evidence, low; benefit, conflicting; grade of evidence, I

Pharmacologic Treatment

Pharmacologic treatment with angiotensin-converting enzyme (ACE) inhibitors for pneumonia and aspiration has been reported[56–58] in patients with stroke and also in the elderly. ACE inhibitors prevent the breakdown of substance P, which is thought to play a role in cough and swallow sensory pathways. Lower serum substance P levels have been reported[56] in hypertensive patients with stroke and symptomless dysphagia compared to control patients without dysphagia. Dysphagia was assessed by technetium tin colloid scanning. The technetium tin colloid was administered through a nasal catheter during sleep, and in the morning the lungs were scanned for evidence of technetium tin colloid. There was a decrease of technetium tin colloid in the lungs in 62% of patients treated with an ACE inhibitor. Of those patients treated with ACE inhibitors (n = 127), pneumonia developed in 7% of patients compared to 18% of patients who had been treated with other antihypertensive agents (relative risk, 2.65; 95% CI, 1.3 to 5.3; $p = 0.007$).[56] In another study[57] from this same research group, the rate of pneumonia was shown in elderly hypertensive patients (n = 576) who had been treated with an ACE inhibitor and compared to those who had been treated with a calcium channel blocker, and pneumonia rates of 3.3% and 8.9%, respectively, were found. In a later study[58] of elderly patients with stroke and dysphagia (n = 53), which also used the technetium tin colloid-scanning technique, patients were randomized to receive either ACE inhibitors or calcium channel blockers. The amount of technetium tin colloid found in the lungs was reduced in 71% of patients (23 of 32 patients) in the ACE inhibitor group, while none of the patients in the calcium channel blocker group showed improvement of dysphagia.[58] These studies assume that aspiration during sleep is the cause of pneumonia without considering other factors. It cannot be assumed that the nocturnal aspiration of secretions correlates to the aspiration of food and liquids. A study to correlate nocturnal aspiration with aspiration during VSE or FEES needs to be performed before nocturnal aspiration can be equated to oral-pharyngeal dysphagia; therefore, no recommendation can be made for the use of ACE inhibitors. These patients should be categorized as dysphagic on the basis of VSE or FEES findings in order to determine the effectiveness of ACE inhibitors in preventing oral pharyngeal aspiration.

Surgical Intervention To Prevent Aspiration

Surgeries for intractable aspiration include radical procedures such as laryngectomy, tracheostomy, and laryngeal suspension diversion, and conservative procedures that preserve speech and swallowing functioning. Standard laryngectomy is a radical approach that redirects respiration from the mouth and nose to the trachea through a surgically created stoma in the neck. The procedure eliminates both speech and the risk for aspiration. A preliminary report[59] of the first attempt at controlling human aspiration through dynamic laryngotracheal separation included two stroke patients with a need for tracheostomy and documented aspiration during VSE. An implantable stimulator was placed subcutaneously on the chest wall with electrodes implanted around the left recurrent laryngeal nerve. Aspiration was significantly reduced for thin and thickened liquids but not for puree consistencies when electrical stimulation was applied during the swallow, as verified by VSE and monitored monthly by FEES. One patient had improved VC when elicited with stimulation impulses. Strong effective VC was necessary to expel residue, and the results were stable for 9 months. The author speculated that patients might further improve with electrical stimulation as muscle strength improves. Conservative procedures include supracricoid partial laryngectomy, which involves suturing the epiglottis to the aryepiglottic folds. Retrospective studies found that that 52.1%[60] to 68.1%[61] of patients achieved normal swallowing by the first postoperative month after these procedures. However, these studies did not verify swallowing function with VSE or FEES. In one of these studies,[60] aspiration pneumonia occurred in 21.7% of patients (15 of 69 patients). A temporary gastrostomy was required in 13 patients with a permanent gastrostomy rate of 1.4% (1 of 69 patients); one patient died of aspiration pneumonia in 3 years. The actuarial survival rate was 68% for 5 years.

The American Gastroenterological Association[43] has provided clinical practice guidelines regarding surgical intervention for oral pharyngeal dysphagia. Surgical intervention is recommended for patients with pharyngeal or cricopharyngeal strictures, oropharyngeal tumors, posterior pharyngeal diverticulum, and cervical webs. Dilatation is recommended for the treatment of benign stenoses or webs based on the expert opinion of the authors. Dilatation was not recommended for anomalies such as cricopharyngeal bars, prominent cervical osteophytes or skeletal hyperostosis, and lateral pharyngeal diverticula. Cricopharyngeal myotomy is the most common surgical treatment for oral-pharyngeal dysphagia characterized by hyperfunction of the upper esophageal sphincter, which results in hypopharyngeal retention of swallowed material and subsequent aspiration. The operation is recommended for patients with dysphagia that is caused by structural abnormalities, but not for those with dysphagia caused by neurologic insult.

Petiole supraglottopexy in which the petiole of the epiglottis is plicated to the false vocal folds and the interarytenoid mucosa has also been used for intractable aspiration.[62] Two pediatric patients were capable of being fed orally yet remained nonverbal. Two adults utilized augmentative communication devices and electrolarynx, and three treated adults relied on gestures and facial expression for communication. Four of the five adults returned to partial oral nutrition with supplemental tube feeds. A thorough cost-and-outcomes analysis needs to be pursued to further evaluate the usefulness of these procedures in the treatment of aspiration.

Recommendation

15. Patients with intractable aspiration may be considered for surgical intervention. Level of evidence, low; benefit, substantial; grade of recommendation, B

Summary of Recommendations

1. In patients with cough, a medical history particularly directed at identifying conditions increasing the likelihood of oral-pharyngeal dysphagia and aspiration, as indicated in Table 1, should be obtained. Patients with high-risk conditions should be referred for an oral-pharyngeal swallowing evaluation. Level of evidence, low; benefit, substantial; grade of recommendation, B

2a. Patients with cough and their caregivers should be questioned regarding perceived swallowing problems, including an association of cough while eating or drinking and a fear of choking while eating and drinking. If a patient with cough reports swallowing problems, further evaluation for oral-pharyngeal dysphagia is indicated. Level of evidence, low; benefit, substantial; grade of recommendation, B

2b. Further evaluation, including a chest radiograph and a nutritional assessment, should be considered in patients with cough or conditions associated with aspiration. Level of evidence, low; benefit, substantial; grade of recommendation, B

3. Patients with oral-pharyngeal dysphagia and cough should be referred, ideally to a speech-language pathologist (SLP), for an oral-pharyngeal swallow evaluation. Level of evidence, low; benefit, substantial; grade of recommendation, B

4. Patients with cough related to pneumonia and bronchitis who have received medical diagnoses and conditions associated with aspiration (Table 1) should be referred, ideally to a SLP, for an oral-pharyngeal swallow evaluation. Level of evidence, low; benefit, substantial; grade of recommendation, B

5. Patients with a reduced level of consciousness are at high risk for aspiration and should not be fed orally until the level of consciousness has improved. Level of evidence, low; benefit, substantial; grade of recommendation, B

6. Alert patients with cough who are in high-risk groups for aspiration (Table 1) should be observed drinking small amounts of water (3 oz). If the patient coughs or shows clinical signs that are associated with aspiration (Tables 2, 3), the patient should be referred for a detailed swallowing evaluation, preferably to a SLP. Level of evidence, low; benefit, substantial; grade of recommendation, B

7. In patients with cough, the value of the subjective assessment of VC as the sole predictor of aspiration is uncertain because of poor reliability and an unclear association with evaluation. Level of evidence, low; benefit, conflicting; grade of evidence, I

8. The assessment of the RC response to inhaled irritants as a predictor of aspiration risk and subsequent pneumonia is not recommended due to a lack of adequate supportive studies. Level of evidence, low; benefit, conflicting; grade of evidence, I

9. In acute stroke patients, the expulsive phase rise time of VC may predict aspiration. The use of this test has not been validated in other patient groups, and further studies comparing the accuracy of objective measures of VC to the clinical swallow evaluation to identify aspiration risk are needed. Level of evidence, low; benefit, small; grade of recommendation, C

10. Patients with dysphagia should undergo VSE or FEES evaluation of swallow to identify appropriate treatment. Level of evidence, low; benefit, substantial; grade of recommendation, B

11. Patients with dysphagia should be managed by organized multidisciplinary teams that may include a physician, a nurse, an SLP, a dietitian, and physical and occupational therapists. Level of evidence, low; benefit, substantial; grade of recommendation, B

12. In patients with dysphagia, VSE or FEES can be useful for determining compensatory strategies enabling patients with dysphagia to safely swallow. Level of evidence, low; benefit, substantial; grade of recommendation, B

13. In patients with dysphagia, dietary recommendations should be prescribed when indicated, and can be refined by testing with foods and liquids simulating those in a normal diet during the VSE or FEES. Level of evidence, low; benefit, substantial; grade of recommendation, B

14. For patients with muscular weakness during swallowing, muscle strength training, with or without electromyographic biofeedback, and electrical stimulation treatment of the swallowing musculature are promising techniques but cannot be recommended at this time until further work in larger populations is performed. Level of evidence, low; benefit, conflicting; grade of evidence, I

15. Patients with intractable aspiration may be considered for surgical intervention. Level of evidence, low; benefit, substantial; grade of recommendation, B

References

1 Ding R, Logemann JA. Pneumonia in stroke patients: a retrospective study. Dysphagia 2000; 15:51–57

2 Robbins J, Coyle J, Rosenbek J, et al. Differentiation of normal and abnormal airway protection during swallowing using the penetration-aspiration scale. Dysphagia 1999; 14: 228–232

3 Feinberg MJ, Ekberg O. Deglutition after near-fatal choking episode: radiologic evaluation. Radiology 1990; 176:637–640

4 Thach BT. Maturation and transformation of reflexes that protect the laryngeal airway from liquid aspiration from fetal to adult life. Am J Med 2001; 111(suppl):69S–77S

5 Logemann JA. Evaluation and treatment of swallowing disorders. San Diego, CA: College-Hill Press, 1983

6 Plant RL, Schechter GL, eds. Dysphagia in children, adults and geriatrics. Philadelphia, PA: WB Saunders, 1998

7 Derkay CS, Schechter GL. Anatomy and physiology of pediatric swallowing disorders. Otolaryngol Clin North Am 1998; 31:397–404

8 Pikus L, Levine MS, Yang YX, et al. Videofluoroscopic studies of swallowing dysfunction and the relative risk of pneumonia. AJR Am J Roentgenol 2003; 180:1613–1616

9 Rosenbek JC, McCullough GH, Wertz RT. Is the information about a test important? Applying the methods of evidence-based medicine to the clinical examination of swallowing. J Commun Disord 2004; 37:437–450

10 Daniels SK, Brailey K, Priestly DH, et al. Aspiration in patients with acute stroke. Arch Phys Med Rehabil 1998; 79:14–19
11 Mann G, Hankey GJ, Cameron D. Swallowing function after stroke: prognosis and prognostic factors at 6 months. Stroke 1999; 30:744–748
12 Smith-Hammond CA, New KC, Pietrobon R, et al. Prospective analysis of incidence and risk factors of dysphagia in spine surgery patients: comparison of anterior cervical, posterior cervical, and lumbar procedures. Spine 2004; 29:1441–1446
13 Loeb M, McGeer A, McArthur M, et al. Risk factors for pneumonia and other lower respiratory tract infections in elderly residents of long-term care facilities. Arch Intern Med 1999; 159:2058–2064
14 Vergis E, Breunen C, Wagener M. Pneumonia in long-term care: a prospective case control study of risk factors and impact on survival. Arch Intern Med 2001; 161:2378–2381
15 Langmore SE, Terpenning MS, Schork A, et al. Predictors of aspiration pneumonia: how important is dysphagia? Dysphagia 1998; 13:69–81
16 Smith CH, Logemann JA, Colangelo LA, et al. Incidence and patient characteristics associated with silent aspiration in the acute care setting. Dysphagia 1999; 14:1–7
17 McCullough GH, Wertz RT, Rosenbek JC. Sensitivity and specificity of clinical/bedside examination signs for detecting aspiration in adults subsequent to stroke. J Commun Disord 2001; 34:55–72
18 Mari F, Matei M, Ceravolo MG, et al. Predictive value of clinical indices in detecting aspiration in patients with neurological disorders. J Neurol Neurosurg Psychiatry 1997; 63: 456–460
19 Logemann JA, Veis S, Colangelo L. A screening procedure for oropharyngeal dysphagia. Dysphagia 1999; 14:44–51
20 Horner J, Massey EW, Brazer SR. Aspiration in bilateral stroke patients. Neurology 1990; 40:1686–1688
21 Stephens RE, Addington WR, Widdicombe JG. Effect of acute unilateral middle cerebral artery infarcts on voluntary cough and the laryngeal cough reflex. Am J Phys Med Rehabil 2003; 82:379–383
22 Aviv JE, Martin JH, Keen MS, et al. Air pulse quantification of supraglottic and pharyngeal sensation: a new technique. Ann Otol Rhinol Laryngol 1993; 102:777–780
23 Aviv JE, Sacco RL, Thomson J, et al. Silent laryngopharyngeal sensory deficits after stroke. Ann Otol Rhinol Laryngol 1997; 106:87–93
24 Higenbottam T, Jackson M, Woolman P, et al. The cough response to ultrasonically nebulized distilled water in heart-lung transplantation patients. Am Rev Respir Dis 1989; 140:58–61
25 Ferrari M, Olivieri M, Sembenini C, et al. Tussive effect of capsaicin in patients with gastroesophageal reflux without cough. Am J Respir Crit Care Med 1995; 151:557–561
26 Katsumata U, Sekizawa K, Ebihara T, et al. Aging effects on cough reflex. Chest 1995; 107:290–291
27 Sekizawa K, Ujiie Y, Itabashi S, et al. Lack of cough reflex in aspiration pneumonia. Lancet 1990; 335:1228–1229
28 Ebihara S, Saito H, Kanda A, et al. Impaired efficacy of cough in patients with Parkinson disease. Chest 2003; 124:1009–1015
29 Fontana G, Pantaleo T, Lasvorini F, et al. Defective motor control of coughing in Parkinson's disease. Am J Respir Crit Care Med 1998; 158:458–464
30 Fontana GA, Pantaleo T, Lavorini F, et al. Coughing in laryngectomized patients. Am J Respir Crit Care Med 1999; 160:1578–1584
31 Smith PE, Wiles CM. Cough responsiveness in neurogenic dysphagia. J Neurol Neurosurg Psychiatry 1998; 64:385–388
32 Niimi A, Matsumoto H, Ueda T, et al. Impaired cough reflex in patients with recurrent pneumonia. Thorax 2003; 58:152–153
33 Nakajoh K, Nakagara T, Sekizawa K, et al. Relation between incidence of pneumonia and protective reflexes in post-stroke patients with oral or tube feeding. J Intern Med 2000; 247:39–42
34 Addington WR, Stephens RE, Gilliland KA. Assessing the laryngeal cough reflex and the risk of developing pneumonia after stroke: an interhospital comparison. Stroke 1999; 30: 1203–1207
35 Watando A, Ebihara S, Ebihara T, et al. Daily oral care and cough reflex sensitivity in elderly nursing home patients. Chest 2004; 126:1066–1070
36 Smith Hammond C, Golstein L, Zajac D, et al. Assessment of aspiration risk with quantification of voluntary cough. Neurology 2001; 56:502–506
37 Goldstein L, Chilkuri V. Retrospective assessment of initial stroke severity with the Canadian Neurological Scale. Stroke 1997; 28:1181–1184
38 Chaudri M, Liu C, Hubbard R, et al. Relationship between supraximal flow during cough and mortality in motor neurone disease. Eur Respir J 2002; 19:434–438
39 American Speech-Language-Hearing Association. Scope of practice in speech-language pathology. Rockville, MD: American Speech-Language-Hearing Association, 2001
40 American Speech-Language-Hearing Association. Guidelines for speech-language pathologists performing videofluoroscopic swallowing studies. ASHA Suppl 2004; 24:77–92
41 Agency for Health Care Policy and Research. Diagnosis and treatment of swallowing disorders (dysphagia) in acute-care stroke patients: evidence report/technology assessment, No. 8. Washington, DC: Agency for Health Care Policy and Research, US Dept. of Health and Human Services, 1999; AHCPR Publication No. 99-E024
42 Langmore SE, Schatz K, Olsen N. Fiberoptic endoscopic examination of swallowing safety: a new procedure. Dysphagia 1988; 2:216–219
43 American Gastroenterological Association. Medical position statement on management of oropharyngeal dysphagia. Gastroenterology 1999; 116:452–454
44 Englert J, Davis K, Koch K. Using clinical practice analysis to improve care. Jt Comm J Qual Improv 2001; 27:291–301
45 Newell S, Englett J, Box-Taylor A, et al. Clinical efficiency tools improve stroke management in a rural southern health system. Stroke 1998; 29:1092–1098
46 Rasley A, Logemann J, Kahrilas P, et al. Prevention of barium aspiration during videofluoroscopic swallowing studies: value of change in posture. AJR Am J Roentgenol 1993; 160:1005–1009
47 Kuhlemeier K, Palmer J, Rosenberg D. Effect of liquid bolus consistency and delivery method on aspiration and pharyngeal retention in dysphagic patients. Dysphagia 2001; 16:119–122
48 Daniels SK, Corey DM, Hadskey LD, et al. Mechanism of sequential swallowing during straw drinking in healthy young and older adults. J Speech Lang Hear Res 2004; 47:33–45
49 Khoshoo V, Ross G, Kelly B, et al. Benefits of thickened feeds in previously healthy infants with respiratory syncytial viral bronchiolitis. Pediatr Pulmonol 2001; 31:301–302
50 Shaker R, Kern M, Bardan E, et al. Augmentation of deglutitive upper esophageal sphincter opening in the elderly by exercise. Am J Physiol 1997; 272:G1518–G1522
51 Shaker R, Easterling C, Kern M. Rehabilitation of swallowing by exercise in tube-fed patients with pharyngeal dysphagia secondary to abnormal UES opening. Gastroenterology 2002; 122:1314–1321

52 Fujiu M, Logemann J. Effect of a tongue-holding maneuver on posterior pharyngeal wall movement during deglutition. Am J Speech Lang Pathol 1996; 5:23–30
53 Huckabee M, Cannito M. Outcomes of swallowing rehabilitation in chronic 8: 284- brainstem dysphagia: a retrospective evaluation. Dysphagia 1999; 14:93–109
54 Leelamanit V, Limsakul C, Gester A. Synchronized electrical strimuation in treating pharyngeal dysphagia. Laryngoscope 2002; 112:2204–2210
55 Freed M, Freed L, Chatburn R. Electrical stimulation for swallowing disorders caused by stroke. Respir Care 2001; 46:466–474
56 Arai T, Yasuda Y, Taakaya T. ACE inhibitors and symptomless dysphagia. Lancet 1998; 352:115–116
57 Arai T, Yasuda Y, Toshima S. ACE inhibitors and pneumonia in elderly people. Lancet 1998; 352:1937–1938
58 Arai T, Yasuda Y, Taakaya T, et al. Angiotensin-converting enzyme inhibitors, angiotensin II receptor antagonists, and symptomless dysphagia. Chest 2000; 117:1819–1820
59 Broniatowski M, Grundfest-Broniatowski S, Tyler D, et al. Dynamic laryngotracheal closure for aspiration: a preliminary report. Laryngoscope 2001; 111:2032–2040
60 Laccourreye O, Brasnu D, Muscatello L, et al. Supracricoid partial laryngectomies in the elderly: mortality, complications, and functional outcome,. Laryngoscope 1998; 108:237–242
61 Naudo P, Laccourreye O, Weinstein G, et al. Complications and functional outcome after supracricoid partial laryngectomy with cricohyoidoepiglottopexy. Otolaryngol Head Neck Surg 1998; 118:124–129
62 Castellanos P. Method and clinical results of a new transthyrotomy closure of the supraglottic larynx for the treatment of intractable aspiration. Ann Otol Rhinol Laryngol 1997; 106: 451–460