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Assessment of Airway Defenses in the Neurologically Impaired Patient

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Impairment of cough and swallow is a potential consequence of neurological dysfunction that places affected patients at increased risk for respiratory compromise and death. Nurses are critical to early identification and frequent screening of airway defense mechanisms to reduce aspiration risk and improve clinical outcomes in patients with neurological impairment.

The human airway is protected by various defense mechanisms that manifest as a continuum of behaviors, including cough (corrective mechanism) and swallow (preventive mechanism) (Pitts et al., 2013; Troche, Brandimore, Godoy, & Hegland, 2014). Cough and swallow mechanisms are controlled by a complex and integrated network involving both the central and peripheral nervous systems. Damage to this network can occur from head injury, stroke, or neurodegenerative disease. Neurologic diseases and injury are associated with declined respiratory muscle strength, impaired airway defenses, and increased risk of uncompensated aspiration, defined as an absence of corrective airway defense responses with no attempt to correct inhaled foreign matter. Aspiration may contribute to lung infection (Pitts et al., 2012; Sanches et al., 2014; Thompson et al., 2014).

Nurses have a critical role in early identification and screening of patients at risk for impaired airway defense mechanisms. Although nurses routinely conduct neurological assessments, they may not be familiar with the importance of effective cough and swallow physiology as indicators of neurological dysfunction. An overview of the neural bases of cough and swallow, relevant terminology related to cough and swallow (see Table 1), and a brief review of guidelines for screening and referral is presented.

TABLE 1.
Airway Protection Terminology

Term	Definition
Dysphagia	Difficulty swallowing
Dystussia	Inadequate cough
Atussia	Inability to cough
Apnea	Lack of breathing
Aspiration	Ingestion of foreign substances or particles into the airway
Augmented (quad) coughing	Modified or assisted coughing accomplished by placement of hands on the anterolateral base of the lungs, serves to increase abdominal pressure and aid in production of a forceful cough
Urge to Cough	Cognitive sensation driving reflex cough response
Uncompensated aspiration	Absence of corrective airway defense responses with no attempt to correct inhaled foreign matter

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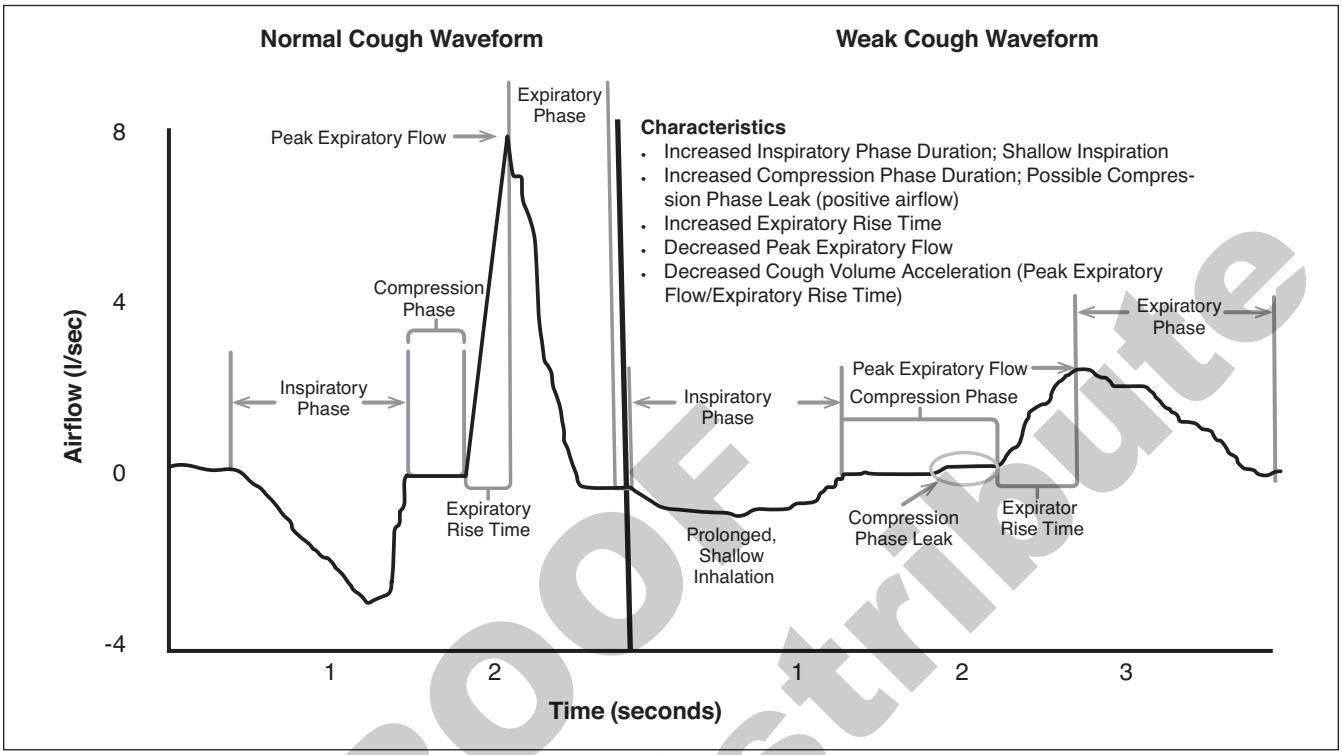
FIGURE 1.
Comparison of Weak and Strong Cough Waveforms



Note: Cough strength is judged through application of quantitative and qualitative factors as depicted in this illustration within the context of an aerodynamic cough signal. When cough is weakened, an overall slowing of the cough response cycle and attenuation of key aerodynamic measures occur. For additional information on cough patterns, see Pitts and coauthors, 2013.

Source: Original illustration from Voice & Speech Physiology Clinical Lecture of Erin Silverman, PhD, CCC-SLP.

Neural Control of Cough

Cough is an airway defense mechanism designed to correct aspiration and clear the airway (Pitts, 2014). Cough is a cortical and subcortical process, and the perception of airway stimuli is mediated cortically except in advanced coma states (Mazzone et al., 2013; van den Bergh, van Diest, Dupont, & Davenport, 2012). Consequently, neuropathological conditions affecting either subcortical or cortical structures may produce alterations in both reflexive and voluntary cough (Hegland, Bolser, & Davenport, 2012).

Typically, mechanical and chemical irritation of the airways stimulates sensory receptors, signaling the central nervous system via afferent neural pathways. This elicits a cognitive sensation referred to as *urge-to-cough* (UTC) (Janssens et al., 2014), which is followed closely by a reflex cough response produced to protect the airway through active expulsion of foreign material. If the cough stimulus is sufficient to surpass cough sensory thresholds and initiate a cough response, a gated sequence of stereotypical motor behaviors will occur (see Figure 1).

The ability of cough to clear the airway effectively can be compromised through sensory impairment (e.g., cough threshold is elevated, preventing stimulation of the urge to cough and subsequent cough response) and/or motor weakness. In the case of motor weakness, reduced force-generating capacity within the cough musculature may have a variable effect on inspiration (weak or shallow inspiratory effort), glottal closure (incomplete glottal closure), or cough expulsion (slowed or diminished release of subglottal air to clear aspirate). See Figure 1 for a visual depiction of an aerodynamic signal representing effective versus ineffective cough.

If sensory and/or cough motor capabilities are compromised, the individual risks uncompensated aspiration and subsequent lung infection or aspiration pneumonia (Taylor-Clark, 2015). Sensory and/or motor impairment of cough is identified clinically as *dystussia*. Absence of a cough response to stimulation with silent aspiration is *atussia*, and both conditions represent breakdown within the airway defense mechanisms (Bolser, Gestreau, Morris, Davenport, & Pitts, 2013).

Neural Control of Swallowing

Normal human swallowing consists of a rapid series of muscular contractions that result in pre-

dictable patterns of displacement of various upper airway structures. Initiation of oral swallow is a voluntary process with initial patterns of cortical activation evident within the lateral precentral gyri, postcentral gyri, supplementary motor area, and insular cortex (Aida et al., 2015). Once swallow is initiated, the associated rhythmic movements of the tongue and jaw are controlled by central pattern generators located within the brainstem (trigeminal nucleus, reticular formation). Sensory inputs to these areas activate the internal branch of the superior laryngeal nerve as well as the pharyngeal branch of the glossopharyngeal nerve (Bolser, Pitts, Davenport, & Morris, 2015), triggering the pharyngeal swallow response. Components of this response extend far beyond the pharynx, encompassing pharyngeal peristalsis, glottal closure, and opening of the upper esophagus during a complex, multi-system reconfiguration of a common brainstem control assembly governing the interrelated processes of respiration and swallowing (Matsuo & Palmer, 2015).

Pathophysiology of Impaired Airway Defenses

Neurological injury may have deleterious effects on mechanisms of airway defense. Cough and/or swallow frequently are impaired as a result of trauma (e.g., stroke, tumor, traumatic brain injury), iatrogenic causes (e.g., medications, surgery), or neurodegenerative conditions (e.g., amyotrophic lateral sclerosis, Parkinson's disease [PD], Alzheimer's disease, multiple sclerosis, Huntington's disease) (Abdel `Jalil, Katzka, & Castell, 2015; Sanches et al., 2014). In patients with PD, aspiration pneumonia is one of the leading causes of death (Matsumoto et al., 2014) and is likely attributable to ineffective airway clearance (Hegland, Okun, & Troche, 2014). These impairments can manifest as either sensory (decrease in the perceived need to cough or swallow) or motoric (disrupted cough or swallow motor sequencing or reduced displacement of airway structures secondary to muscular weakness) in nature (Pitts et al., 2013).

Inability to clear the airway places the patient at increased risk for aspiration pneumonia (AP). A strong association exists among dystussia, dysphagia, and aspiration, and together they increase the probability of aspiration in patients with neurological disease (Bolser et al., 2013). While 5%-15% of all pneumonia cases can be attributed to aspiration, patients with AP are older and more likely to die (30-day mortality rate 21%) than patients with community-acquired pneumonia (Lanspa, Jones, Brown, & Dean, 2013). Assessment of cough and swallow thus is critical for nurses caring for patients with neurologic injury or dysfunction.

Nursing Assessment

Following a standard respiratory assessment (Miller, Owens, & Silverman, 2015), patients at increased risk for impaired airway defense should undergo specific screening of cough and swallow function to elucidate these potential deficits and refer for additional assessment by a specialist (e.g., speech-language pathologist [SLP]). Screening should encompass review of the patient's history and risk factors for impairment of airway defense mechanisms, screening of mental status (due to the role of cortical processing of airway stimuli), and brief assessment of swallow and cough. As review of a thorough mental status examination is beyond the scope of this article, the following will focus on cough and swallow.

Clinical Assessment of Cough

No universally accepted bedside tools exist for screening of effective cough function (Silverman et al., 2016). Thus, clinical cough assessments often are based on subjective measures, including cough sounds and strength (Silverman et al., 2014). Birring and Spinou (2015) recommended a combination of subjective and objective tools to assess cough clinically. Though informal, procedures for screening cough function have been useful in predicting aspiration risk in patient groups, and serve as a useful adjunct to standard bedside clinical swallow assessments (Hegland et al., 2014).

In clinical settings, cough is assessed most frequently by listening (Ludlow, 2015). In most cases, weak or ineffective cough can be distinguished audibly from strong cough through observation of perceptual qualities, such as loudness and sharpness. Ineffective cough will appear weak or sluggish, with a diminished explosive quality suggestive of weak or incomplete glottal closure. To assess voluntary cough, the nurse should help the patient to an upright position to maximize thoracic expansion. This also allows increased diaphragmatic excursion due to downward shift of internal organs from gravity. Standing to the side of the patient, the nurse should instruct the patient to take a deep breath, hold for 3 seconds, and cough as deeply as possible. If the patient has an abdominal or chest incision, he or she can hold a pillow or rolled blanket over the incision (splinting) for support and pain reduction during coughing (Hoch, 2016).

Aerodynamically, effective cough is the product of quick expiration of a large volume of air. These variables can be captured from the cough aerodynamic signal and quantified as peak expiratory airflow (PEF; volume) and cough volume acceleration (rate). Cough volume acceleration is difficult to measure clinically as it requires a pneumotachograph and related equipment. However, PEF is obtained easily through use of inexpensive handheld peak flow meters, available as analog or digital devices. Historically used as a measure of airway obstruction, PEF also serves as a measure of cough strength. Normative PEF values vary based on age, height, and sex. In patient groups, reductions in PEF (<2.9 l/sec for patients with stroke; <5.24 l/sec in patients with PD; <3.97 l/sec in amyotrophic lateral sclerosis) have been associated with

increased risk of aspiration (Hegland et al., 2014; Plowman et al., 2016). Voluntary cough peak flow measurements are related to PD severity and serve as a noninvasive screening for aspiration risk (Silverman et al., 2014).

Aside from easily executed auditory-perceptual and airflow measures of cough, reflexive cough can be assessed through inhalation of an aerosolized tussive stimulus such as capsaicin. These measures are not used commonly in clinical settings because of the need for sophisticated equipment and clearance for use of a tussive stimulus such as capsaicin. In the interest of providing a comprehensive overview, however, the process of reflexive cough assessment warrants mention. Cough threshold can be determined by measuring the concentration of the aerosolized stimulus that elicits a cough response (Ludlow, 2015). Preceding the reflex cough is the cognitive sensation of UTC (Hegland et al., 2012). Reduced UTC may result in a suppressed, delayed, or weak cough response following inhalation of a tussive stimulus, placing the individual at increased risk for uncompensated aspiration. UTC measures can be obtained using a modified Borg scale (0=no UTC, 10=maximum UTC) and asking the patient to rate his or her UTC following presentation of the tussive stimulus (Silverman et al., 2016).

A patient with pronounced neuromuscular weakness may not be able to generate sufficient airway pressure. Augmented coughing (quad coughing) can benefit this patient; the provider places both hands on the anterolateral base of the patient's lungs to increase abdominal pressure and aid in production of a forceful cough (Arbour, 2016). If the patient is not able to produce a forceful cough to clear the airway, further intervention is required. Cough assessment may be contraindicated in the patient who is recovering from abdominal/thoracic surgery or is at risk for increased intracranial pressure.

Clinical Assessment of Swallow

The American Heart Association, American Stroke Association, and Veterans Health Administration (VHA) established swallow screening as a protocol before administration of any food, liquid, or medication to patients admitted under suspicion of acute stroke (Donovan et al., 2013). The VHA in particular mandated all initial nursing assessments include swallow screening (Daniels, Anderson, & Petersen, 2013). In spite of ubiquitous recognition of the importance of swallow screening in hospital settings, little consensus exists for best practice. This lack of consensus, coupled with a lack of empirical evidence to support or refute the usefulness of bedside swallow screening procedures, led The Joint Commission to rescind its stroke dysphagia screening guidelines (STK-7) in 2010 (Donovan et al., 2013; Morrison, 2014).

According to the American Speech-Language-Hearing Association (ASHA, 2014), the process of inpatient swallow screening involves nurses playing an integral role in three out of five of the swallow screening models. Screening itself can take many different forms, from physiological screens involving assessment of signs and symptoms of airway compromise following intake of small amounts of water (coughing or sputtering), voice changes following swallow (wet or gurgly voice), changes in respiratory pattern, or marked change in peripheral capillary oxygen saturation before and after swallow (O'Horo, Rogus-Pulia, Garcia-Arguello, Robbins, & Safdar, 2015). Other screening tools consist of questions posed to the patient or caregiver about risk factors for aspiration. These questions can take the form of a decision tree, with screening continuing until at least one response acts as a trigger to suggest further assessment is warranted. At this point, the patient is referred to an SLP for comprehensive assessment of swallow. Donovan and coauthors (2013) offered a fairly comprehensive overview of various screening protocols. Of the tools reviewed, nurses often administer the Toronto Bedside Swallowing Screening Test (TOR-BSST) (Martino, Maki, & Diamant, 2014), 3-ounce water swallow test, Standardized Swallow Assessment, Gugging Swallow Screen (GUSS) (Sebastian, Nair, Thomas, & Tyagi, 2015), and the Barnes Jewish Hospital Stroke Dysphagia Screen (Edmiaston, Connor, Steger-May, & Ford, 2014). The Nurse Dysphagia Screen Tool (Cummings et al., 2015) provides a thorough four-step process of observation (e.g., decreased alertness), instruction (asking patient to cough and swallow), and two water challenges with observation of risk factors. Dysphagia screening tool selection varies based on institutional preference and available healthcare professionals, as well as the evolving science of dysphagia assessment and management. Regardless of screening tool used, precautions of no oral intake are implemented commonly while the patient awaits further assessment (ASHA, 2014).

Nursing Implications

Patients with neurologic disease frequently have impaired airway protection, predisposing them to aspiration (Bolser et al., 2013; Silverman et al., 2016). Identifying patients at risk for cough and swallow deficits can decrease the incidence of aspiration pneumonia (Cummings et al., 2015). Because nurses often are the clinical service providers first encountered by patients on admission to a healthcare facility, they hold a central role in determination of a patient's ability to tolerate food, liquid, or medications by mouth. Nurses are critical in the early identification of risk for impaired airway protection and subsequent aspiration in the neurologically impaired patient. Following a standard respiratory assessment, a focused inspection of cough and swallow can identify airway clearance weaknesses and offers specific clinical indicators of respiratory function and airway protection. If identified, deficits in airway protective mechanisms should be evaluated with a more comprehensive assessment by a credentialed SLP (ASHA, 2014).

Instructions For Continuing Nursing Education Contact Hours

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Conclusion

Cough is an important airway protective mechanism (Irwin, French, Zelman-Lewis, Diekemper, & Gold, 2014; Pitts et al., 2014). Impairment of cough and swallow is a potential consequence of neurological dysfunction that places affected patients at increased risk for respiratory compromise and death. Nurses are critical to early identification and frequent screening of airway defense mechanisms to reduce aspiration risk and improve clinical outcomes in patients with neurological impairment. They assess mentation and respiratory condition, review risk factors, evaluate cough quality, measure peak cough airflow (if indicated), and perform bedside screening of swallow function. MSN

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