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Toolbox for Tracheostomy Issue

In this Issue:

Considerations for tools used for voice, respiratory, and swallowing disorders in patients with tracheostomies

Volume 8, Issue 1

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Welcome to Passy-Muir, Inc.'s *Aerodigestive Health*:

Considerations for the Clinical Toolbox

Welcome to this issue of *Aerodigestive Health*. The focus of this publication is to provide education and clinically relevant information for patients with tracheostomies and the safe and efficacious use of the Passy Muir® Tracheostomy & Ventilator Swallowing and Speaking Valve (PMV®). Each edition of *Aerodigestive Health* features articles and other resources specifically tailored to a topic related to the care of adult and pediatric patients, with a focus on those who are tracheostomized, including those with or without mechanical ventilation. The Editor's objective is to provide readers with clinical perspectives and cutting-edge research to address specific questions raised by practitioners relating to the care of patients.

In this edition, you will find these key elements:

- Editor's commentary – An overview of the publication topic.
- Healthcare practitioners' perspectives – Articles by healthcare professionals on clinical issues and interventions.
- Clinical take-home boxes – Relevant clinical information for healthcare practitioners, including protocols and research summaries.

For this issue, the primary focus is the ***Clinical Toolbox***. Determining the appropriateness of interventions and the type of interventions to be provided can be a daunting task, especially when considering patients with tracheostomies. Questions often arise regarding treatment interventions and how to determine the best practices. Often, clinicians are left searching for what type of therapy tool will best meet the needs of their patients. Questions also arise regarding the efficacy of some therapy tools and how to select what fits patients' needs. This issue provides a unique overview of several types of therapy tools and devices. From respiratory muscle strength training, electrical stimulation, and lingual strengthening tools to interventions related specifically to the tracheostomy, this issue of *Aerodigestive Health* provides articles that review the evidence and provide clinical considerations for implementing various tools into clinical practice. It is imperative that clinical professionals have awareness of evidence-based practices and current standards of care.

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This issue of *Aerodigestive Health* also brings together perspectives that present considerations for tools used for voice, respiratory, and swallowing disorders, with a primary focus on patients with tracheostomies. In this issue, Lewis reviews respiratory muscle training and its implications for patients. She presents considerations for both inspiratory and expiratory training with pressure threshold devices and the rationale for use with patients with tracheostomies.

Dumican delves into sensorimotor changes that occur following a tracheostomy and how neuromuscular electrical stimulation may be implemented for patients with dysphagia and tracheostomies. He reviews electrode placement considerations and the impact that perturbation may have on laryngeal closure and airway protection. This viable therapeutic intervention for patients with tracheostomies does carry certain special considerations, and Dumican reviews them.

Puno and Sutt introduce a newer therapy modality that is being used in the UK and, more recently, in the United States. They share their perspective on introducing a Phagenyx into their medical facility and how they garnered success. They also share two case studies related to implementing this new therapy option.

A consideration for patients with tracheostomies that is not discussed much is the impact of lingual strength on airway protection and pressure generation – both key components of recovery for patients with tracheostomies. In the article by Bice, he reviews considerations for lingual weakness and options for improving lingual strength.

Having a clinical toolbox and being well-prepared is important for practicing clinicians. The Clayton article addresses inhalation burn injury and considerations for the role of the speech-language pathologist for both the care pathway and treatment considerations. Samra walks us through a patient case study and reviews what tools she used and how she implemented them into her patient's plan of care. In this article, she illustrates care from education of both patient and staff to incorporating therapies to support patient recovery, leading to decannulation.

This issue is rounded out by an article from Ortiz, shifting to considerations for the tracheostomy itself and reviewing the importance of humidification. She addresses options for the tracheostomy and for meeting the needs of the patient to have proper humidification and avoid complications. Why every patient with a tracheostomy should have a heat and moisture exchanger or a humidifier is addressed.

These articles discuss various tools for clinicians to evaluate for their toolbox. What therapies to consider and best practices for patients with tracheostomies are addressed. Some of the therapy modalities have special considerations for patients with tracheostomies related to placement and use. Being fully aware of the benefits, contraindications, and proper techniques is essential for best care. When considering therapies, if the patient has a Passy Muir Valve and more normal physiologic function has been restored by closing the system, then the therapeutic options are often the same as what we would do for a patient who does not have a tracheostomy. Pullens and Streppel (2021) discussed the importance of restoring normal airway physiology to assist with feeding and swallowing, which would include restoring pressures. When the system is restored to a more normal pressurized system, then the therapy considerations often revert to standard practices for the identified issues. If the patient has poor voice, swallowing, or respiratory function, then initiating therapies that address these areas would be appropriate. However, several of the presented techniques require special training and understanding of how to implement them, with special consideration for the tracheostomy. In this issue, the authors share therapeutic interventions regardless of tracheostomy presence and address special considerations for patients with tracheostomies.

The primary takeaways from this issue are that having appropriate staff training improves overall care for the patient with a tracheostomy, and treatment interventions with this patient population may require modification secondary to the tracheostomy. Appropriate assessment is key to successful interventions. The sooner clinicians have their **CLINICAL TOOLBOX**, the better for both the patient and their recovery.

Kristin A King PhD, CCC-SLP

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About the Editor

With over 25 years of experience in medical settings, academia, and industry, Dr. King brings a unique perspective to care of patients with medical diagnoses. Her experience included a clinical focus on critical care and trauma, with an emphasis on TBI and tracheostomy and vent patients. As a professor, she conducted research and published in peer-reviewed journals on TBI and swallowing disorders. She continues her career by working in the industry to improve patient outcomes through the development of multi-media education and participating in product development and regulatory requirements for medical devices. She is the host of the CAM Podcast for Passy Muir, editor of Aerodigestive Health by Passy Muir, and contributes regularly at the state, national, and international levels for both speaking and clinical papers. She also is co-editor of the book *Tracheostomy and Ventilator Dependence in Adults and Children: Learning Through Case Studies*.

Upcoming Issues:

If you have an interest in submitting or writing for one of our upcoming issues, please contact me at ***aerodigest@passymuir.com***.

Clinical Toolbox: Managing Voice, Swallowing, and Respiratory Changes for Patients with Tracheostomies and Mechanical Ventilation

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Tracheotomy, the surgical creation of an opening through the neck into the trachea, is a critical intervention for patients requiring long-term mechanical ventilation, airway protection, and secretion management. While lifesaving, a tracheostomy introduces significant changes to the physiology of voice production, swallowing, and respiration. These changes often pose challenges for patients and clinicians tasked with managing the patients' complex needs.

An integrated, multidisciplinary toolbox is essential to assess, monitor, and rehabilitate voice, swallowing, and respiratory functions in this patient population. This issue of *Aerodigestive Health* focuses on clinical tools available for use with patients following tracheostomies. It includes articles specific to some of the primary tools available to clinicians, including speech-language pathologists (SLP), respiratory therapists (RT), nurses, and physicians, to address changes secondary to a tracheostomy and to optimize patient outcomes.

Multidisciplinary Team Roles

- **SLP:** Assess candidacy by evaluating airway patency, cuff status, and patient tolerance of changes. Evaluate and treat voice and swallowing, as needed.
- **RT:** Assess candidacy by evaluating airway patency, cuff status, and patient tolerance of changes. Manage the ventilator for appropriate modes, settings, and alarms to ensure adequate ventilation during communication options that require cuff deflation.
- **Nursing:** Collaborate with RTs and SLPs to monitor oxygen saturation and respiratory effort. Provide support for patient use of communication options once evaluated.

Voice and Communication Tools

Patients with tracheostomies and inflated cuffs have impaired communication and voicing due to a lack of airflow through the upper airway and through the vocal folds for voice generation. As patients' rights include access to effective communication and, therefore, participation in their healthcare, it is essential that clinicians have tools that assist with restoring the voice and providing patients with functional communication. Research has also shown that access to their voice and communication reduces the risk of ICU delirium and has significant psychological benefits for patients (Freeman-Sanderson et al., 2018; Freeman-Sanderson et al., 2021). Ideally, the form of communication restored for a patient is the primary form they used prior to injury or illness.

Clinical Application

1. Speaking Valves (e.g., Passy Muir® Tracheostomy & Ventilator Swallowing and Speaking Valve)

One of the most effective tools for restoring vocal communication in patients with tracheostomies is the speaking valve. The Passy-Muir Tracheostomy & Ventilator Swallowing and Speaking Valve (PMV®) is the only bias-closed, no-leak speaking Valve which allows air to be inhaled through the tracheostomy tube but redirects 100% of exhaled air out through the vocal folds, enabling phonation and many other evidence-based benefits. Use of a no-leak speaking valve has been shown in research to restore verbal communication, improve swallowing, enhance secretion management, and normalize subglottic pressure (O'Connor et al., 2019).

2. Electrolarynx and AAC Devices

For patients who cannot tolerate speaking valves due to significant vocal fold damage or upper airway obstruction, alternative methods like electrolarynx devices or augmentative and alternative communication (AAC) tools (e.g., communication boards, tablet-based apps) can facilitate communication (Beukelman & Light, 2020). An electrolarynx with proper placement can be used to generate sound during the mouthing of speech, while communication boards and communication-based apps may provide ready access

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ready access to basic wants and needs through text to speech or the use of icons. In determining a mode of communication, the clinician must consider cognitive ability, motor skills, and patient preferences.

3. Cuff Management and Leak Speech

Some patients may achieve phonation through "leak speech" when the tracheostomy cuff is partially deflated or the tracheostomy tube is fenestrated. A small amount of air escapes around the tube and through the vocal folds, allowing for some voicing, although the quality may be variable (Zaga et al., 2023; Wallace et al., 2022). This technique also requires appropriate ventilator management for the best voice production while maintaining appropriate ventilatory support.

4. Above the Cuff Vocalization (ACV)

ACV is a method for restoring airflow through the vocal folds and allowing for some vocalization. With this technique, a special tracheostomy tube with a subglottic port (a small opening above the cuff of the tracheostomy tube) is placed for the patient, the cuff is NOT deflated for this technique, and oxygen tubing is connected to provide airflow out the port to the upper airway and vocal folds. While this technique does allow for some vocalization, the voice quality is variable but audible and may be better than mouthing attempts (Wallace et al., 2022).

Swallowing Assessment and Rehabilitation Tools

1. Clinical Swallow Evaluation (CSE)

Following intubation or tracheostomy, early intervention with a non-instrumental bedside assessment conducted by SLPs to evaluate oral motor function, secretion management, and swallowing safety is vital for accurate swallowing assessment and planning (Wallace & McGrath, 2021).

2. Blue Dye Test (Cuff Deflation and Dye Protocol)

This controversial screening method has been shown to have limited sensitivity in detecting silent aspiration but contributes to the holistic perspective of the swallow and may assist in planning the timing of instrumental assessments (Belafsky et al., 2003; Lui et al., 2024). Therefore, it is recommended as a supplementary rather than a standalone tool.

3. Dysphagia Tools

A. Instrumental Assessments

For more information on dysphagia, assessment, and treatment for patients with tracheostomies, please see the following issues of *Aerodigestive Health*: Dysphagia Issue (2023); Special Edition: Collection of Key Articles (2022); Treatment Intervention (2022); and Protocol Issue (2019).

1) Fiberoptic Endoscopic Evaluation of Swallowing (FEES):

A flexible endoscope is inserted transnasally to visualize the pharyngeal phase of swallowing. FEES is effective for patients with tracheostomies, especially those unable to tolerate transport to radiology, and especially for those patients requiring mechanical ventilation. FEES has also been shown to assist with educating the multidisciplinary team and developing the plan for weaning and decannulation (Miles & Wallace, 2025).

2) Videofluoroscopic Swallow Study (VFSS):

Also known as a modified barium swallow study, VFSS provides dynamic imaging of all phases of swallowing and may assist in determining optimal management with patients following tracheostomies (Martin-Harris et al., 2008; Wallace & McGrath, 2021).

B. Swallowing Therapy Tools

1) Respiratory Muscle Strength Training (RMST):

Expiratory and inspiratory muscle training (EMT/IMT) has been proven beneficial for respiratory and swallowing muscle strengthening, particularly in neurogenic populations and more recently in patients with tracheostomies (Troche et al., 2010; Freeman-Sanderson et al., 2021; Brooks et al., 2021; Clayton et al., 2022).

2) Neuromuscular Electrical Stimulation (NMES):

Recent studies suggest NMES may be effective for improving swallowing in selected patients and may even shorten wean times for mechanical ventilation, although evidence remains mixed (Clark et al., 2009; Lui et al., 2023).

3) Lingual Strengthening Interventions:

With the high incidence of dysphagia in patients with tracheostomies (Skoretz et al., 2020), swallowing therapy may include lingual strengthening tasks. Lingual strength has been linked to pharyngeal residue and pressure generation (Fukuoka et al., 2022). Patients with

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tracheostomies have a loss of pressure due to the "hole" in their system, and they are at risk of increased pharyngeal residue and poor airway protection secondary to the loss of pressure. Addressing lingual strengthening for patients with dysphagia and tracheostomies may be key to lessening the risk of aspiration and enhancing decannulation potential.

4) Swallow Maneuvers and Exercises:

Interventions like the supraglottic swallow maneuver and effortful swallow are commonly used to enhance airway protection and swallowing function (Huckabee & Macrae, 2014; Kadri et al., 2024). For more information on dysphagia interventions, see the Dysphagia Issue of *Aerodigestive Health* (2023).

C. Diet Modification Tools

1) IDDSI Framework (International Dysphagia Diet Standardisation Initiative):

Provides standardized terminology and guidelines for modifying food and liquid textures, often used for patients with tracheostomies and dysphagia (Cichero et al., 2017; Howard et al., 2021).

2) Thickening Agents:

Commercial products used to increase liquid viscosity and reduce aspiration risk, although individual tolerance varies (Garcia et al., 2005).

Respiratory Management Tools

1. Cuff Pressure Manometers

Manometers are tools used to maintain appropriate cuff pressures, which is crucial for airway management and to reduce the risk of tracheal injury. Optimal range is reported to be 20 – 30 cmH_2O (Seegobin & van Hasselt, 1984; Credland, 2014), but ideally for patients with tracheostomies, pressure between 20 – 25 cmH_2O should be considered. Research has shown that pressure above 25 cmH_2O may start to impair swallow function (Amathieu et al., 2012). See the Special Edition: Collection of Key Articles for *Aerodigestive Health* (2022) for more information on cuff management and the Complex Diagnoses issue (2024) for more on transtracheal pressure measurements – another option for using a manometer to assess airway patency and to assist in the proper use and management of speaking valves with tracheostomies.

2. Humidification Systems

Because a tracheostomy bypasses natural humidification, artificial humidifiers (e.g., heat and moisture exchangers (HME) or heated humidifiers) are essential for maintaining mucociliary function (Hess, 2005) and decreasing suctioning requirements (Kearney et al., 2023). It also has been suggested that the use of humidification may even provide cost savings for the patient and facility (Kearney et al., 2023). Humidification may be provided for a patient both on and off mechanical ventilation. When using a humidifier, a speaking valve may be in place as long as the humidification does not have a medicated aerosol treatment included. Another option for patients with a tracheostomy is to use a heat and moisture exchanger; however, HMEs would not be effective with a speaking valve in place if airflow does not pass through the valve during exhalation.

3. Viral and Bacterial Filter

Previously, available filters for tracheostomies had been intended for use with ventilators, anesthesia machines, and open-flow systems where filtration of inspired and/or expired gases was desired. These filters are often developed in combination with a heat and moisture exchanger component to allow the provision of both filtering and humidification for patients on mechanical ventilation. However, it is a large device that is not designed or intended for placement directly on a tracheostomy tube hub. And, while HME devices are designed for placement on the hub, the HME design is for humidification and has little to no filtration capability. However, the Passy-Muir Tracheostomy Viral & Bacterial Airway Protection Filter (PM-APF15) is a filter available for use directly on tracheostomy tube hubs and intended for both pediatric and adult patients. See the Complex Diagnoses issue (2024) of *Aerodigestive Health* for more information.

PM-APF15 Airway Protection Filter

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4. Suctioning Equipment

Critical for managing secretions, suctioning must be performed with proper technique to avoid hypoxia or mucosal injury (AARC, 2010).

5. Mechanical Insufflation-Exsufflation Devices

A non-invasive technology used to clear secretions by simulating coughs. It can be used with patients on mechanical ventilation without disrupting ventilatory support and may be safer than the standard invasive catheter suctioning (Be'eri et al., 2024).

6. Capnography and Pulse Oximetry

Used for continuous monitoring of respiratory status and to detect early signs of deterioration, capnography is recognized as a tool for monitoring patient safety (Kodali, 2013; Wollner et al., 2023).

Multidisciplinary Team Roles and Collaboration

Multidisciplinary collaboration improves patient safety, facilitates comprehensive care, and enhances outcomes in tracheostomy management (McGrath et al., 2020). Each clinician brings a unique perspective, and communication between team members ensures that tools and techniques are used effectively and appropriately.

Patient and Caregiver Education

Training in tracheostomy care, speaking valve use, and emergency response is critical. Providing written materials, demonstrations, and return demonstrations improves confidence and safety in home settings (Mitchell et al., 2010; Antoniou et al., 2022). Being familiar with educational tools and materials is essential for providing appropriate support to patients and families, especially after discharge from a medical setting.

1. Tracheostomy T.O.M./Pocket T.O.M./P.A.M.

These educational tracheostomy observation models display an anatomical representation of a tracheostomy tube placement and may be used to assist with demonstrating basic functions impacted by a tracheostomy. Use of the models also allow placement of a speaking valve on a manikin prior to patient placement. These tools may be used for training clinical professionals, caregivers, and patients.

Emerging Tools and Innovations

1. High-Flow Oxygen Therapy via Tracheostomy

Recent evidence supports the use of high-flow systems with patients following tracheostomies to improve oxygenation and secretion clearance (Egbers et al., 2023). See the Protocol Issue of *Aerodigestive Health* (2019) for more information on the use of high-flow oxygen therapy.

2. AAC and Wearable Tech Innovations

Eye-tracking devices and voice synthesis technologies are increasingly used in patients with severe speech impairments or progressive conditions (Beukelman & Light, 2020).

3. Telehealth and Remote Monitoring

These tools are now being applied for remote monitoring of respiratory parameters and for delivering therapy services, especially in outpatient or rural settings (Hines et al., 2020).

Conclusion

Patients with tracheostomies face complex challenges involving voice, swallowing, and respiration. A multidisciplinary toolbox of evidence-based tools and techniques – including speaking valves, swallowing assessments, secretion management systems, and AAC devices – enables clinicians to effectively address these challenges. Through collaborative care, ongoing assessment, and technological integration, clinicians can improve both safety and quality of life for individuals with tracheostomies. This issue of *Aerodigestive Health* presents various devices that may be effective when used with patients following tracheostomies.

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RMST: A Tool for Patients with Tracheostomies

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Respiratory Muscle Strength Training

Respiratory muscle strength training (RMST) can be utilized as a clinical intervention to target improvement in the force-generating capacity of the skeletal muscles involved in respiration (Troche, 2015). This intervention can address clinical deficits that include dystussia (impaired cough function), dysphonia, and dysphagia, which are areas of impairment that patients with tracheostomies frequently exhibit. RMST may consist of targeting the strengthening of the muscles of expiration, expiratory muscle strength training (EMST), and the muscles of inspiration, inspiratory muscle strength training (IMST), to address impaired cough strength, vocal function, and swallowing function (Troche, 2015; Walterspacher et al., 2018).

Completion of RMST addresses cough strength by targeting either the muscles of inspiration or expiration. Increasing maximum inspiratory pressure results in increased lung volume which in turn provides a greater amount of air on which to exhale. Increasing strength of the expiratory muscles increases the velocity of the flow of air upon exhalation (Kim et al., 2009; Hegland et al., 2016). Improved cough strength improves pulmonary toilet and airway protection. Consider that if a patient with dysphagia has a strong cough, they may be able to expel penetrated or aspirated material. Regarding swallowing function, published research studies have shown that EMST can improve the force generation of the submental muscles; this results in an increase in movement of the hyolaryngeal complex, thus improving airway protection and opening of the UES during the swallow (Park et al., 2016; Wheeler-Hegland et al., 2008; Wheeler et al., 2007). As airflow also impacts voice production and vocal quality, including the ability to generate subglottic pressure, research also has reported that RMST may improve voice production (Wingate et al., 2007; Chiara et al., 2007; Desjardins et al., 2022; Atonsson et al., 2024).

Clinical judgement can be utilized to determine which respiratory muscle groups, inspiratory (the diaphragm and the external intercostal muscles) or expiratory (the abdominal and the internal intercostal muscles), should be targeted in treatment. In some patient cases, addressing both inspiratory and expiratory muscle strength may be of benefit.

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Benefits of IMST and EMST

There have been numerous research studies published that outline the benefits of both IMST and EMST in a wide range of patient populations, including neurological disorders such as Parkinson's disease, cerebrovascular accident, amyotrophic lateral sclerosis, multiple sclerosis and spinal cord injury along with pulmonary diseases, including chronic obstructive pulmonary disease (Troche, 2015). Research has also been published on the impact of RMST with patients who are severely deconditioned and those who are on or recovering from mechanical ventilation (Bisset et al., 2016, 2019). Research findings have also included the use of RMST in healthy normals and athletes (Hartz, 2018; Illi et al., 2012; Sapienza, 2002; Sasaki, 2005), professional voice users (Wingate, et al., 2007), as well as the elderly (Kim & Sapienza, 2006; Mello, 2024). Many recent studies have also reported findings regarding the benefits of RMST for patients with a additional diagnoses, such as head and neck cancer (Cheng et al., 2024; Hutcheson, 2018) and COVID-19 (Morgan et al., 2024).

Pressure Threshold Device

Much research in RMST has been completed with the use of pressure threshold devices. This type of device is spring-loaded, and the device setting remains consistent throughout one individual breath as well as from breath to breath; they are not flow dependent. This means that the patient utilizing the device must generate a set level of force consistently throughout the exercise (Dietsch, 2024; Troche, 2015), resulting in less variability in the training task that is being completed. As muscle strength is gained through the completion of the exercise, the pressure device threshold setting can be increased in small increments based on patient performance, which allows for continued strength training.

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Patients With Tracheostomies

Patients with tracheostomies are a heterogeneous group. They have a wide variety of medical diagnoses and medical complexities, some related to illness and others potentially with iatrogenic etiologies. This patient population has diverse medical and surgical histories that likely include contributing factors leading to the need for tracheostomy placement. Determining candidacy for RMST use with patients who have tracheostomies should be considered by clinicians on a case-by-case basis. For these complex patients, each patient's circumstances, medical condition(s), and past medical history should be analyzed. Determining patient candidacy and completing RMST, when appropriate, should include collaboration with the patient's tracheostomy care team. This may include medical doctors, surgeons, nurses, respiratory therapists, speech-language pathologists, physical therapists, occupational therapists, and others. Care of this patient population takes a "clinical village," and interdisciplinary collaboration can be key. These interdisciplinary collaborations are an excellent way to build stronger relationships among the team members, resulting in better communication and informed professionals who can best serve this complex patient population.

Rationale for Considering RMST in Patients With Tracheostomies

Patients with tracheostomies may have a variety of deficits that negatively impact cough, voice, and swallowing function. As discussed earlier, published research findings demonstrate the benefits of EMST and IMST for a wide variety of medical conditions. There are many clinical layers to consider for this complex patient population. Deficits that these patients experience may result from medical conditions or treatments that necessitated the need for tracheotomy surgery in the first place. This may include an acute onset of neurological change, such as stroke, or progression of a degenerative neurological disease process, such as ALS. Many patients with tracheostomies may also have a history of prolonged intubation, which by itself can contribute to impaired cough strength, voice, and swallowing dysfunction (McIntyre et al., 2021; Rassameehiran et al., 2015; Wallace & McGrath, 2021).

> *In addition to illness and disease, other factors may play a role in the deficits that patients with tracheostomies experience.*

In addition to illness and disease, other factors may play a role in the deficits that patients with tracheostomies experience. Both aging and immobilization due to hospitalization result in sarcopenia, a loss in mass and strength of skeletal muscles (Kim et al., 2009; Wan et al., 2023), which negatively impact respiratory muscle function. Receiving mechanical ventilation itself is also a contributing factor (Bissett et al., 2016). Exercise programs targeting skeletal muscles are of benefit in addressing sarcopenia (Trethewey et al., 2019; Vorona et al., 2018), which can contribute to the deficits that necessitate speech-language pathology intervention.

Another clinical layer to consider with these patients is their past medical history, which can be quite complex and include underlying conditions that serve as contributing factors. Consider the impacts for a patient who has been hospitalized with a severe upper respiratory illness that required oral intubation for respiratory distress who may also have a history of a neurological disorder, such as Parkinson's disease or prior stroke. Or one may see a patient with a history of chronic obstructive pulmonary disease who may have developed acute respiratory failure due to a community-acquired pneumonia. In these types of cases, the patient may have had reduced respiratory muscle strength at baseline, which then worsened due to their acute illness. In summary, in many cases, the etiology of respiratory muscle weakness is multifactorial.

Another consideration for this patient population is the timing of the referral for services. Intervention for patients with tracheostomies may be requested at varying stages of their illness and recovery. This means that patients with a wide range of clinical conditions and functional impairments will be seen in a variety of clinical settings that may include inpatient acute care, acute rehabilitation, subacute rehabilitation, long-term acute rehabilitation, home health, and the outpatient clinic. Clinicians' understanding of each patient's unique needs in their specific medical setting is crucial.

Clinical Insights

Typically, RMST is completed by generating airflow through the mouthpiece of a device, either by inhaling or exhaling through it. Patients with tracheostomies who can be considered for RMST (completed with oral placement of the device mouthpiece) share some similarities with patients who are being considered for Passy-Muir Speaking Valve (PMV) use or who are currently utilizing a PMV. To complete RMST with oral placement of the device mouthpiece, a patient must

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be tolerating deflation of the tracheostomy tube cuff as well as tolerating at least intermittent occlusion of the tracheostomy tube. When completing RMST, the tracheostomy cuff must be fully deflated, and the patient must have a patent airway with enough space around the tracheostomy tube, and within the trachea, to allow for airflow around the tracheostomy tube and up through the upper airway. This is the same as the airway patency that is required for candidacy for the use of a Valve. RMST can be completed and is more effective with either a PMV in place or a tracheostomy tube cap or plug. If a patient is not a safe candidate for hands-free tracheostomy tube occlusion due to contraindications that could potentially include laryngeal or tracheal stenosis, or another condition that limits the size of the airway, finger occlusion of the tracheostomy tube hub during exhalation (for completion of EMST) or inspiration (for completion of IMST) could be trialed to determine patient tolerance. For medically fragile patients, it can be helpful to monitor respiratory rate and oxygen saturation levels during trials to gain further insight regarding patient tolerance. To occlude the hub of the tracheostomy tube, assistance may be required depending on the patient's manual dexterity and their ability to coordinate respiration with device use. The patient's ability to hold an RMST device may also be impacted by impairment in motor strength and manual dexterity; in many cases, collaboration with occupational therapy can be helpful in problem-solving potential adaptive solutions.

Although published studies on RMST have utilized a variety of treatment protocols, many researchers have utilized the 5-5-5 treatment cadence (Troche, 2015). In this protocol, the patient completes 5 sets of 5 breaths, 5 out of 7 days per week, for 4-5 weeks with the device threshold setting at 70-75% of their maximum inspiratory or maximum expiratory pressure (Troche, 2015). It is important to keep in mind that this treatment plan may be modified to suit individual patient needs. This is especially important to consider with medically complex patients, including individuals with tracheostomies. A debilitated and acutely ill patient may not be able to tolerate this threshold level or the number of repetitions. The device threshold setting and the number of repetitions can be modified based on patient performance. For example, if a patient can only complete 1 set of 5 breaths with the device at the lowest threshold setting, training could begin there. The number of repetitions can be increased as the patient's strength improves.

Safety

Patient safety should always be the first consideration in the delivery of all clinical interventions. As stated previously, not every patient is a candidate for RMST. Clinicians should be aware of the warnings and contraindications that are provided with RMST devices. Overall, clinical judgment about each patient's individual medical condition and clinical status must be considered when developing a treatment plan. If a patient falls within certain categories for contraindications, they may not be a good candidate for RMST device use. The following are a representative sample of contraindications and special patient considerations for RMST device use (Aspire Products, LLC, 2025; POWERBreathe, 2025):

- Asthma patients who have low symptom perception and suffer from frequent severe exacerbations or those with an abnormally low perception of dyspnea.
- Ruptured eardrum or any other condition of the ear.
- Pregnancy.
- Untreated and uncontrollable reflux.
- Untreated and uncontrollable hypertension.
- Abdominal hernia or recent abdominal surgery.

Conclusion

Providing clinical intervention for patients with tracheostomies can be both challenging and rewarding. Clinicians from multiple disciplines treat these patients and play a role in addressing patient deficits, such as dystussia, dysphonia, and dysphagia, through a variety of interventions that have an impact on clinical outcomes and patient quality of life. Understanding the use of RMST and having the ability to identify patients, including those with tracheostomies, who are appropriate candidates for this treatment are valuable skills in the clinical setting. RMST can be a useful tool to add to the care provider's clinical "toolbox".

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Considerations for the Use of Neuromuscular Electrical Stimulation for Patients with Tracheostomy Tubes

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Abstract

It is well documented that patients with tracheostomies are at a significant risk for dysphagia, often marked by increased frequencies of airway invasion (i.e., penetration and/or aspiration). This may be due to alterations in sensory function, motor function, or mechanical insufficiency, any of which may be contributors to the multi-factorial manifestation of dysphagia in these patients. Dysphagia in these patients contributes to delays in weaning and decannulation, as well as overall functional outcomes, highlighting the importance of identifying and then managing or rehabilitating swallow function. Early and targeted rehabilitation of swallowing function is recommended whenever possible, and various approaches may be functionally useful. An understudied and underutilized modality for targeting swallow function in patients with tracheostomy and dysphagia may be neuromuscular electrical stimulation. Here, we discuss the applications of neuromuscular electrical stimulation in patients with tracheostomies and dysphagia, including considerations of the factors contributing to dysphagia, such as underlying illness and physiological impairment, as well as tracheostomy-specific factors such as cuff status and speaking valve use.

Introduction

Dysphagia is a known risk factor in patients with a tracheostomy (Skoretz et al., 2020) and is recognized as negatively contributing to several aspects of patient recovery, including weaning, decannulation, and general functional outcomes (Gallice et al., 2024; Wallace & McGrath, 2021). Though not every patient with a tracheostomy in place may have dysphagia (Skoretz et al., 2020), many patients with a tracheostomy tube placed also have underlying diseases, disorders, injuries, or other co-morbidities causing dysphagia that contributed to the need for tracheostomy placement (Mills et al., 2023; Skoretz et al., 2020). Early assessment and intervention for dysphagia are recommended to facilitate positive outcomes, including decannulation (Romero et al., 2010; Wallace & McGrath, 2021). However, the evidence surrounding interventions designed to directly address the sensorimotor function of an area most likely to be compromised by a tracheostomy, the larynx, is limited. Approaches such as tactile stimulation and pharyngeal electrical stimulation

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show promise in specific populations (Eskildsen et al., 2024), while other oral-based neuromuscular retraining showed no effect on time to decannulation (Blichfeldt et al., 2025). In addition, it is documented that the care pathway leading to decannulation involving cuff deflation and the use of a speaking valve may have positive effects on swallowing outcomes due to restoration of airflow to the upper aerodigestive tract (Mills et al., 2023). However, this may not target other underlying physiological impairments. This leaves a substantial gap in translatable knowledge of what treatment approaches clinicians may have in their tool belt when approaching a patient with tracheostomy and dysphagia. Another treatment option to consider may be the use of neuromuscular electrical stimulation (NMES).

Sensorimotor Alterations to the Larynx With a Tracheostomy

It is theorized that the presence of a tracheostomy with an inflated cuff contributes to the desensitization of the larynx and upper aerodigestive tract, due to the air being redirected through the tracheostomy tube rather than through the glottis (Ding & Logemann, 2005; Shaker et al., 1995). A recent study by Marvin and Thibeault (2021) highlighted that in patients with tracheostomy who aspirated, 81% aspirated silently, adding support to the theory of reduced sensation in the airway with a tracheostomy. This is similar in theory to findings that restoring airflow through the glottis via a speaking valve, where appropriate, allows for the sensorimotor interplay between an adducted glottis and the buildup of subglottal pressure to resume (Gross et al., 2003, 2006; Skoretz et al., 2020) and significantly reduces the odds of aspiration (O'Connor et al., 2019). While approaches have documented positives both in the lab and at the

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bedside, it is critical to factor in patient individuality in the rehabilitation of dysphagia with a tracheostomy (Brodsky et al., 2020; Marvin & Thibeault, 2021). As another example from Marvin and Thibeault (2021), 97% of their patient sample had their cuff deflated, yet still saw substantial rates of silent aspiration. As such, while in many patients' circumstances cuff deflation may improve aspects of swallow function, like aspiration status (Davis et al., 2002; Ding & Logemann, 2005), we must consider the underlying etiology leading to the tracheostomy placement and the subsequent physiological impairment of swallowing because of this etiology.

Individualistic considerations must also be taken in terms of motor impairment with a tracheostomy. There is conflicting evidence regarding whether the presence of a tracheostomy itself affects swallowing biomechanics, such as the hyolaryngeal movement. Suiter et al. (2003) found that a deflated cuff resulted in greater hyoid bone displacement, and Ding & Logemann (2005) found reduced laryngeal elevation with an inflated cuff. Jung et al. (2012) also found that decannulation of a tracheostomy tube resulted in greater hyolaryngeal excursion. In contrast, Terk et al. (2007) found no effect of tracheostomy presence on hyolaryngeal movement. Therefore, it is important to consider the individual patient's anatomy (i.e., "size of their system", post-surgical changes, etc.) in relation to the tracheostomy and then to implement instrumental assessment when it is thought that the tracheostomy is impeding hyolaryngeal movement (Van Der Kruis et al., 2011).

Of greater rehabilitation-specific concern are changes and alterations in muscular and motor function due to the presence of a tracheostomy (i.e., disuse), the underlying impairment (i.e., stroke), or both. Patients with tracheostomies are often in critical or intensive care units or wards and are susceptible to muscle weakness and deconditioning (Brodsky et al., 2020; Jolley et al., 2016), which may be attributed to disuse (DeVita & Spierer-Rundback, 1990; Wallace & McGrath, 2021). Critical illness polyneuropathy and myopathy as syndromes affect the sensorimotor function systemically in a large portion of patients in critical or intensive care, including those with tracheostomies (Gutmann & Gutmann, 1999; Zhou et al., 2014) and have been linked to high rates of dysphagia in these critically ill patients (Mirzakhani et al., 2013). It is therefore paramount to consider the combination of the current status of the patient (i.e., prolonged disuse of laryngeal musculature, prolonged NPO status) and underlying factors precipitating the tracheostomy placement (Suiter, 2014), many of which are known to contribute to neuromuscular dysfunction in dysphagia, including stroke and acquired brain injury.

Basis for Neuromuscular Electrical Stimulation for Dysphagia in Patients With a Tracheostomy

Implementing a treatment approach for dysphagia in patients with tracheostomies should be approached based on the individual needs and status of the patient. As an example, a therapy approach such as pharyngeal electrical stimulation may be beneficial in applying sensory electrical stimulation to the pharynx of patients with tracheostomies who were recently weaned from mechanical ventilation or after prolonged disuse of swallowing musculature (Suntrup et al., 2015). Given the data discussed above regarding the impact of sensory input having positive effects on swallowing, it may be that the input of sensory level stimulation in patients who may not be able to tolerate cuff deflation or speaking valve placement may be beneficial. Similarly, Facio-Oral Tract Therapy (FOTT) provides a sensory-based facilitation technique, including to the larynx, useful in patients with tracheostomies who are appropriate for cuff deflation (Eskildsen et al., 2024). While useful for incorporating sensory stimuli, patients with a tracheostomy and dysphagia experiencing disuse atrophy, muscle weakness, or polyneuropathy may require more direct facilitation of motor function.

Protocols for incorporating active laryngeal exercises in patients who can tolerate a deflated cuff but still have aspiration have been proposed, including the Mendelsohn maneuver (Vandenbruaene et al., 2008). However, to our knowledge, no follow-up studies have been implemented specifically incorporating active laryngopharyngeal-based exercises to evaluate improved swallow function. Protocols requiring active exercises are also dependent on the ability of the patient to participate, as well as other factors such as fatigue. It, therefore, may not be possible for the patient to achieve sufficient stimulus to perform the number of swallows to see a benefit in muscular function. An approach that applies to a combined sensorimotor, facilitative, and perturbative approach, such as NMES, may be beneficial for maximizing gains in swallow function in this population.

> *It is vital to understand the underlying biomechanical impairment leading to dysphagia in the patient.*

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NMES as a therapeutic modality to target improved neuromuscular function has been suggested for use in rehabilitative settings for decades (Lake, 1992; Sheffler & Chae, 2007; Ward & Shkuratova, 2002). Ongoing research has contributed to understanding its underlying neuromuscular mechanisms (Doucet et al., 2012), its ability to improve deficits related to motor performance (Maddocks et al., 2013), and its contribution to therapeutic programs for rehabilitation of progressive diseases affecting optimal muscle function (Jones et al., 2016). Generally, NMES is meant to be utilized as a modality that generates muscular contractions, facilitates muscular movement, and is intended to do so in conjunction with muscular contractions (Doucet et al., 2012).

It is therefore vital to understand the underlying biomechanical impairment leading to dysphagia in the patient. It is also imperative to utilize NMES not as a "set it and forget it" dysphagia modality. The key here is to facilitate muscular movement during functional tasks. During active NMES, the patient should be making efforts to swallow. Patients cannot perform functional goal-oriented tasks without actually performing the task (swallowing) and doing so safely, with saliva swallows only.

Electrode Placement and Type

In the context of pharyngeal stage dysphagia in patients with tracheostomies and considering the potential for decreased muscular function and underlying comorbidities with a tracheostomy, such as brain injury or stroke, elevation of the hyolaryngeal complex for biomechanical goals, such as optimal airway protection, is also likely to be affected. Many investigations have explored various electrode placements on the anterior neck to affect hyolaryngeal movement and decrease penetration or aspiration, including on the suprahyoid muscles alone, infrahyoid muscles alone, or in some combination (Diéguez-Pérez & Leirós-Rodríguez, 2020). From the physiological standpoints (generating contractions, facilitating movement, and actively working to move these facilitated muscles), the most appropriate placement of electrodes when performing NMES is over the suprahyoid musculature.

In terms of suprahyoid structure and function, in-depth muscular analysis based on fiber bundle types and concentration indicates that, when functioning together, muscles including the geniohyoid, mylohyoid, and anterior belly of the digastric are designed to move the hyolaryngeal complex superiorly and anteriorly, quickly, and timely (Shaw et al., 2017). When swallowing, a major biomechanical goal that serves as a protective mechanism is hyolaryngeal excursion. Therefore, it makes the most physiological sense that we want to generate contractions of these suprahyoid muscles to facilitate elevation of the hyolaryngeal complex, as this is a function we are trying to improve. The utilization of NMES as a dysphagia treatment modality is unlikely to be beneficial if it is used to stimulate and facilitate the antagonist muscles (infrahyoids) of this pivotal movement.

It could be argued that causing descent of the hyolaryngeal complex may introduce a perturbation effect, whereby patients must overcome the resistance applied during stimulation as a therapeutic approach (Humbert et al., 2015). However, a major point of NMES, aside from generating contractions of a target muscle and facilitating that muscle moving towards a goal-oriented point (i.e., extension of the knee when the quadriceps contract or, more relevant, elevation of the hyolaryngeal complex via the suprahyoids contracting), is the potential for improved muscular strength and hypertrophy (size). It is well recognized that the use of NMES improves strength and size in the muscles being stimulated (Alqurashi et al., 2023). We must therefore carefully consider the muscles (and the goals of these muscles) to which we want to apply these effects. From a physiological standpoint, it makes the most sense to stimulate muscles in a goal-oriented direction that aligns with swallow function (hyolaryngeal excursion) rather than the opposite. Recent studies have shown that when using suprahyoid placement (and appropriate parameters), significant elevation of the hyolaryngeal complex can be achieved (Ogura et al., 2022; Safi & Mohamud, 2021) to facilitate a functional motor pattern of upward and forward movement for swallowing function. Understanding the goals and effects that NMES can have should serve as foundational guidance for clinicians considering its use as a dysphagia treatment modality.

A final consideration when discussing placement may be the electrode type being used over the suprahyoids. It is established in the exercise physiology literature that when implementing NMES, larger electrodes are more comfortable for patients (Flodin et al., 2022). Using an approach to NMES that incorporates larger-sized electrodes spreads out the density of the current over a larger area. While this has been documented to then require a higher intensity of current for muscle contraction, it also reduces how concentrated the current is over the suprahyoids (Flodin et al., 2022). The important

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takeaway here is that this makes NMES more comfortable for the patient because the intensity is spread out over a greater area. This also allows the patient to tolerate more intensity, which may be linked to increased muscle strength beyond certain intensity levels (Glaviano & Saliba, 2016).

Within these points, something that is less clear is how electrode shape may affect things like patient comfort and placement with a tracheostomy. Electrode shape does not appear to affect patient tolerance to simulation (Forrester & Petrofsky, 2004). However, electrode shape should certainly be a point to consider, given the unique shape of the suprahyoid/submandibular space. An example of electrode placement in Figure 1 shows the suprahyoid/submandibular space, and it does not look like an arm or leg. However, much of the research has been conducted on extremities, making it much harder to fit large circular or square electrodes to the neck. This space is small and angular, shaped like a boomerang, and does not have a large surface area to place electrodes. Additionally, while a muscle like the anterior digastric is shaped similarly to muscles like the rectus femoris in the quadriceps (a long, bandlike muscle), other muscles of the neck are quite different in shape, yet still a suprahyoid muscle, like the mylohyoid (triangular, fan-shaped). We are also trying to contract these other muscles; therefore, using a size and shape electrode that works efficiently to reach muscle fibers that are superficial and band-shaped (geniohyoid) but also deep to this muscle and fan-shaped (mylohyoid) is preferable to smaller, less efficiently shaped electrodes that may not cover this area and may cause more discomfort. Consideration must be given to the muscle that is being stimulated and the electrode that is to be used.

Figure 1: Placement example for NMES

Parameters

Skeletal muscle unit firing rates during voluntary contractions tend to occur anywhere between a frequency of 10-50 Hz (Asmussen et al., 2018; Doucet et al., 2012). These factors indicate that NMES in dysphagia treatment should be implemented at the typical firing rate of skeletal motor units and be used in a facilitative manner to induce muscular contractions. Other considerations include the amplitude or intensity of the stimulation, the phase duration of the stimulation, and the duty cycle (how long the stimulation is on/off).

For duty cycle, if a contraction continues for too long without a recovery phase (i.e., if stimulation is provided to a muscle for too long), waste products build up to a level that causes metabolic fatigue and prevent the muscle from using the energy needed to continue contracting (Hunter et al., 2004). In a very practical example, applying stimulation to a muscle for significant amounts of time (i.e., 60 seconds) at frequencies (i.e., 80 Hz) beyond what is necessary for muscles to contract comfortably increases the likelihood of fatigue in a muscle and requires increased recovery time for that muscle. In a patient with a tracheostomy and dysphagia due to neuromuscular impairment, the goal with NMES should be to make the muscle work to improve strength and function, not to try to force it to contract for as long as possible. The duty cycle and stimulation intensity, therefore, must be great enough to apply a load to the muscles, but not too much to fatigue the muscles so that they no longer contract. The purpose here is to achieve and facilitate hyolaryngeal excursion as the primary biomechanical movement. From here, other secondary effects may be observed due to the inherent anatomical connections of other structures and the larynx.

When NMES in dysphagia rehabilitation is implemented at the typical firing rate of skeletal motor units and used in a facilitative manner to induce muscular contractions for a set period that also includes time for muscles to recover, the intervention can be beneficial for patients. These are especially important factors to consider for the tracheostomy patient population who have the added complexity of a tracheostomy tube inserted into the trachea just below the larynx. The amount and intensity of work put through these muscles must be carefully weighed against what the patient can tolerate.

Please see Table 1 for recommendations regarding parameters for suprahyoid NMES use.

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Table 1 Recommended parameters and electrode size/shape considerations for NMES implementation

Parameter	Suggested Use
Pulse Rate / Frequency	30Hz
Amplitude	0 – 100mA
Phase Duration	50 µsec to 250 µsec
Duty Cycle (On-Off time)	5/25, 5/20, 5/15
Electrode Size / Shape	Triangular, > 1 inch

Considerations for Using Perturbation

A consideration is the use of NMES not only as a facilitative modality for improved hyolaryngeal excursion but also to provide a source of perturbation to improve laryngeal vestibule closure. When using suprahyoid electrode placement, perturbation to this mechanism may not be ideal. However, in regard to improving how the airway closes, perturbation may be a good thing.

Limited data are available on timing events of the airway in patients with tracheostomies. However, in the broad dysphagia literature, there are two major contributors reported to airway invasion: issues with hyolaryngeal excursion and time-to-laryngeal vestibule closure (LVC), and they are both closely related (Smaoui et al., 2022). As an example, during swallowing, the onset of hyolaryngeal excursion often precedes the arytenoid elevation and tilting for complete laryngeal vestibule closure (Perlman & Van Daele, 1993; Shaker et al., 1990), which may create a brief internal stretch (opening) of the vestibule. When NMES is actively applied to the suprahyoid muscles, research is establishing that it creates a significant size increase in the laryngeal vestibule (it opens the airway) (Ogura et al., 2022; Safi & Mohamud, 2021). Facilitating this stretch introduces a perturbation effect to the laryngeal vestibule, forcing the patient to close the airway over a greater distance.

The effects of this may be improved with faster closing speed of the laryngeal vestibule (Watts & Dumican, 2018). Because patients must close the airway across a greater distance from this perturbation, they also need to cover that distance in a time frame that still protects the airway. So, in order to do that, they must close the laryngeal vestibule faster. Time-to-laryngeal vestibule closure is one of the primary factors leading to airway invasion, and prolonged timings substantially increase the likelihood of airway invasion. Though hyolaryngeal kinematics or timing events were not measured, suprahyoid NMES using parameters already discussed resulted in significant improvement in penetration and aspiration occurrence (Martindale et al., 2019; Sproson et al., 2018), suggesting improved movement and timing of the hyolaryngeal complex and the airway. Since patients with tracheostomy have been reported to have a high rate of aspiration, and 81% aspirated silently, laryngeal vestibule closure would be a significant consideration in this patient population (Marvin & Thibeault, 2021).

An important caveat is that NMES should be performed without introducing a bolus and with saliva swallows only. Given the discussion regarding the stretching of the laryngeal vestibule when NMES is active, introducing a bolus for the patient to swallow while NMES is active is contraindicated due to increased aspiration and asphyxiation risk. Safi and Muhamud's (2021) findings clearly suggest there is a heightened risk of aspiration when actively swallowing a bolus with stimulation on.

Application of NMES in the Patient With a Tracheostomy

To summarize the most salient points: 1) dysphagia in patients with tracheostomies should be considered alongside underlying comorbidities, 2) NMES may be a useful treatment approach if the underlying dysphagia is associated with laryngeal impairment (hyolaryngeal excursion, airway closure, airway invasion), and 3) factors such as placement and parameters of the stimulation are vital to not just implement but understand. But what other factors should be considered when using this approach in a patient with a tracheostomy?

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Cuff Status

Just like placing a speaking valve, it is paramount to ensure that the use of NMES placed on the suprahyoids is done with the cuff deflated. Earlier discussion highlighted how a deflated cuff contributes to improved hyoid bone movement (Ding & Logemann, 2005; Suiter et al., 2003). As the application of NMES is to facilitate hyolaryngeal excursion, the patient should be able to tolerate cuff deflation during the treatment session, and treatment session lengths can be adapted depending on patient tolerance.

Beyond facilitating maximal hyolaryngeal excursion, it is also a safety precaution to ensure cuff deflation during NMES application to prevent increasing the odds of tracheal or mucosal injury, stenosis, or granulomas. Additionally, creating muscular contractions that maximize hyolaryngeal excursion may cause the cuff to shift and potentially impinge on the airway or the esophagus, reducing esophageal motility or causing reflux.

In patients who cannot tolerate cuff deflation, sensory levels of stimulation may be used when using the same electrode placement. Sensory levels of stimulation have been used in other studies (Eskildsen et al., 2024) directly on the pharyngeal mucosa in patients with tracheostomies, and as such, transcutaneous sensory stimulation may be applied over the suprahyoid area. This may still provide at least sensory level stimulation to the anterior neck, suprahyoid musculature, and larynx, and has been shown to be effective at reducing aspiration in stroke patients without tracheostomies (Gallas et al., 2010).

Tracheostomy Status and Type

Final considerations are the status of the tracheostomy and the tubing itself. The application of NMES on or near an open wound is contraindicated. Therefore, starting at NMES as an immediate treatment for a new tracheotomy is not advised. In addition, initiating NMES too quickly after tracheostomy placement may cause increases in movement, irritation, and edema around the tracheal housing. The timeframe from post-tracheostomy placement to appropriate use of NMES is variable, but the patient should not have any active wounds or bleeding. Additional types of tracheostomy tubes and cuffs should also be considered. As an example, a metal tracheostomy tube may be contraindicated for the use of NMES due to the active current being produced and passed by the stimulator. Foam cuffs would also be contraindicated, as they cannot be deflated.

Conclusion

NMES, when applied with physiologically appropriate placement and parameters, may be a viable rehabilitative approach to patients with tracheostomies. Specifically, where patients experience dysphagia related to impaired hyolaryngeal movement or airway closure, the use of suprahyoid NMES with functional exercise (e.g., swallowing during stimulation) should be considered as a treatment approach. Sensory level stimulation may also be an alternative approach. Patient and tracheostomy-centered factors must be accounted for, including cuff deflation tolerance, speaking valve use, and tracheostomy type.

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Lessons Learned: Introducing Phagenyx at a London-based NHS Critical Care Unit and Neurosciences Service

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Introduction

Barking, Havering and Redbridge University NHS Trust (BHRUT) serves a population of approximately 800,000 in outer North East London and Essex. The trust operates from two sites - Queen's Hospital and King George Hospital, with approximately 900 beds across both sites – and employs over 8,000 permanent staff. The emergency departments see over 300,000 patients and deliver over 7,000 babies a year. It is the regional neurosurgical service for Essex and its surrounding areas with 2x 30-bedded Neuroscience wards and is also one of eight designated hyperacute stroke units (HASU) in London, with approximately 1600 stroke inpatients seen each year. There are four critical care units with a regular bed capacity of 57 beds (including a 12-bedded neurocritical care unit) and a surge capacity of 67 beds across both sites. The speech and language therapy (SLT) caseload has an average of 15 tracheostomy patients per month, located within the critical units and neuroscience or stroke wards.

At BHRUT, we provide SLT input from tracheostomy insertion to decannulation or discharge. We cover communication via alternative and augmentative communication (AAC), assessment of and recommendations for one-way valve use for both communication and tracheostomy weaning purposes (including with patients requiring mechanical ventilation), and swallow intervention (clinical bedside, instrumental assessments of VFSS and FEES, and traditional swallow therapy).

As is well documented in literature, the prevalence of dysphagia in patients with a tracheostomy ranges between 11% to 93% (Skoretz et al., 2020), with aspiration 3.4 times more likely to occur if reason for tracheostomy insertion is due to oropharyngeal etilogy such as structural abnormalities, surgery or infection (Marvin & Thibeault, 2021). Therefore, dysphagia management and ventilator or tracheostomy weaning can occur simultaneously in what is usually a medically complex patient cohort. It is especially complex for those patients presenting with severe sensory dysphagia characterized by reduced or no spontaneous swallow, reduced secretion management, and silent aspiration.

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Patients with a tracheostomy are at higher risk of presenting with silent aspiration (Jamroz et al., 2024), but current practices targeting sensation specifically are limited to restoring airflow in the upper airway via cuff deflation trials, one-way valve use, and above-cuff vocalization. Poor secretion management is usually compensated for via pharmacological intervention or suctioning, while traditional swallow therapy targeting reduced sensation is generally limited to thermal tactile interventions such as oral trials of cold or sour boluses or free water protocols (Duncan et al., 2019).

Following various clinical governance and finance meetings leading up to August 2024, we received approval for funding from our Critical Care management team to trial the innovative dysphagia therapy, Phagenyx, for our cohort of patients with severe neurogenic dysphagia. This new treatment has shown promising outcomes for improving severe sensory dysphagia symptoms, such as reduced or no spontaneous swallow, reduced secretion management, and silent aspiration, thereby leading to earlier tracheostomy decannulation and earlier return to oral intake (Suntrup et al., 2015).

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Phagenyx

Phagenyx®: Targeted Neurostimulation for Neurogenic Dysphagia

Phagenyx delivers Pharyngeal Electrical Stimulation (PES)—a targeted therapy that sends electrical pulses to the oropharynx to activate sensory nerves in the throat (*see Figure 1*). These activated nerves relay signals to the motor cortex, promoting neuroplasticity to support the restoration of swallowing function in patients with neurogenic dysphagia.

The electrical pulses are delivered via two integrated electrodes embedded within a single-use patient catheter (*see Figure 2*). Guide marks on the catheter assist with correct placement of the electrodes, while the Phagenyx base station system (see Figure 3) optimizes patient treatment as well as continuously monitors electrode contact quality, ensuring correct positioning throughout the stimulation session.

In addition to therapeutic stimulation, the catheter has an optional secondary function to deliver enteral feeding if required, allowing for nutritional and hydration support for up to 30 days post-placement.

Treatment involves:

- 10-minute sessions per day
- Up to 6 sessions (administered as 2 cycles of 3 daily sessions) (Williams et al, 2024).

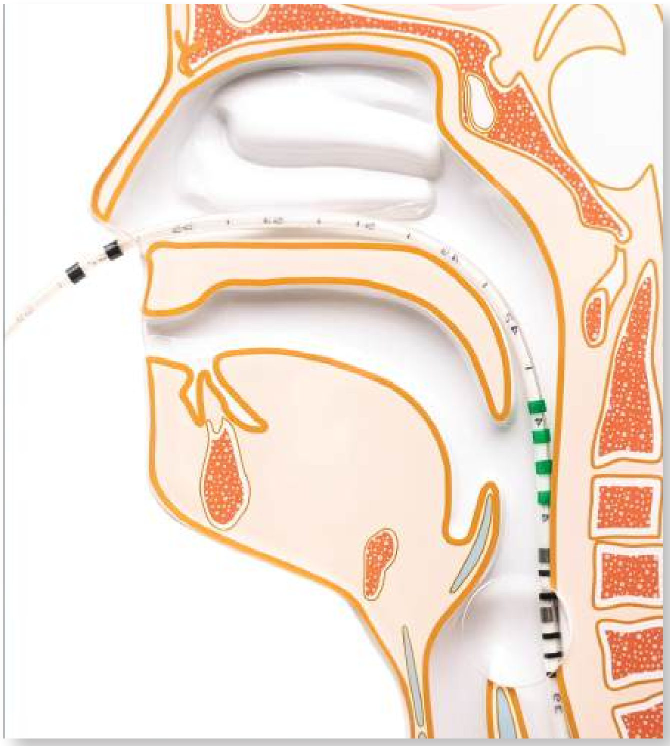

Figure 1: Catheter in situ with correct electrode placement

Figure 2: Catheter components

Figure 3: Base station

Phagenyx is CE/CA marked for the treatment of neurogenic dysphagia in the UK and Europe. It is currently recommended as part of the National Clinical Guideline for Stroke for the UK and Ireland (2023).

"Patients with tracheostomy and severe dysphagia after stroke may be considered for pharyngeal electrical stimulation to aid decannulation where the device is available and it can be delivered by a trained healthcare professional." The European Stroke Organisation and European Society for Swallowing Disorders Guideline for the Diagnosis and Treatment of Post-Stroke Dysphagia (Dziewas et al., 2021) also states, *"In tracheostomised stroke patients with severe dysphagia, we suggest treatment with pharyngeal electrical stimulation to accelerate decannulation".*

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Implementation

After training for the device was completed, a standard operating procedure (SOP) was shared and developed with relevant stakeholders such as medical teams, nursing staff and dietitians. The SOP included information on:

- Roles and responsibilities of multidisciplinary team members.
- Training and education requirements.
- Device and catheter storage and infection prevention and control measures.
- Patient selection, contraindications, and referral process, including patient consent.
- Information governance, patient consent, and confidentiality measures.
- Insertion of catheter, treatment protocols, and documentation standards.
- Process for documenting adverse events and incident reporting.

Since implementing Phagenyx at the end of August 2024, we have treated 17 patients across our critical care units, neuroscience, and stroke wards. Reflecting on our experience, there are lessons we have learned which we are aiming to apply going forward, and we hope will be of use for other clinicians interested in the use of Phagenyx.

LESSONS LEARNED

Patient Selection

As a team, we were very excited about this new intervention targeting sensation specifically, and so it was important to ensure our patient selection was appropriate and objective. There is also the added complication of demonstrating cost-effectiveness for finance and Critical Care service leadership. As a result, our referral and patient selection process has evolved by considering the following factors:

- *Diagnosis.* It was determined that patients with bilateral brain impairments (e.g., multiple strokes, encephalitis) or significant nerve damage following neurosurgery (e.g., brain stem tumour resection) may not exhibit significant improvement post-treatment due to reduced neuroplasticity or remapping to healthy brain areas or due to significant structural impairment of the cranial nerves. Conversely, our patient diagnosed with lateral medullary syndrome made significant gains immediately post-treatment.
- *Dysphagia presentation and severity following instrumental assessment (VFSS or FEES).* We exclude patients presenting with mild to moderate pharyngeal dysphagia or Penetration-Aspiration Scale scores less than 5 (Rosenbek, 1996). This is to ensure we can demonstrate significant improvements post-treatment and is not due to spontaneous recovery, which could be seen in those presenting with mild pharyngeal dysphagia. We also consider excluding patients presenting with significant oral or motor dysphagia symptoms as Phagenyx treatment is not targeting these problem areas.
- *Medical stability.* While early intervention with Phagenyx is recommended, we have found that for the critical care patient population, waiting until patients are optimised for rehabilitation will help reduce any variability in demonstrating post-treatment outcomes. For example, improved tracheostomy weaning may be directly related to Phagenyx treatment rather than any interventions being provided by medical or physiotherapy (respiratory therapy) teams (e.g., vocal fold medialization, prescribed steroids).
- *NGT displacement and reduced cognition.* Assessing cognitive status was important in gaining patient or next-of-kin consent for treatment but also for identifying if patients would tolerate catheter placement for the duration of treatment. Exclusion of patients who have a history of multiple NGT displacements may be warranted as the Phagenyx catheter is single use only. It also is recommended to have mitigations in place for preventing displacement, such as 1:1 nursing or nasal bridles to hold the catheter in place.

Completing Treatment

- *Explaining it to patients and next-of-kin.* Some patient feedback has indicated we may have "undersold" the discomfort that may be felt during treatment, especially on the first treatment session. A "no pain, no gain" approach may be required when explaining to patients with adequate cognition. However, patients reported these feelings of discomfort or pain lessened on subsequent treatment sessions. Other patients reported treatment feeling as "tickling up and down inside my throat" or "constant poking sensation inside."
- *Clinician variables.* Patients feeling distress or discomfort may impact how you establish the threshold and stimulation levels for each patient, especially if it is not the same treating SLT for each

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treatment session. Maintaining the perspective that we are providing a new innovative treatment targeting sensation can help to alleviate these feelings and encourage patients to push through and achieve the highest stimulation levels. Ensuring continuity in SLTs delivering treatment will help increase confidence in knowing any reduction in stimulation levels may be due to patient improvements rather than variable SLT practice.

- *Distractions required.* You will need to distract and encourage patients to persevere during treatment sessions due to the discomfort they feel. The base station allows for short pauses during the treatment; however, the full 10 minutes of stimulation will still be provided regardless of how many pauses are taken in the session. Therefore, making small talk, in the role of motivational speaker, or singing along to favoured music or quoting television or films may be needed for distraction. The presence of next of family can also be a powerful motivator for patients. Most importantly, emphasising the limited number of options for treating reduced swallow sensation can provide further motivation for patients.
- *Observations.* Counting the number of spontaneous swallows observed during treatment may assist with tracking progress between treatment sessions, especially in patients with a prolonged disorder of consciousness (PDOC) presenting with aphasia or showing reduced cognition. We have also found that some patients had a noticeable increase in heart rate during treatment, but it settled once the stimulation was completed and did not appear to contribute to any discomfort patients reported.

Evidence and Outcomes

- *Timing of post-treatment instrumental assessment.* In our experience, improved outcomes were more clearly demonstrated when instrumental assessments were completed greater than 3 days after the final treatment session. In some cases, significant improvement was noted more than a week later, particularly in patients who presented with severe oropharyngeal dysphagia pre-treatment.
- *Secretion management.* Consider comparing secretion management strategies pre- and post-treatment to further indicate improvements. Patients may still present with excess secretions; however, they may no longer require suctioning or prescription medication as a drying agent, such as glycopyrronium or hyoscine, which is indicative of improvement post-treatment. If patients were not prescribed such medications pre-treatment, then we would advocate avoiding prescribing medications during the treatment cycle. This is to ensure you can directly link any reduction in excess secretions to the treatment with Phagenyx.
- *Tracheostomy cuff status and one-way valve (OWV).* Consideration for one-way valve use during treatment sessions may be required, as an increase in spontaneous swallows would hopefully be seen. If patients are not suitable for OWV use, then consider including oral intake with cuff up during instrumental assessment pre-treatment (in a select patient group) to allow for direct comparison for outcome measurement in post-treatment assessment.
- *Improved sensation but not swallow function.* We have treated patients where the only improvement observed post-treatment was a cough response to aspiration (i.e., no longer silently aspirating). This may have a positive impact on SLT services as reviews may be completed at the bedside with increased confidence, which may lead to a reduced need for repeat instrumental assessments. For one patient, it improved their mood and reduced anxiety as they had “more confidence in knowing if [food and fluids] were going the wrong way” and increased their understanding as to why they were unable to eat and drink.
- *Financial Outcomes.* Ensure you’ve set up user-friendly data collection records to assist with analysis later. Collecting data on consumables avoided by tracheostomy decannulation or returning to oral intake earlier than usual is important for ongoing business considerations. For example, consider the potential reduced spend on 1:1 nursing staff required to care for tracheostomy patients, including tracheostomy tubes and related paraphernalia; feeding tubes and feeds; pharmaceuticals for aspiration pneumonia or secretion management; and reduced length of stay in both critical care units and the hospital overall. From our very small sample size, our finance team estimated a potential reduced length of stay of 1.7 days on our Critical Care unit, resulting in £2,087.85 ($ 2,815.79 USD) cost saving per patient for those patients treated with PES. However, this requires further formal and more robust research protocols that include a larger sample size.

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Current Status

At present, our service is much more confident with patient selection and treating with Phagenyx. We hope to pivot our pilot project into formal research with real-world clinical application of this innovative device. Simultaneously, our business case for continued funding to embed Phagenyx as a standardized treatment for appropriate patients is ongoing. It can be difficult to put a price on what is important to our individual patients, and the conflict between demonstrating cost effectiveness for a whole service versus the clinical outcomes for individual patients has been challenging to resolve. Reframing outcomes into a language that finance teams can understand, highlighting immediate impacts of any improvements in service or patient health and wellbeing, and finding allies in finance, executive, and leadership teams have been vital for championing our cause and persevering through hospital red tape.

For additional information, review the two patient case studies included to illustrate the standard use of Phagenyx *(Appendices A and B)*.

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Article Summary

Enhancing communication in critically ill patients with a tracheostomy: A systematic review of evidence-based interventions and outcomes.

Gentile, M. N., Irvine, A. D., King, A. M., Hembrom, A. S., Guruswamy, K. S., Palivela, N. E., Langton-Frost, N., McElroy, C. R., & Pandian, V. (2024). Enhancing communication in critically ill patients with a tracheostomy: A systematic review of evidence-based interventions and outcomes. *Tracheostomy* (Warrenville, Ill.), 1(1), 26–41. https://doi.org/10.62905/001c.115440

In this article, the authors evaluated how different types of communication devices for patients with tracheostomies affect QOL, speech intelligibility, voice quality, time to significant events, clinical response and tolerance, and healthcare utilization. They found that various forms of communication enhance patient QOL and clinical care. They identified both facilitators and barriers to device implementation, focusing on a patient-centered approach as being critical. The authors addressed above cuff vocalization and Passy Muir Valve use. They found that early intervention facilitated early communication and implementation of devices, but they emphasized the multifaceted nature of the care.

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Appendix A

Phagenyx case report

NHS
Barking, Havering and Redbridge University Hospitals
NHS Trust

Presenting complaint

54y male
05/10/2024: admitted with traumatic mild SAH and left SDH
15/10/24 developed ARDS, left lower lobe pneumonia
23/10/24 percutaneous tracheostomy

pMHx HTN, varicose vein surgery, heavy smoker, social drinker, cocaine and cannabis smoker
sHx independent, lives with family, owns on business

13/11/2024: 24 hours TM with 3x 2 hours cuff down and PMV trials
Instrumental Assessment (FEES): mild-moderate laryngeal oedema and excess, thick mucoid secretions throughout the pharynx and larynx which were silently aspirated during cuff inflation. Cuff deflation, PMV use and ice chips were effective in significantly reducing secretion load and aspiration risk.

Presented with moderate-severe oropharyngeal dysphagia, characterised by pre-swallow spillage to the level of the laryngeal vestibule with thin fluids, reduced pharyngeal contraction and poor airway protection. This led to pre- and intra-swallow deep penetration with diet consistencies, silent aspiration of fluids and diffuse pharyngeal residue over time.
Recommended: NBM + NGT
PAS: 8 **NZSS:** 7 **ORS:** 3
RBHOMS: 1 **FOIS:** 1

Treatment details

Rationale for PES due to:
- ✓ Reduced spontaneous swallows
- ✓ Reduced pharyngeal sensation impacting on swallow efficiency
- ✓ Reduced laryngeal sensation impacting on swallow safety

Commenced 15/11/2024 (day 41 post-admission)
6 consecutive treatments (2 cycles)
Nil adverse events with catheter or treatment

DAY	THRESHOLD	TOLERANCE	STIMULATION
1	17mA	50mA	42mA
2	19mA	50mA	42mA
3	22mA	50mA	43mA
4	13mA	50mA	41mA
5	14mA	50mA	41mA
6	6mA	50mA	39mA

FEES 13/11/24 – NZSS: 7

FEES 26/11/24 – NZSS: 3

Patient outcomes

26/11/2024:
Repeat FEES: completed 4 days post PES
Improved secretion management despite ongoing excess salivary secretions. Spontaneous swallow responses to bilateral touch test, spontaneous clearing swallows as well as his independent use of yankeur suction to clear oral secretions are indicative of some improvement in pharyngeal and laryngeal sensation.

Ongoing mild-moderate oropharyngeal dysphagia characterised by reduced oral control, reduced pharyngeal contraction and reduced hyolaryngeal excursion. Ongoing intra- and post-swallow silent aspiration seen with thin fluids, slightly thick fluids and soft & bite-sized diet.

Recommended: IDDSI Level 2 Mildly thick fluids & IDDSI Level 4 Puree diet
PAS: 8 **NZSS:** 3 **ORS:** 2
RBHOMS: 6 **FOIS:** 5

27/11/2024: Decannulated
17/12/2024: Tolerating IDDSI Level 0 Thin Fluids and IDDSI Level 7 Regular Diet

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Appendix B

Phagenyx case report

NHS
Barking, Havering and Redbridge University Hospitals
NHS Trust

Presenting complaint

59y male
14/11/2024: admitted with L Cerebellar & Lateral Medullary infarcts
pMHx nil significant
sHx independent, lives with family, works as engineer

Instrumental Assessment (FEES):
18/11/2024: severe-profound oropharyngeal dysphagia, characterised by reduced swallow initiation, pre-swallow spillage to the level of the laryngeal vestibule, significantly reduced pharyngeal contraction, reduced epiglottic deflection and poor airway protection. This leads to pre-, intra- and post-swallow silent aspiration of fluids and reduced secretion management.
Recommended: NBM + NGT
PAS: 8 **NZSS:** 7 **ORS:** 2
RBHOMS: 1 **FOIS:** 1

29/11/2024: minimal change in dysphagia presentation however improvement seen with reduced excess secretions. There is ongoing aspiration with diet and fluids with silent aspiration of puree observed.
Recommended: NBM + NGT
PAS: 8 **NZSS:** 3 **ORS:** 2
RBHOMS: 3 **FOIS:** 1

Treatment details

Rationale for PES due to:
- ✓ Reduced spontaneous swallows
- ✓ Reduced pharyngeal sensation impacting on swallow efficiency
- ✓ Reduced laryngeal sensation impacting on swallow safety

Commenced 04/12/2024 (day 20 post-admission)
6 consecutive treatments (2 cycles)
Nil adverse events with catheter or treatment

DAY	THRESHOLD	TOLERANCE	STIMULATION
1	12mA	42mA	35mA
2	5mA	42mA	33mA
3	5mA	32mA	25mA
4	9mA	41mA	33mA
5	11mA	36mA	30mA
6	10mA	39mA	32mA

FEES 18/11/24 - NZSS: 7

FEES 13/12/24 - NZSS: 0

Patient outcomes

13/12/2024:
Repeat FEES: completed 2 days post PES

Significant improvement in swallow function, now presenting with mild-moderate pharyngeal dysphagia characterised by ongoing reduced pharyngeal contraction and epiglottic deflection. Nil aspiration was observed on any oral trials. Improved laryngeal sensation
PAS: 3 **NZSS:** 0 **ORS:** 2
RBHOMS: 7 **FOIS:** 6
Recommended:
IDDSI Level 0 Thin fluids & IDDSI Level 4 Puree diet
16/12/2024: NGT removed
18/12/2024: Discharged home

Comments: PES treatment allowed commencement of safe oral intake and removal of NGT, therefore patient **discharged home earlier on 16/12/24** with Stroke Early Supported Discharge Therapy team rather than wait for an available bed at inpatient rehabilitation unit.

PHAGENESIS®

The Role of Tongue Strength in Swallowing

Ed Bice, MEd, CCC-SLP

The pressure created by the tongue plays an essential role in swallowing. Studies indicate that diminished tongue strength can be a clinical sign of an inefficient swallow (Clark et al., 2003; Yoshida et al., 2006). An inefficient swallow resulting from reduced tongue strength is often marked by delayed initiation of the oral swallow, impaired bolus transport, the presence of residue in the oral cavity and pharynx, and prolonged meal durations (Logemann, 2014; Namasivayam-MacDonald et al., 2017; Stierwalt & Youmans, 2007). Decreased swallow efficiency is known to lower the quality of life (García-Peris et al., 2007) and extend hospital stays (Altman et al., 2010). Additionally, decreased swallow efficiency is associated with an elevated risk of aspiration pneumonia (Cabre et al., 2014), dehydration (Tanrıverdi et al., 2024), and malnutrition (Hudson et al., 2000; Huppertz et al., 2022; Pizzorni et al., 2022; Pizzorni et al., 2020).

The incidence of dysphagia in people requiring mechanical ventilation in the United States ranges from 3% to 62% (Rassameehiran et al., 2015). One study found that 83% of people with prolonged ventilation exhibited swallowing pathophysiology during a modified barium swallow study (Tolep et al., 1996). After receiving a tracheostomy, dysphagia occurs in 11% to 93% (Skoretz et al., 2020).

Examining tongue strength in people who have been extubated is less studied. One study found significant pharyngeal residue secondary to decreased lingual strength (Kim et al., 2015). Another study examined tongue weakness and somatosensory disturbance following extubation. The investigators reported that when controlling other factors such as age, gender, and comorbidities following extubation, tongue strength was decreased, and sensory function was impaired. While sensory disturbances recovered with time, tongue weakness remained (Su et al., 2015).

The good news is that strengthening the tongue can increase lingual pressure (Fukuoka et al., 2022; Robbins et al., 2005; Robbins, 2007). However, an issue arises when determining who needs lingual strengthening and how to accomplish it.

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Assessing Tongue Strength

Typically, tongue strength is measured as part of a clinical swallow evaluation (CSE). Often, the measurement of tongue strength relies on the subjective judgment of the force applied by the tongue against resistance provided by a speech pathologist holding a tongue depressor (Clark et al., 2003; Rodríguez-Alcalá et al., 2021). Clark et al. (2003) examined SLP accuracy in a binary task (normal versus abnormal) and found weak relationships between subjective (tongue depressor) and objective (instrumentation) tongue measures. Interestingly, the study reported that inexperienced clinicians displayed greater accuracy than experienced clinicians. Consequently, the subjective assessment of tongue strength seems inadequate.

The IOPI (IOPI Medical, Woodinville, WA) is the only device currently available in the United States with established tongue pressure normative data (*see Figure 1*). The IOPI is a hand-held portable device that displays a digital readout of the pressure exerted on a standard-sized air-filled disposable bulb. The device measures the amount of air displaced in the bulb during compressions in kilopascals (kPa). After obtaining maximum tongue pressure with the IOPI, the clinician can compare the value with the normative data and current swallow function to determine if tongue strengthening should be part of a comprehensive treatment plan.

Figure 1: IOPI Pro

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Benefits of Strength Training

The main morphological adaptations that occur with strength training include an increase in the overall muscle cross-sectional area and the size of individual muscle fibers. The change is attributed to a rise in the size and number of myofibrils. Satellite cells are activated early in training, and their proliferation and subsequent fusion with existing fibers play a key role in the hypertrophy process. Additional potential morphological changes include hyperplasia, fiber type shifts, muscle architecture alterations, increased myofilament density, and modifications to connective tissue and tendons (Folland & Williams, 2007). In most cases, hypertrophy is not the primary goal of swallowing treatment. During the early stages of strength training, before noticeable muscle changes occur, adaptive changes take place across multiple sites within the nervous system. The changes improve muscle strength (Jenkins et al., 2017; Sale, 1988). Although not clearly understood, it is hypothesized that the adaptation is due to an increased ability to activate the motor neuron pool maximally. The adaptation may result from heightened descending excitatory drive, reduced inhibition, and/or enhanced facilitatory mechanisms. Ultimately, the neurological changes lead to improved force or torque production. Neurological changes are likely the goal of strength training in swallowing therapy. Interestingly, Jenkins et al. (2017) report that neuro adaptations occur when higher levels of resistance (≥ 60% of maximum ability) are utilized during treatment.

How to Strengthen Muscle

The seminal work in the swallow literature outlining the principles of strength training was published in 2007 (Burkhead et al., 2007). The article explains several components of strength training.

- Intensity: Engaging the system in activities that push it beyond the normal level.
- Volume: The number of times the system is engaged in an activity that pushes it beyond the normal level. The volume can be increased through the number of repetitions in a set, the number of sets in a session, the number of exercise times per day, and/or the number of days per week.
- Specificity: Only activities that are task-specific to the system trying to be changed will result in the desired effect.
- Progression: Once the system has adapted to the current intensity load, the load must be increased to experience further gains.

The issue facing the SLP without an instrument to measure tongue strength is that establishing maximum ability is not possible, the percentage of maximum cannot be applied to therapy, adaptation cannot be measured, and progressing the target is difficult.

Integrating IOPI Into a Strength Training Program

IOPI is a tool that allows the clinician to specifically measure current tongue strength and apply the principles of strength training during treatment. Once the maximum strength of the tongue is determined and it is agreed that tongue strengthening will be a part of the treatment plan, the level of intensity can be adjusted to the specific patient. A light array provides the patient with simple feedback, which allows the person with dysphagia to know if they reached their target on each attempt. The feedback provides an incentive to continue working at an intense level. Measuring tongue strength at established intervals allows the SLP to know when adaptation has occurred and progress the target. The SLP can advise the patient concerning the suggested volume of exercise.

Conclusion

Based on current research, people who have been extubated or who have tracheostomy tubes may have decreased tongue strength and may benefit from tongue strengthening being incorporated into their treatment plan. Ultimately, the clinician must consider tongue strength measurements and the pathophysiology of the swallow to determine if the treatment is indicated.

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Article Summary

Management of adults with a tracheostomy: An international survey of speech-language pathologists' practice.

Miles, A., & Wallace, S. (2025). Management of adults with a tracheostomy: An international survey of speech-language pathologists' practice. *International Journal of Speech-Language Pathology,* 1–14. https://doi.org/10.1080/17549507.2025.2482865

This global survey investigated the practices, perceived knowledge, skills, and roles of speech-language pathologists (SLP) in the care of patients with tracheostomies. The survey showed that SLPs are specialists for facilitating communication and weaning as a part of a multidisciplinary team; however, SLPs voiced that there are challenges with an MDT, standardized practices, and available resources. The authors felt we must first track and benchmark the challenges before they can be fully addressed and that the role of SLPs is evolving when it comes to the role with patients with tracheostomies.

Inhalation Burn Injury: Implications for Communication and Swallowing

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Introduction

Inhalation burn injury is a highly complex and potentially devastating form of trauma, particularly when accompanied by extensive cutaneous burns (Gill & Martin, 2015; Darling et al., 1996). It is recognized as the third most critical factor in determining both burn severity and predicting survival outcomes (Colohan, 2010). While existing literature offers guidance on assessment and treatment of inhalation injury, the focus is largely on the emergency and acute phases, with comparatively little attention given to the sub-acute and rehabilitation stages (Colohan, 2010; Enkhbaatar et al., 2004; Sutton et al., 2017). Speech-language pathologists (SLPs) have an important role to play in managing this specialized population, addressing both communication and swallowing needs (Rumbach et al., 2011; Rumbach et al., 2014; Clayton et al., 2020). However, SLP contribution remains under-recognized and is often poorly understood and not well utilized (Rumbach et al., 2016).

What is inhalation injury?

Inhalation injury occurs as a result of the inhalation of hot air, gases, liquids, or chemicals, and is a significant contributor to morbidity and mortality in burn patients. Prevalence rates of inhalation injury range from 10% to 47% among all burn cases, with the risk increasing in association with the percentage of total body surface area (TBSA) affected (Reid & Ha, 2019; Zhen et al., 2023). It is considered one of the most critical factors in predicting both short- and long-term outcomes (Tang et al., 2022; Reid et al., 2019).

Inhalation injury is typically classified into three categories: thermal injury to the upper airway (from the mouth and nose to the glottis), thermal injury to the lower airway (from the glottis to the trachea), and systemic injury due to the inhalation of irritant gases (Endorf & Gamelli, 2007; Sheridan, 2016). Upper airway injury is associated with acute edema and potential laryngeal obstruction, while lower airway injury can result in mucosal sloughing, infection, bronchiolar plugging, atelectasis, and bronchospasm, often emerging during the immediate to early acute phases following injury (Cancio et al., 2005; Clark et al., 2018). Systemic inhalation injury may lead to acute pulmonary edema, acute lung injury, and acute respiratory distress syndrome (ARDS), typically presenting with delayed onset several days post-injury (Brusselaers et al., 2010; Bjorkbom & Braband, 2018).

Diagnosis is initially based on clinical suspicion, often informed by the circumstances of the burn (e.g., exposure within an enclosed space), physical signs such as singed nasal or facial hair, the presence of soot in the upper airway, altered voice quality, and signs of respiratory distress (Endorf & Gamelli, 2007; Clark et al., 2018). While these indicators guide early recognition, bronchoscopy and flexible nasendoscopy are considered the gold standards for diagnosis (Cancio et al., 2005; Woodson et al., 2018) (*See Figure 1*). In addition, CT bronchography with virtual bronchoscopy may provide further insight into the extent and severity of airway involvement (Gore et al., 2004).

What sequelae are associated with inhalation injury?

Inhalation injury can lead to a wide range of complications, the nature and severity of which depend largely on the extent of the injury. Key factors influencing outcomes include the intensity of the heat or toxic gas source, duration of exposure, and the time taken to achieve cooling or neutralization of the airway. Additionally, complications may be aggravated by upper airway interventions such as endotracheal intubation, tracheostomy, or feeding tube placement (Sheridan, 2016; Clark et al., 2018).

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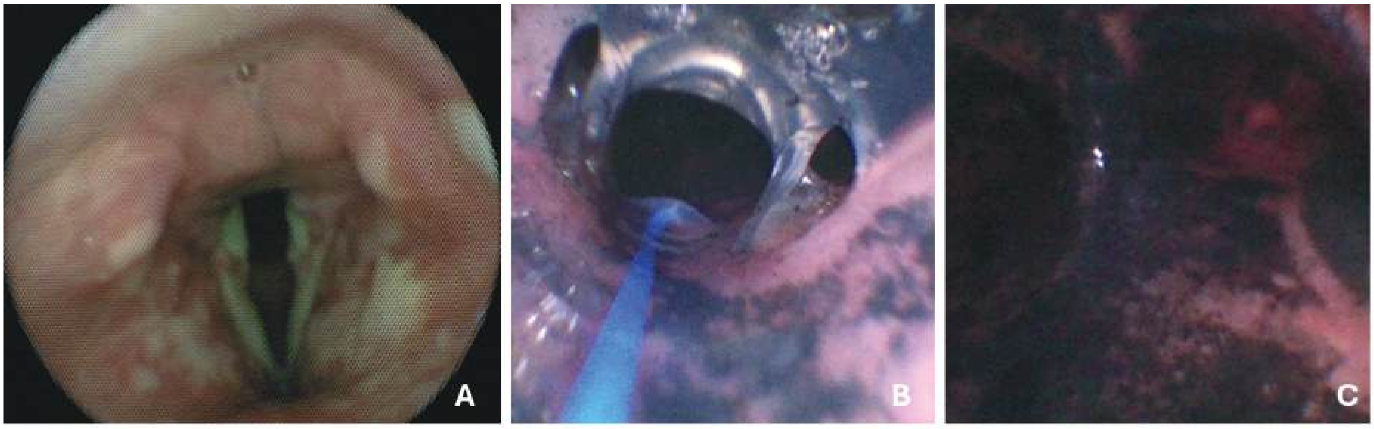

Figure 1: *Inhalation injury at the level of (A) larynx, (B) trachea (via ETT) and (C) main carina.*

These sequelae are often categorized according to time of onset:

- Immediate complications (minutes to hours post-injury): Airway edema, airway erythema, dysphonia, pain on coughing or swallowing, laryngeal obstruction, bronchospasm
- Early complications (hours to days post-injury): Systemic toxicity, Acute Lung Injury (ALI), Acute Respiratory Distress Syndrome (ARDS), mucosal tissue necrosis, adhesions, dysphonia and dysphagia, hyposmia (reduced sense of smell), hypogeusia (reduced sense of taste)
- Late complications (weeks to months post-injury): Laryngeal contractures, Posterior Glottic Stenosis (PGS), subglottic stenosis, tracheal stenosis, persistent dysphonia, atelectasis, pulmonary fibrosis

An important consideration when examining and treating an individual with possible inhalation injury is the anatomy of the upper aerodigestive tract. The larynx and larger conducting airways are uniquely situated to absorb the majority of the thermal and chemical insult in the event of an inhalation injury (Zhen et al., 2023). The laryngeal adductor reflex, while protective of the distal airways, inadvertently increases the risk of significant laryngeal trauma by causing reflexive glottic closure in response to noxious stimuli. Consequently, the larynx often sustains substantial damage. The presence of initial laryngeal abnormalities post-burn significantly increases the likelihood of persistent airway, voice, and swallowing dysfunction (Reid et al., 2019).

Histology of the aerodigestive tract – a quick refresher

The histological structure of the laryngeal mucosa differs significantly from that of the skin, making it more prone to prolonged edema and erythema, as well as slower healing and scar formation (Flexon et al., 1989). While some structures heal very quickly, such as the tongue blade, studies have shown that re-epithelialization of vocal fold injuries can extend up to ten weeks post-injury, with the collagen matrix within vocal fold scars stabilizing around six months later (Jones et al., 2017; Romanowski et al., 2016). These timelines are notably longer than those observed in cutaneous wounds. This extended healing period and delayed scar maturation likely contribute to the late onset of upper airway complications, such as persistent dysphonia, posterior glottic stenosis, and tracheal stenosis, which may result from the inhalation injury, related medical interventions in addition to variable individual inflammatory responses (Reid & Ha, 2019; Zhen et al., 2023; Tang et al., 2022; Gaissert et al., 1993).

Throughout the upper aerodigestive tract, there are anatomical locations that are recognized to be either more prone or more resistant to scar tissue development. These locations correlate with the sequelae listed above and are illustrated in *Figure 2*.

> *Compared with the broader burn patient cohort, individuals with inhalation injury demonstrate an eight-fold greater risk of dysphagia*

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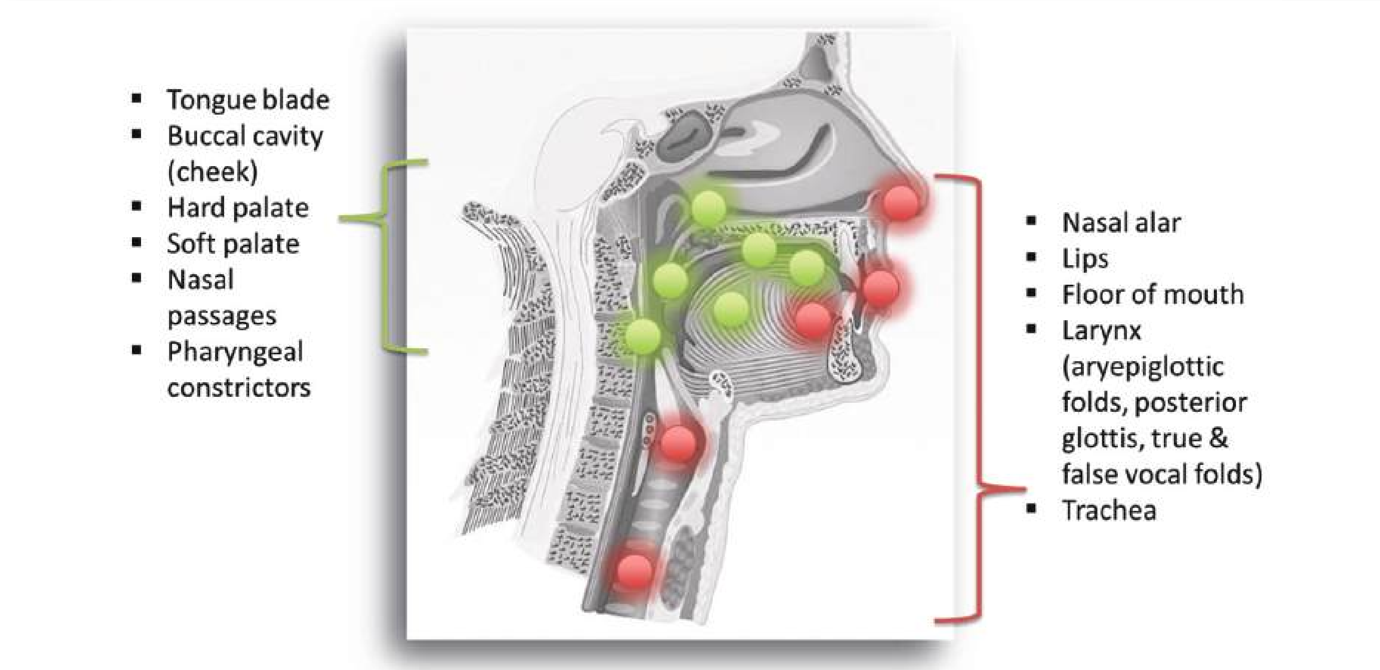

Figure 2: *Risk for scar tissue development throughout the upper aerodigestive tract.*

What do we know about dysphagia post-inhalation injury?

Inhalation injury has been identified as an independent predictor for the presence of dysphagia in burn patients (Rumbach et al., 2011; Rumbach et al., 2014). Evidence indicates that patients with inhalation injury are at substantially higher risk of developing swallowing impairments compared with both the general burn population and those without inhalation injury.

Compared with the broader burn patient cohort, individuals with inhalation injury demonstrate an eight-fold greater risk of dysphagia, with reported prevalence rates of 89% versus 11% (Clayton et al., 2020). When compared specifically to burn patients without inhalation injury, the risk increases to sixteenfold (89% vs 6%). In addition to the increased incidence, dysphagia severity in the inhalation injury population is significantly greater.

These patients typically experience a prolonged time to initiation of oral intake, extended reliance on enteral feeding, and a longer duration to resolution of swallowing impairments. Underlying mechanisms behind the presentation of dysphagia in this cohort are postulated to be muscle disuse atrophy in the context of endotracheal intubation, direct insult from the burn itself on the oropharyngeal mucosa, as well as acute deconditioning as a consequence of post-burn hypermetabolic state (Clayton et al., 2020). Such findings highlight the importance of early dysphagia screening, close multidisciplinary management, and targeted rehabilitation strategies in burn patients with inhalation injury.

What do we know about communication post-inhalation injury?

Dysphonia is a common sequela of inhalation injury, with reported prevalence ranging from 55% to 100% (Casper et al., 2002; Clayton et al., 2025). The risk of dysphonia increases with the severity of inhalation injury (Reid et al., 2019) and the need for upper airway interventions (Clayton et al., 2020; Cheung et al., 2013). Patients with severe inhalation injury demonstrate poorer voice outcomes, with dysphonia more likely to persist beyond hospital discharge in moderate to severe cases (Reid et al., 2019).

Intubation is an additional contributing factor, with both the risk and severity of dysphonia increasing in intubated patients (Casper et al., 2002). Voice quality frequently deteriorates before showing improvement, and recovery to premorbid voice is reported in only 53% to 88% of cases (Hogg et al., 2017; Clayton et al., 2025).

In one study of 62 patients, dysphonia was present in 55% overall, rising to 87% in those with severe inhalation injury. At six months, dysphonia had resolved in 98% of the non-severe group compared with only

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73% of the severe cohort. Severe inhalation injury was significantly associated with dysphonia ($p < 0.001$), poor resolution of dysphonia at six months ($p < 0.001$), and longer duration of intubation ($p = 0.033$) (Clayton et al., 2025). Overall, approximately one in two burn patients with inhalation injury experience dysphonia, and one quarter of those with severe injury will still have persistent voice impairment at six months.

From a clinical perspective, and if left untreated, these patients often present with a voice quality that is lower-pitched, rough, and breathy with poor pitch range. This is most often due to the presence of scar tissue in the posterior glottic region, splinting the posterior glottis open (seen as a posterior glottic gap) during phonation, along with shortening of the aryepiglottic folds, limiting vocal fold lengthening.

What do we know about laryngotracheal pathology post-inhalation injury?

The risk of laryngeal pathology increases in proportion to the severity of inhalation injury. Persistent laryngeal pathology at six months post-injury has been reported in 47% of patients (Clayton et al., 2020). Posterior glottic pathology is the most common finding, occurring in 71% of patients who required intubation as part of their treatment (Tang et al., 2022). Tracheal lesions frequently occur at points of mechanical contact, such as the site of the endotracheal tube (ETT) cuff, tracheostomy cuff, or tracheostomy stoma (Gaissert et al., 1993; Reid & Ha, 2019). Bronchial lesions are more prominent in cases of chemical inhalation injury and are reported more frequently in the left bronchus compared to the right (Ghanei et al., 2004). The overall incidence of long-term airway complications following change II to inhalation injury ranges from 5% to 7% (Zhen et al., 2022).

Figure 3 illustrates a patient with laryngeal contractures and flexible nasendoscopy during deep inspiration. This image specifically highlights the presence of posterior glottic stenosis and shortening of the aryepiglottic folds.

What treatments are available?

Most treatments for inhalation injury are supportive in nature, with a focus on improving airway treatments and minimizing the associated impacts of iatrogenic trauma on airway structures (Tang et al., 2023). Unfortunately, less information is available for evidence-based interventions to prevent laryngeal complications and to rehabilitate dysphonia and dysphagia with the application of education, compensatory strategies, and pharmacological intervention, as more commonly cited (Clayton et al., 2025).

Figure 3: Laryngeal contractures on flexible endoscopy

Table 1 provides an overview of treatments that may be considered throughout the various stages of patient recovery.

Speech-Language Pathology Treatment Considerations

The high prevalence and increased severity of dysphagia in individuals with inhalation injury emphasizes the importance of initiating early and intensive swallowing rehabilitation. Proactive strategies aimed at preventing and reducing the impact of deconditioning and contracture formation on swallowing are essential to maximize functional recovery. Emerging evidence supports this approach (Clayton et al., 2017; Rumbach et al., 2015; Rumbach et al., 2009; Rumbach et al., 2011), though further research is needed to determine the most effective treatment protocols to facilitate a timely and safe return to oral intake in this complex patient group.

Furthermore, a need also exists for targeted guidance on the most effective laryngeal and voice rehabilitation approaches following inhalation injury, including optimal timing, intensity, and length of therapy. While conventional voice therapy often concludes once a functional voice is restored, individuals with inhalation burn injury may require extended treatment and a maintenance phase due to the unique histological features of the larynx, which can lead to markedly prolonged wound healing and delayed scar maturation (Reid & Ha, 2019; Zhen et al., 2023; Jones et al., 2017). Additional research examining therapy timing, dosage, and duration would provide valuable evidence to inform and refine future clinical management strategies.

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Table 1 Potential treatments for inhalation injury throughout the recovery period

Potential Complications	Treatment Considerations
Immediate:	
• Airway edema	Maximal oxygenation
• Airway erythema	Increased fluid resuscitation
• Dysphonia	Endotracheal Intubation
• Pain (cough/swallow)	Tracheostomy
• Laryngeal obstruction	Serial flexible nasendoscopy for diagnosis, guiding need for intubation & steroids
• Bronchospasm	Bronchoscopy for diagnosis & therapeutic lavage Steroids
Early:	
• Systemic toxicity	Maximal oxygenation
• Acute Lung Injury	Bronchoscopy for therapeutic lavage
• ARDS	Pulmonary toileting
• Mucosal tissue death	Reflux prophylaxis
• Adhesions	Assess depth & extent of head & neck burns
• Dysphonia	Flexible nasendoscopy for diagnosis, guiding the need for steroids
• Dysphagia	Steroids
• Hyposmia	Assess neck burn depth – advocate for early closure (small mesh) in preparation for possible tracheostomy
• Hypogeusia	
	Extubation vs tracheostomy
	Tracheostomy one-way valve (inline or off ventilation)
	Oral, pharyngeal & laryngeal range of movement exercises
	Pharyngeal strengthening
	Respiratory Muscle Strength Training (Inspiratory & Expiratory)
	Nasogastric feeding vs percutaneous endoscopic/radiological inserted gastrostomy
Late:	
• Laryngeal contractures	Oral, pharyngeal & laryngeal range of movement exercises
• Posterior Glottic Stenosis	Oral splinting
• Subglottic stenosis	Active assisted exercises to the orofacial region
• Tracheal stenosis	Pressure-loaded exercises (laryngeal) - RMST
• Dysphonia	Repeated flexible nasendoscopy (to track progress)
• Atelectasis	Tracheostomy
• Pulmonary fibrosis	Tracheostomy one-way valve
	Tracheal stenting / T-tubes
	Surgical resection (laser cordotomy, tracheal resection)

Conclusions

SLPs play a critical role in the comprehensive management of patients with inhalation injury, addressing the complex interplay of voice, swallowing, and laryngotracheal pathologies. Through early assessment, targeted intervention, and ongoing rehabilitation, SLPs are integral to optimizing communication, airway safety, and overall functional outcomes in this high-risk population. However, further research is needed to strengthen the evidence base for assessment and treatment practices, ensuring optimal, evidence-informed care across all stages of recovery.

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Implementing Toolbox Ideas: A Sub-Acute Case Study

Karen Samra, MS, CCC-SLP

Central to our quality of life is the ability to communicate and swallow. During holidays, first dates, weddings, birthdays, and across cultures and the lifespan, communication and swallowing are essential components to health, as these activities connect us and bring us together. Addressing changes or impairments in these areas is the expertise of the speech-language pathologist (SLP).

Speech-language pathologists evaluate, manage, and treat communication and swallowing impairments. In the medical setting, the caseload for SLPs is frequently high numbers of patients with dysphagia. Much research has been done to determine the best evidence-based care for patients with dysphagia. When determining an intervention plan, a primary goal of therapy is often to reduce morbidity and mortality associated with chest infections and poor nutritional status by providing swallowing therapy for safe and adequate nutrition and hydration with minimal complications (Wirth et al., 2016).

As speech-language pathologists evaluate patients and develop treatment plans, consideration is given to the quality of life and dignity of the patient. Having access to effective communication and eating is a key component of maintaining patient access to quality of life and dignity. Having the proper toolbox of therapeutic tools and interventions is essential. Using a case study from the sub-acute setting illustrates these concepts.

Case Study

The story of 50-year-old Alexandra in California illustrates how clinicians use resources to assist with the plan of care. Alexandra, a graphic designer in California, suffered a stroke in her apartment. She was single and without children. Her closest family lived in Florida. Before her stroke, she enjoyed skiing, bike riding, watching sitcoms, and cooking Italian food. From her apartment, paramedics sent her to a hospital, and eventually, she transferred to a subacute facility, a level of care often occurring before returning to the home setting.

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Alexandra came into the subacute facility with a severe communication impairment, characterized by severe aphasia and apraxia of speech (AOS; a phonetic-motoric disorder of speech production), and severe dysphagia, NPO (non per os; nothing by mouth) as a result of her stroke. She was only able to communicate approximately five words as she entered the facility due to her severe aphasia and apraxia. She also had a history of a tracheotomy performed in the hospital and entered the subacute setting with a tracheostomy tube, Shiley size #6.

The subacute facility had resources for working with the patients, including monthly candlelight dinners for those who could eat, including a themed ice cream shop reminiscent of the 1950s; two visits per month with dogs as therapy pets; and two live-in cats as therapy animals in the building, providing comfort for the residents. The management was also supportive of the staff, including providing funds for continuing education. The staff was a close-knit community who worked well together, and the speech-language pathologist was eager to utilize the resources the facility had.

Comprehensive Cranial Nerve Examination and the Oral Health Evaluation Tool

The clinician completed a comprehensive cranial nerve examination, which was essential for dysphagia and motor speech assessments, assessing the structure and integrity of the oral musculature. The oral health evaluation tool (OHAT) was also utilized as a screening tool regarding oral care. Oral care screening is beneficial for dysphagia assessments and helps screen for oral thrush, potentially impacting patient

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recovery and health by reducing the risk of bacteria. Findings can be shared with the nursing staff and physicians to increase awareness and to address concerns related to oral care. Oral hygiene is key as it is one of the known aspiration pneumonia risk factors (Logeman, 1999). Good oral hygiene can reduce dry oral mucosa as well as reduce hospitalization risks. Screening the structural integrity of the oral cavity provides insight for dysphagia therapy. Screening via the OHAT is also beneficial for further dental professional referrals as needed. The assessment of Alexandra revealed a mild facial asymmetry with slightly reduced strength on the right side (*see Table 1*).

Table 1 Cranial Nerve Assessment Findings

Assessed	Findings
Eye ptosis:	None
Dentition:	Adequate; no missing teeth
Secretions (oral cavity):	Typical; no drooling
Oral hygiene / condition:	Clean / moist
CN V:	Adequate gross facial sensation, closed jaw posture at rest, adequate jaw strength, no adventitious movements noted.
CN VII:	Facial asymmetry at rest (bottom right-side) with eyelid closure: Mildly reduced R side; Eyebrow movement adequate; Labial movement and speed adequate with no adventitious movements noted.
CN IX/X:	Resonance adequate
CN X:	Appropriate loudness, appropriate pitch, vocal quality WFL. Cough appears strong, adequate.
CN XI:	Deferred
CN XII:	Lingual protrusion adequate, lingual ROM adequate, lingual strength adequate, no adventitious movements noted.

Passy Muir Valve® Assessment

The respiratory therapist (RT) and SLP collaboratively assessed and provided education for the patient for use of the Passy Muir® Tracheostomy & Ventilator Swallowing and Speaking Valve (PMV®). The assessment was initiated after a physician's order was received. The RT's role during the assessment was to evaluate Alexandra's respiratory status and function, which included notation of her secretions, secretion management, and suctioning needs. The SLP's role in the assessment involved placement of the Passy Muir Valve and then evaluating how the patient's voice sounded and how her swallowing was. The PMV is used with patients to enable verbal communication by re-establishing airflow through the vocal folds. The benefits of the PMV extended beyond communication. The SLP educated Alexandra that the PMV acts as a midway point between a tracheostomy and normal breathing, restores the ability to exhale through the nose and mouth, facilitates a "normal" breathing pattern for the patient once again, and provides therapy for respiratory function and muscle recovery simply from wearing it.

During the PMV assessment, baseline vital signs were obtained, and the patient's tracheostomy cuff was deflated, a critical step. The SLP provided language and voice techniques during the PMV assessment to help the patient communicate and to enhance her effectiveness. The facility staff utilized the Passy Muir website for guidance, policies and procedures from the Centers of Excellence, and educational materials available for use

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with patients. Troubleshooting tips and the ability to call clinicians from the company furthered staff knowledge and assisted with developing a treatment plan.

Alexandra tolerated the Passy Muir Valve during therapy and for use with other staff, and the SLP utilized the tools below to educate staff on the benefits of the one-way valve. Speech therapy sessions occurred as tolerated, starting at 10 minutes, then 20 minutes, and so on. Physician orders were obtained for use of the PMV outside of the therapy sessions once Alexandra was able to tolerate the PMV for an extended time. Staff were continually educated about proper use. To assist with continuity of care, each PMV comes with a kit including warning labels, which help with staff education, as well as an education booklet that helped with questions, including how to clean the valve and how long each valve lasts.

Tools for Education

Pocket T.O.M. This educational model was utilized to educate staff and caregivers regarding basic anatomy and physiology, including deglutition. Increased education and rapport among individuals were helpful with compliance and ensuring clinician knowledge. Particularly, the use of Pocket T.O.M. was useful in a clinical setting and it can fit in a clinician's lab coat pocket. Many patients and families are more apt to follow recommendations when the therapeutic alliance and knowledge are stronger. Having better education through tools, such as Pocket T.O.M., helps improve patients' adherence to recommendations. The SLP utilized Pocket T.O.M. to educate staff regarding risks of aspiration and food, contaminated secretions, or drinks going 'down the wrong pipe.' Pocket trach T.O.M. was beneficial for education regarding the larynx and general upper aerodigestive system and the role of the speech-language pathologist.

Handouts. After a demonstration with the model, it was helpful to follow up with the Patient Education Handout (PEH) (Passy-Muir, Inc., 2025). The PEH helps educate patients, caregivers, and staff regarding the care and maintenance of the PMV and how it functions, including its benefits. Handouts and swallowing strategy signs were posted in the patient's room (see *Figure 1 and 2*).

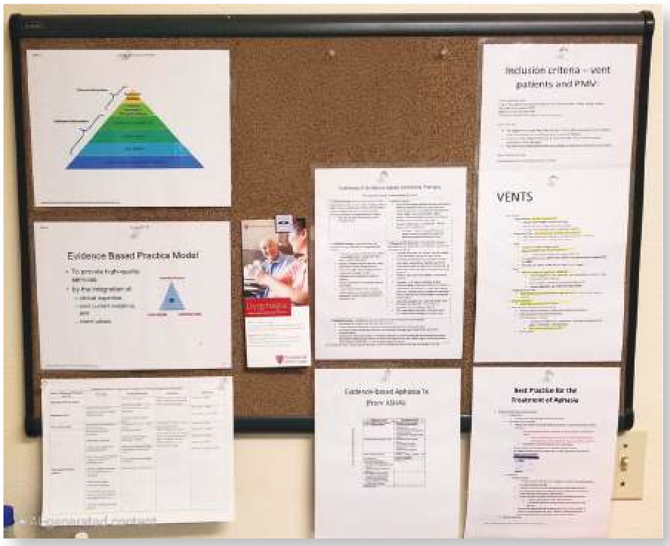

Figure 1: *Posted handouts and educational information.*

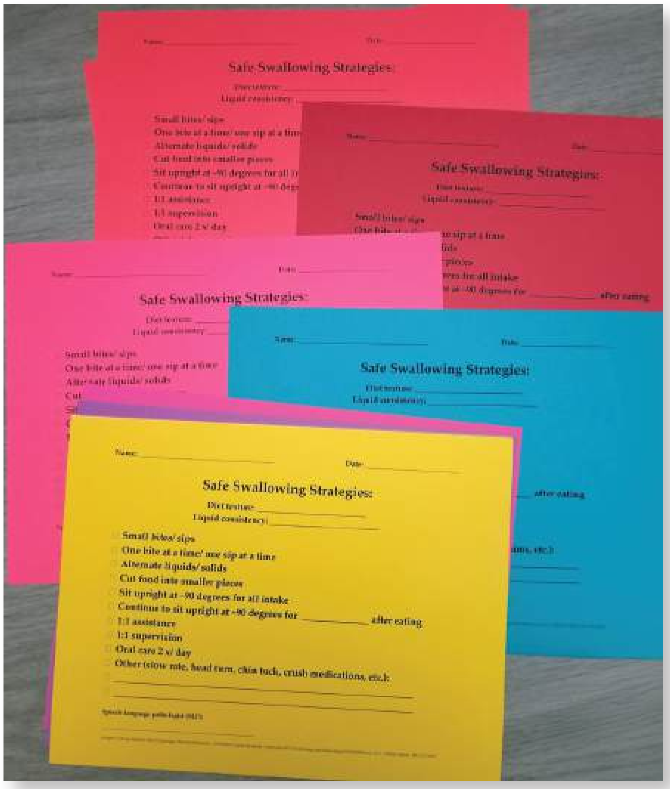

Figure 2: *Swallowing strategy materials.*

MBImP App. Alexandra had completed an instrumental assessment of swallowing in the hospital with the use of a standardized assessment, a videofluoroscopic swallow study. Her swallow study had revealed severe pharyngeal dysphagia and resulted in a recommendation for NPO. Once in the subacute setting, Alexandra's SLP utilized the Modified Barium Swallow Impairment Profile (MBSImp) app to demonstrate and educate the staff and caregivers on the effects of aspiration in real-time

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and highlight the importance of oral care (e.g., potential effects of bacteria on aspiration of secretions) (Daniels et al., 2019). The app also assisted with developing targeted treatment plans for Alexandra (*See Figure 3*).

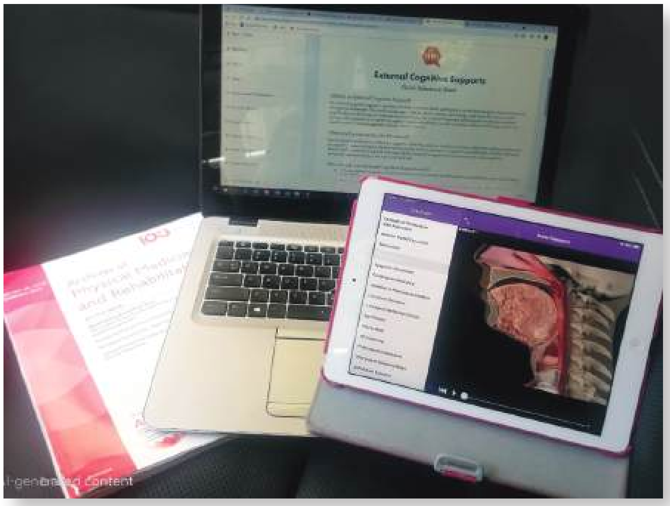

Figure 3: *Various computer programs and apps are used in therapy and for education.*

Overall Treatment Plan

Alexandra's treatment plan included a long-term goal of nutrition and hydration by oral means with decreased signs and symptoms of aspiration, no pulmonary compromise from dysphagia, reduced hospitalization risk related to swallow dysfunction, reduced social embarrassment due to swallow dysfunction, and increased quality of life. Using evidence-based practice, her SLP utilized person-centered care and the World Health Organization's International Classification of Diseases and Functioning (ICF) as a foundation when creating Alexandra's treatment plan.

Rsults of her swallow evaluation revealed her oral phase of swallowing was a strength compared to her pharyngeal phase of swallowing. However, Alexandra had impairments throughout both phases of swallowing. The VFSS report included results indicating mild-to-moderate oral residue, mild-to-moderate anterior loss of liquids and solids, reduced anterior hyoid excursion, incomplete epiglottic inversion, and inadequate laryngeal vestibular closure.

The acute care inpatient clinician had addressed the underlying physiological abnormalities in the recommended dysphagia therapy treatment plan. She provided a listing of the reported physiological abnormalities, and then, next to each impairment, she wrote treatment considerations that would be beneficial. When developing Alexandra's dysphagia therapy plan in the subacute setting, the principles of neural plasticity were utilized in the treatment plan. Research has shown that incorporating exercise-dependent neuroplasticity tasks into a therapy plan assists with improving rehabilitation and functional outcomes (Kleim & Jones, 2008).

Alexandra's treatment plan included dysphagia exercises and education to increase oropharyngeal swallow strength, direct training on both swallowing and tasks, and therapeutic swallowing trials that began in speech therapy sessions and progressed to occurring with trained staff. Safe swallowing strategies were reinforced during therapy. As the trials continued to go well in therapy, oral trials progressed to full oral intake of nutrition. The planned progression was to slowly and carefully move from trials to snacks allowed with trained staff and then to one meal per day, two meals per day, and then three. The trials moved slowly, methodically, and systematically to ensure aspiration risk was minimized, all staff were trained in the proper oral care program, and the safe swallow strategies were utilized. The plan was designed so as not to overwhelm medical staff, as well as considering the patient's environment.

When working with Alexandra and explaining the purpose of therapy, the SLP often referred to the principles of neural plasticity as the "gym for your throat" to improve her understanding of the therapy. Using the principles of exercise-dependent neural plasticity, application in therapy included taking rest breaks between sets, completing a targeted number of reps and sets, and using repetition and drill. Comparing the dysphagia therapy process to going to the gym was a familiar concept that allowed the patient and her family members to better understand the concept of systematically increasing her oral intake.

Additional Tools for Therapy

EMST 75 / 150. For Alexandra, one of the approaches for exercise utilized to assist with both respiratory function and swallowing was respiratory muscle training (RMT). Alexandra was successful with the use of a Passy Muir Valve (PMV). Therefore, as she tolerated the PMV, therapy incorporated EMST 75, beginning at ~45 cm H_2O. The starting point was determined by taking MIP and MEP (maximum inspiratory pressure and maximum expiratory pressure) measurements with a respiratory pressure meter. Measuring MIP and MEP allows a baseline starting point for therapy to be determined.

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As Alexandra had reduced laryngeal vestibular closure, expiratory muscle strength training (EMST) was used to address reduced airway protection. The use of RMT has been shown in research to be beneficial for both respiratory function and swallowing strengthening (Clayton et al., 2022; Freeman-Sanderson et al., 2021).

Results

With a supportive team and a motivated patient, Alexandra had a successful stay in the subacute setting. The staff assisted Alexandra with her swallowing therapy progression and meals, while maintaining good oral care and reducing her aspiration pneumonia risk. Therapeutic PO trials occurred over several weeks. Eventually, with evidence-based practice and person-centered care, Alexandra moved from NPO to a fully regular diet with solids and thin liquids and no pulmonary compromise, hospital visits, or social concerns from being unable to swallow safely. Her tracheostomy team, which included her RT and SLP, was able to ensure her use of the Passy Muir Valve throughout her time in subacute, including during meals, since use of the Valve has been shown to assist with improving both respiratory and swallow function.

Eventually, Alexandra was successfully decannulated, no longer requiring a tracheostomy. She moved from the subacute unit to a lower level of care, the long-term care unit, reducing overall healthcare costs. From having the correct therapy and educational materials, a supportive team, and the right candidate, to the patient's overall recovery progression, her quality of life significantly improved.

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Heat Moisture Exchanger (HME) in Tracheostomy Care

Gabriela Ortiz, BSRT, RCP

Following a tracheostomy, the natural functions of the upper airway responsible for heating, humidifying, and filtering inhaled air are bypassed. Without this natural conditioning, patients become more vulnerable to respiratory complications. The air entering the lungs is cooler and less humidified than what the body typically receives, which can lead to thickened and dry secretions, impaired ciliary function, and potential airway obstructions. To mitigate these risks, supplemental humidification through active humidifiers or heat and moisture exchangers (HMEs) is often necessary to restore adequate moisture and warmth to inspired air (Chandler, 2013).

The role of HMEs in tracheostomy care warrants discussion about the benefits, clinical considerations, and potential effects on patient outcomes. Chandler (2013) also noted that while international guidelines specify a minimum humidity output of 33 mg H_2O/L for active humidifiers, during passive humidification with ventilation, a minimum of 30 mg H_2O/L should be provided by an HME (Restrepo et al., 2013) used with a ventilator.

Key Functions of Active and Passive Humidifiers

Both active humidifiers and HMEs are used to humidify and warm the air for patients with tracheostomies or those on mechanical ventilation. However, they differ in their design, mechanism of action, and clinical applications.

- Active humidifiers rely on an external power source – often a heated water reservoir – to actively add heat and moisture to the air delivered to the patient. They typically feature a heated breathing circuit that helps maintain optimal temperature and humidity levels before the air reaches the airway. Because of the ability to deliver consistent, high-level humidification, these devices are especially suited for patients on mechanical ventilation or those with significant humidification needs. However, they are generally larger, less portable, and best used in hospital settings where they can be closely monitored. Active humidifiers also require regular upkeep, such as cleaning the reservoir or replacing water bags, and incur higher operating costs due to their reliance on electricity and consumable parts. They are ideal for patients who need continuous and precise airway humidification and warming.

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- Heat and Moisture Exchangers (HME) – often referred to as an artificial nose – are passive devices that help warm and humidify inspired air by utilizing the patient's exhaled breath. These small, lightweight devices attach directly to a tracheostomy tube and function by capturing heat and moisture during exhalation, which is then transferred to the next inhaled breath. This process mimics the natural humidification and warming function of the upper airway, helping to condition the air before it reaches the lungs.

HMEs require no external power or water source, making them especially suitable for home care or ambulatory patients. They are low-maintenance, cost-effective, and best suited for individuals with tracheostomies who are breathing spontaneously or receiving minimal ventilatory support. By preserving airway moisture and temperature, HMEs play a critical role in reducing the risk of airway dryness, irritation, and mucus-related complications.

Construction and Types

HMEs are commonly made from foam or paper materials treated with hygroscopic salts, like calcium chloride, and encased in a plastic housing. The core material is usually enclosed in plastic to maintain integrity and hygiene. There are three main types of HMEs:

- **Hygroscopic (hydrophilic):** Absorbs and retains moisture from exhaled air and releases it back into inspired gases.
- **Hydrophobic:** Uses water-repellent materials to absorb moisture from warm exhaled air.
- **Combination (Hygroscopic-Hydrophobic):** Integrates both properties for enhanced performance in heat and moisture retention.

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Considerations in HME Use

Studies have demonstrated that tidal volume significantly influences the performance of HMEs in humidifying inspired airflow for patients with tracheostomies. Specifically, as tidal volume increases, the absolute humidity (AH) provided by HMEs decreases. For example, research indicates that increasing tidal volumes led to a reduction in % RAH (percentage of recovered absolute humidity) for HMEs tested (Chikata et al., 2018).

Newly available, the Passy Muir® Heat Moisture Exchanger (PM-HME) is a non-sterile, lightweight, single-patient-use device specifically designed for placement on a tracheostomy tube hub (*see Figure 1*). It provides passive humidification, supporting airway health and comfort, and mimicking the natural humidification process of the upper airway. The PM-HME is intended for spontaneously breathing patients, enhancing patient outcomes by supporting natural humidification.

Figure 1: PM-HME

Key Benefits of the PM-HME

- Single patient use: Suitable for both adult and pediatric patient populations.
- Friction Fit Design: Ensures a secure fit, designed to fit the 15mm hub of the tracheostomy tube for easy attachment and stability.
- Maintaining Humidity Levels: Accommodates tidal volumes (Vt) > 50 mL, ensuring consistent humidification.
- Device Maintenance: PM-HMEs should be replaced every 24 hours, or more frequently depending on patient needs and clinical settings.

The PM-HME cannot be used with a speaking valve, as an HME must have exhaled airflow to be effective. This device is intended for use by healthcare professionals trained in tracheostomy care. Patients and caregivers may also use it under the supervision of a qualified healthcare provider

Conclusion

Heat and moisture exchangers play a critical role in the management of patients with tracheostomies by restoring essential functions of the upper airway that are bypassed by the tracheostomy tube. By effectively humidifying and warming inhaled air, HMEs help improve patient comfort and enhance overall respiratory function. As a result, HMEs remain a cornerstone for improving the quality of life and clinical outcomes for patients with tracheostomies.

Clinicians should carefully assess the unique needs of each patient to select the most appropriate type of HME, ensuring optimal care and long-term respiratory health. Continued innovation and research in HME technology will further refine treatment options, leading to improved patient outcomes, comfort, and safety in respiratory management.

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Featured Authors

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Ed Bice, MEd, CCC-SLP

Ed Bice is a Clinical Consultant for IOPI Medical and works clinically at a nonprofit speech and hearing clinic. He has experience in various settings and has held various leadership positions, including a Regional Manager, Vice President of Clinical Services, and Chief Operating Officer. He is the co-coordinator of the Speech, Language, and Hearing Association of Virginia's Feeding and Swallowing Disorders group and President-elect of the Association. He co-authored Adult Dysphagia: Clinical Reasoning and Decision-Making Guide (Plural Publishing). Ed has served as an expert witness in court cases related to swallowing and swallowing disorders and has been an invited speaker for universities, state, national, and international conventions on various topics in dysphagia..

Nicola Clayton, PhD, MScMed, BAppSc

Dr Nicola Clayton is a Clinical Specialist Speech Pathologist at Concord Hospital in Sydney with over 25 years in experience in complex dysphagia management. She is also a clinical academic, completing her Master of Science in Medicine and PhD with focusses on respiratory disease and severe burn injury. She holds honorary affiliations with the University of Queensland, University of Sydney and is internationally recognised for her expertise, research, and education in the field of dysphagia, severe burn injury and critical care.

Matthew Dumican, PhD, CCC-SLP

Dr. Matthew Dumican is an Assistant Professor at Western Michigan University in the Department of Speech, Language, and Hearing Sciences. He received his Masters degree and Ph.D. from Texas Christian University. He has worked clinically in skilled nursing, rehabilitation, and hospital settings. He specializes in and conducts research on laryngeal function for voice and swallowing, including screening, assessment, and treatment methods. In addition, he teaches undergraduate courses such as Anatomy and Physiology, and graduate level courses including Voice Disorders and Dysphagia.

Kristin King, PhD, CCC-SLP

With over 25 years of experience in medical settings, academia, and industry, Dr. King brings a unique perspective to care of patients with medical diagnoses. Her experience included a clinical focus on critical care and trauma, with an emphasis on TBI and tracheostomy and vent patients. As a professor, she conducted research and published in peer-reviewed journals on TBI and swallowing disorders. She continues her career by working in the industry to improve patient outcomes through the development of multi-media education and participating in product development and regulatory requirements for medical devices. She is the host of the CAM Podcast for Passy Muir, editor of Aerodigestive Health by Passy Muir, and contributes regularly at the state, national, and international levels for both speaking and clinical papers. She also is co-editor of the book *Tracheostomy and Ventilator Dependence in Adults and Children: Learning Through Case Studies*.

Vicki Lewis, MA, CCC-SLP

Vicki Lewis, MA, CCC-SLP graduated from Kent State University in Kent, OH in 1993 and began her work in the area of medical speech-language pathology. She has worked in both clinical and leadership roles in acute care, long-term acute care hospitals, inpatient rehabilitation, outpatient, and sub-acute care. Additionally, Vicki has gained experience as both an adjunct and full-time faculty member in a university setting, teaching a variety of undergraduate and graduate CSD courses. Her work has also included conducting research and she has co-authored peer-reviewed publications in the areas of voice and swallowing and has edited and authored textbook chapters in these topic areas. Vicki began her work as a federal government contractor in July 2023. She currently works as a full-time instructor in the areas of healthcare safety and leadership and also is employed as a clinical educator for Aspire Respiratory Products.

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Gabriel Ortiz, BSRT, RCP

Gabriela Ortiz brings a wealth of experience across the full spectrum of respiratory care, including acute, sub-acute, sleep therapy, and homecare settings. In her previous role as Respiratory Clinical Director and General Manager for a respiratory care provider, she oversaw all aspects of company operations, focusing on patient assessment and case management for adult and pediatric patient populations. She transitioned into clinical education and sales, specializing in critical care ventilation solutions for ICU and PICU environments in acute and sub-acute hospitals. She now offers comprehensive training, in-service programs, and clinical support for healthcare professionals. Gabriela is an invited speaker for educational institutions, state and national conferences, and the Better Breather's Club and ALS support groups. She also contributes to the field by authoring clinical articles and white papers, including peer-reviewed, on topics such as ALS progression, neonatal tracheostomy, speaking valves, and respiratory care strategies. She is a full-time Clinical Specialist with Passy-Muir, Inc.

Virginia Puno, MS, CCC-SLP

Virginia Puno is clinical lead speech & language therapist at Barking, Havering & Redbridge University NHS Trust (BHRUT). She graduated from the University of Sydney in 2009 and moved to London in 2015. She has 15 years of experience working with adult patients predominantly within stroke (acute, rehab and community settings), neurosciences and critical care services in the public health sector across Sydney and London, working the past 7 years at BHRUT. She completes instrumental assessment clinics weekly (Videofluoroscopy and FEES) and has achieved non-vented and ventilatory dependent tracheostomy competencies. Virginia regularly provides training in these areas and leads or participates in service development and quality improvement initiatives. She currently leads a team of over 20 SLTs across multiple specialities and is currently working with them and other stakeholders to evaluate outcomes since the introduction of Phagenyx to BHRUT at the end of August 2024.

Karen Samra, MS, CCC-SLP

Karen Samra is a Speech Pathologist in California. She graduated with a bachelor's degree in Communicative Disorders from California State University, Fresno. She also mentored students with Asperger's/ high-functioning Autism. After completing graduate school with a Master of Science (MS) degree, she completed a research assistantship at Stanford Hospital in Palo Alto, CA and created treatment materials for their Speech Pathology department. She has worked in various settings in California, including a hospital system's home care department and a joint venture company with UCLA.

Anna-Liisa Sutt, PhD, SP

Anna-Liisa Sutt is a Speech Pathologist whose work involves communication and dysphagia management of adult intensive care patients. Most of Anna-Liisa's career to date has been in Brisbane, Australia. She is currently living in the UK, and working clinically at The Royal London Hospital, alongside continued teaching commitments and research nationally and internationally. Her passion is improving the management of patients with tracheostomies, from insertion to decannulation and longer-term outcomes. She is devoted to advancing speech pathology input and its evidence base in the critical care environment. In her PhD Anna-Liisa assessed the effect of one-way valves on regional ventilation and communication success of ventilated ICU patients with a tracheostomy.

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