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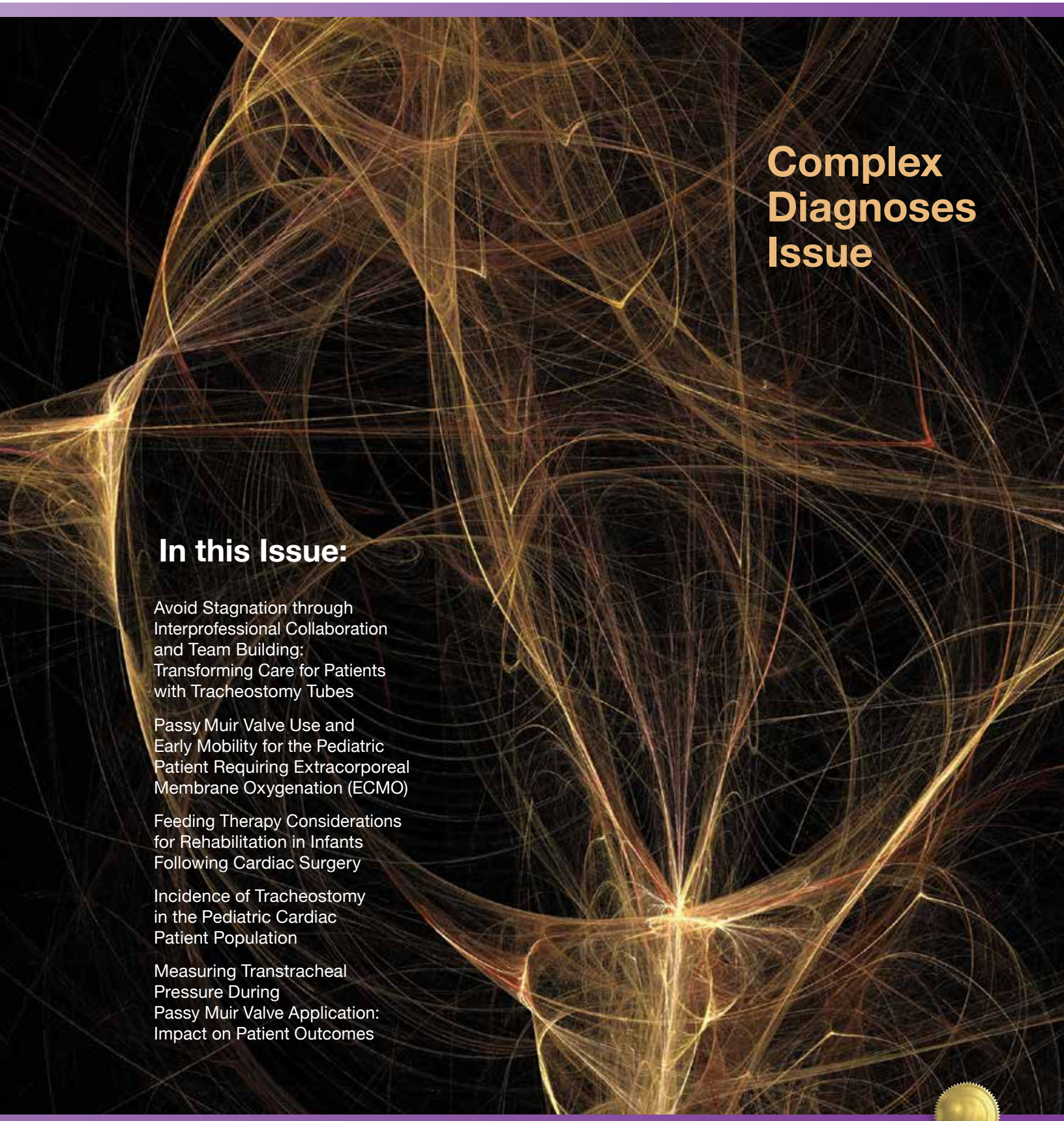

Complex Diagnoses Issue

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Passy Muir Valve Use and Early Mobility for the Pediatric Patient Requiring Extracorporeal Membrane Oxygenation (ECMO)

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ARTICLES LEGEND

Case Studies · ECMO · Feeding Infant · Filtration

Pediatric Cardiac · Team Building · TTP

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

Considerations for Complex Diagnoses

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* provides articles and other resources on the care of adult and pediatric patients, focusing on those who are tracheostomized, with or without mechanical ventilation. The editor's objective is for *Aerodigestive Health* to provide readers with clinical perspectives and cutting-edge research that 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.
- Bibliography – a list of relevant research on pediatric and special patient populations with complex medical diagnoses.

For this issue, the primary focus is ***Considerations for Complex Diagnoses***. This issue provides a unique overview of assessment and treatment considerations for the pediatric patient population with complex medical diagnoses. The number of neonatal, pediatric, and adult patients with tracheostomies is growing each year secondary to advancements in medical care and interventions to sustain life. It is imperative that clinical professionals maintain awareness of evidence-based practices and current standards of care.

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When considering information for addressing assessment and treatment considerations for patients with tracheostomies, the typical standard procedures may not apply when the patient is more medically complex; they may require some modification or special considerations. Determining the appropriateness and type of interventions to be provided can be a daunting task, especially when considering dysphagia. Questions often arise regarding treatment interventions and how to determine best practices. When considering special patient populations with complex diagnoses, it is often difficult to find information.

This issue of *Aerodigestive Health* brings together perspectives that present considerations for pediatric patients with cardiac issues and those undergoing ECMO. One of the primary evidence-based considerations for all patient populations is to have a team approach with staff who are trained in the management of patients with tracheostomies. In this issue, Cabacungan and Davis present relevant information on how to address both team development and the education of staff. They share a mobile training unit that their facility has implemented to best meet training needs.

Brooks et al. provide an overview of ECMO and its impact on the pediatric patient, illustrating special considerations through a case study. They also review factors related to the pediatric patient with a tracheostomy who is receiving ECMO, including best practices for Passy Muir Valve use. In her article, Waters addresses feeding considerations in the pediatric patient population following cardiac surgery. When considering the increased associated risks with airway compromise in patients with congenital heart disease and the series of surgeries for heart issues, the potential for airway or respiratory compromise leading to a tracheostomy is significant. In a companion piece, Waters presents case studies for consideration. The supplementary article by King reviews the prevalence of tracheostomy occurrence in the pediatric population with cardiac issues and considerations for addressing this special subgroup.

This issue is rounded out by Brooks who presents considerations for the use of transtracheal pressure (TTP) measurements to ensure a patent airway when addressing speaking valve use in pediatrics. In this article, she presents the information through four case studies, each with a unique perspective on how TTP provides a more objective measure of airway patency and lends itself to improved clinical practice. She also shares a protocol for best practice.

These articles and the interventions presented touch on what therapies to consider and best practices for Valve use when the patient has a tracheostomy. 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 what we would do with 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 pressure. Considering the feeding issues that Waters presented for the pediatric cardiac patient if the patient has a tracheostomy and the system is restored to a more normal pressurized system, then the therapy considerations revert to standard practices for the identified issues. What this means is that once the system is closed, if the patient has poor feeding and swallowing skills, then initiating therapies that address feeding and swallowing would be appropriate, following traditional, evidence-based practice guidelines with considerations for the tracheostomy. In this issue, the authors share either therapeutic interventions regardless of tracheostomy presence or specifically address modifications that may be necessary with a tracheostomy.

The primary takeaways from this issue are that having a team and appropriate staff training improves overall care for the patient with a tracheostomy; treatment interventions with these medically complex patient populations are the same regardless of tracheostomy; and appropriate assessment of airway patency is key to successful interventions. The sooner the many benefits begin, the better for both the patient and their recovery.

Kristin A King PhD, CCC-SLP

About the Editor

Kristin King, PhD, CCC-SLP has been a speech-language pathologist in a variety of settings since 1995. She earned her PhD in Communication Sciences and Disorders from East Carolina University in 2008. Her expertise is in cognitive-communication and swallowing disorders with medically complex patients of all ages, particularly those with needs secondary to traumatic brain injury (TBI), tracheostomy and ventilator, and pre-term birth. Dr. King has published several peer-reviewed articles regarding evaluation and treatment of TBI, and she speaks to both domestic and international audiences regularly on the use of speaking valves, evaluation and treatment following TBI, and swallowing disorders. She is the co-editor of the 2023 book, *Tracheostomy and Ventilator Dependence in Adults and Children.*

Upcoming Issues:

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

Avoid Stagnation through Interprofessional Collaboration and Team Building: Transforming Care for Patients with Tracheostomy Tubes

JoAnn Beck Cabacungan, MS, CCC-SLP, CBIS | Colby Davis, RRT, MHA

Introduction

Consistently achieving "good" patient outcomes should not impede the evaluation of current practices or hinder the initiation of quality improvement processes. It is during moments of self-reflection and implementation of change that advancements in best practices can be made. In 2021, Cleveland Clinic Rehabilitation Hospital, Edwin Shaw (CCRH ES), evaluated its processes and standards of care for patients with tracheostomy tubes. This assessment led to the implementation of new initiatives aimed at improving interdisciplinary teamwork and continuity of care, benefiting not only individual patients but also the broader patient population. This article aims to elucidate how enhanced communication between respiratory therapy (RT), speech-language pathology (SLP), and the medical team improved continuity of care and decision-making in the tracheostomy decannulation process.

Several studies indicate that multidisciplinary care is beneficial in the treatment of patients with tracheostomy tubes (Bedwell et al., 2019; Bonvento et al., 2017; Carton et al., 2021; de Mestral et al., 2011; Speed & Harding, 2013). Acknowledging the fact that teamwork is not inherently effective and that initiating or improving a team can be a challenging endeavor, it becomes evident that ongoing process improvement is essential. Building a successful team requires dedicated effort and a commitment to continuous enhancement. Mayo and Woolley (2016) state that "those with relevant knowledge must speak up if their expertise is to be used effectively by the team." It was this driving principle that led to speaking up and further explaining how the SLP's knowledge of the aerodigestive system and its impacts on tracheostomy decannulation decisions could benefit decision-making and patient outcomes which resulted in the development of an interdisciplinary tracheostomy team.

Who should be on the team?

Prior to 2021, decannulation decision-making at our facility primarily occurred with input from respiratory therapy, internal medicine, physical medicine, and rehabilitation physicians (PM&R). The initial phase of the interdisciplinary team (IDT) approach added an SLP to the team. During the COVID-19 pandemic, there was an influx of medically complex patients who required higher respiratory care. To combat these complexities, pulmonary medicine services were added to the IDT approach, further expanding the expertise of the primary decision-making. The addition of pulmonary medicine to the inpatient rehabilitation team marked a unique approach to the decannulation process. Comprised of a specialized physician and clinical nurse practitioner, the pulmonary medicine team is available five days a week and actively participates as part of the tracheostomy team within the inpatient rehabilitation setting.

Pulmonology presence provides valuable expertise and insight into the complex respiratory needs of patients, further enhancing the decision-making process. This integration of pulmonary medicine within the team structure demonstrates a commitment to comprehensive care and highlights the dedication to providing exceptional care to highly complex patients without sacrificing positive results. This core team communicates daily in-person or electronically to discuss each individual patient's progress. In addition, IDT weekly rounding was created to discuss the plan of care (POC) specifically relating to the tracheostomy including tolerance of Passy Muir® Valve use, capping trials, barriers to decannulation, secretion management, swallowing, chest x-ray, sputum culture, and referrals to other medical professionals.

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The IDT also expanded to include dieticians, occupational therapists, physical therapists, nursing, wound care, and administration to evaluate other opportunities to improve patient outcomes, increase efficiency of protocols and scheduling, and educate staff. The addition of these disciplines also increased the overall communication within the clinical teams. Through the increased communication within the interdisciplinary team, efficiency in timely communication was achieved, ensuring that relevant information was promptly shared among team members. By utilizing EMR SmartPhrases [pre-generated phrases utilized for each session which requires clinicians to input specified information], the team centralized pertinent information into one documentation note, streamlining the process and eliminating unnecessary data, resulting in a clear and concise timeline of events for each patient's tracheostomy care. This improved approach to documentation was later applied to patients without tracheostomy tubes who required high levels of oxygen, thereby positively impacting the care of other patient populations.

Evidence-Based Practice Improvements

Peak Flow

The implementation of evidence-based practices focused on enhancing the use of objective measures and establishing shared reference points among the interdisciplinary team. By incorporating objective measures, the team achieved a more standardized and consistent approach to patient care. One notable improvement involved the utilization of peak expiratory flow rate (PEFR) as an objective respiratory measurement. The tracheostomy team expanded the use of the PEFR, including the SLPs utilizing the PEFR, as a standard measure during dysphagia evaluations. It was used to assess airway protection and the risk of pulmonary complications in various patient populations such as the elderly, those with Parkinson's disease, amyotrophic lateral sclerosis (ALS), stroke, and generalized dysphagia (Bianchi et al., 2012; Kulnik et al., 2016; Pitts et al., 2010; Plowman et al., 2016; Watts et al., 2016). Drawing upon the literature, the team established PEFR measurements as a routine practice for all patients with tracheostomy tubes. This objective measure became an essential component in the decision-making process for decannulation, with a threshold of >160 L/min, either independently or with assisted cough, as a predictive value for decannulation outcomes (Bach & Saporito, 1996; Chan et al., 2010; Jiang et al., 2017; Tzeng & Bach, 2000).

PEFR was also utilized to standardize discussions involving cough strength and efficacy. The shift from a subjective assessment to an objective measurement of cough function was supported by research indicating suboptimal inter- and intra-rater reliability during subjective cough assessments and the inability to accurately assess airway protective mechanisms, dysphagia severity, and the risk of pulmonary compromise (Miles & Huckabee, 2013; Miles et al., 2014; Watts et al., 2016). These objective measurements also influenced the direction of care in helping to determine a patient's need for a cough assist device and respiratory muscle strength training.

Secretion Management and Swallowing Evaluations

In the realm of secretion management, on-site capabilities for modified barium swallow studies (MBSS) were already in place. However, the addition of flexible endoscopic evaluation of swallowing (FEES) to the SLP practice allowed visualization of the pharynx and larynx, providing objective information for secretion assessment utilizing the New Zealand Secretion Scale (Miles et al., 2018) and evaluating swallowing residue with the Yale Pharyngeal Residue Severity Rating Scale (Neubauer et al., 2015). Furthermore, FEES enabled screening for laryngeal injuries, leading to appropriate referrals to laryngology as necessary. Collaborating with laryngologists, the SLP team established a referral system which included pertinent information from instrumental swallowing assessments, laryngoscopic screen/exam results, and dysphagia concerns. This collaborative approach improved continuity of care and facilitated appropriate follow-up with laryngology, both during the inpatient rehabilitation stay and post-discharge.

By implementing these evidence-based improvements, the IDT ensured a shared vocabulary and standardized approach to assessing cough strength, secretion management, and swallowing severity. This enhanced teamwork was further supported by frequent presentations of FEES and MBSS results by SLPs to physicians and RTs during IDT discussions. These collaborative interactions fostered informed decision-making and the sharing of discipline-specific expertise, ultimately delivering the best possible care for patients.

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Moving forward, the comprehensive documentation of these evidence-based objective measures ensures that the next level of care providers have a clear understanding of the accomplishments achieved and the necessary steps for continued patient progress. This ensures continuity of care and sets the stage for ongoing improvement in patient outcomes beyond our facility.

Needs Assessment and Education

An assessment survey of staff needs was completed in early 2022 to receive staff input on needed educational opportunities for working with patients with tracheostomies. By leveraging the insights gained from the needs assessment survey, discipline-specific caregiver education was successfully developed. This tailored approach addressed the specific educational needs identified through the questionnaire by each discipline, resulting in a greater comfort level among staff. Moreover, the survey findings led to innovative solutions to enhance education accessibility. Notably, oxygen and air 50psi interface ports were mounted on a portable cart creating a "rolling classroom." This classroom was taken to new employee orientations as well as to patient floors so staff members could practice without being required to leave the clinical floors. This portable solution eliminated the barrier of designated education rooms and set times, enabling timely and efficient education regarding oxygenation, medical air, and suctioning capabilities to be held at workstations in as little as five-minute intervals (*see Figures 1 and 2*).

Figure 1: Rolling classroom used for providing education to staff.

Armed with an improved understanding of the room equipment, staff benefited from newly created signage specifically for patients with tracheostomy tubes. These signs provided a quick reference for specific tracheostomy tube information, the expected decannulation plan, and respiratory therapy contact information. The signs were given a specific background color for easy recognition and were consistently placed at the head of a patient's bed.

Educational efforts were not limited to just staff. An increased emphasis and concerted effort were placed on improving patient and family education. The team purchased and utilized the Passy-Muir Pocket T.O.M. (Tracheostomy Observation Model) to provide hands-on learning regarding the impact of the tracheostomy tube on the aerodigestive system and the decannulation process. Both patients and families have expressed appreciation for more in-depth and personalized explanations regarding breathing, speaking, and swallowing.

Recognizing the need for continuous improvement, a follow-up survey was completed later in 2022 to further assess needs. New and ongoing collaborations included RT and occupational therapy working jointly to improve safety in showering by collaborating on the assessment of the patient at admission and then developing specific pulmonary safety criteria. These criteria include any changes in oxygen needs during therapy sessions.

Figure 2: Closeup of the oxygen and air 50 psi interface ports.

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Conclusion

The journey of the IDT at Cleveland Clinic Rehabilitation Hospital, Edwin Shaw has paved the way for transformative care for our patients with tracheostomy tubes. Furthermore, the culture of interdisciplinary collaboration has fostered knowledge exchange that benefits other patient populations with medically complex upper airway challenges including chronic obstructive pulmonary disease (COPD), paradoxical vocal cord disorder (PVCD), obstructive sleep apnea (OSA), and patients with high flow oxygen needs. The team continues to share the valuable lessons learned through our IDT approach with inpatient rehabilitation hospitals within our division. Together, the CCRH ES team continues to raise the bar for transformative patient care, bringing the benefits of true interdisciplinary teamwork to all our patients.

References:

Bach, J. R., & Saporito, L. R. (1996). Criteria for extubation and tracheostomy tube removal for patients with ventilatory failure: A different approach to weaning. *Chest, 110*(6), 1566–1571. https://doi.org/10.1378/chest.110.6.1566

Bedwell, J. R., Pandian, V., Roberson, D. W., McGrath, B. A., Cameron, T. S., & Brenner, M. J. (2019). Multidisciplinary tracheostomy care: How collaboratives drive quality improvement. *Otolaryngologic Clinics of North America, 52*(1), 135–147. https://doi.org/10.1016/j.otc.2018.08.006

Bianchi, C., Baiardi, P., Khirani, S., & Cantarella, G. (2012). Cough peak flow as a predictor of pulmonary morbidity in patients with dysphagia. *American Journal of Physical Medicine & Rehabilitation, 91*(9), 783–788. https://doi.org/10.1097/PHM.0b013e3182556701

Bonvento, B., Wallace, S., Lynch, J., Coe, B., & McGrath, B. A. (2017). Role of the multidisciplinary team in the care of the tracheostomy patient. *Journal of Multidisciplinary Healthcare, 10,* 391–398. https://doi.org/10.2147/JMDH.S118419

Carton, E., Fitzgerald, E., Elebert, R., Malone, C., O'Brien, S., Dunne, A., Ní Muircheartaigh, R., & Phelan, D. (2021). Changes in multidisciplinary tracheostomy team practice over time. *Irish Medical Journal, 114*(8), 433.

Chan, L. Y. Y., Jones, A. Y. M., Chung, R. C. K., & Hung, K. N. (2010). Peak flow rate during induced cough: A predictor of successful decannulation of a tracheotomy tube in neurosurgical patients. *American Journal of Critical Care, 19*(3), 278–284. https://doi.org/10.4037/ajcc2009575

de Mestral, C. (2011). Impact of a specialized multidisciplinary tracheostomy team on tracheostomy care in critically ill patients. *Canadian Journal of Surgery, 54*(3), 167–172. https://doi.org/10.1503/cjs.043209

Jiang, C., Esquinas, A., & Mina, B. (2017). Evaluation of cough peak expiratory flow as a predictor of successful mechanical ventilation discontinuation: A narrative review of the literature. *Journal of Intensive Care, 5*(1), 33. https://doi.org/10.1186/s40560-017-0229-9

Kulnik, S. T., Birring, S. S., Hodsoll, J., Moxham, J., Rafferty, G. F., & Kalra, L. (2016). Higher cough flow is associated with lower risk of pneumonia in acute stroke. *Thorax, 71*(5), 474–475. https://doi.org/10.1136/thoraxjnl-2015-207810

Mayo, A. T., & Woolley, A. W. (2016). Teamwork in health care: Maximizing collective intelligence via inclusive collaboration and open communication. AMA *Journal of Ethics, 18*(9), 933–940. https://doi.org/10.1001/journalofethics.2016.18.9.stas2-1609

Miles, A., & Huckabee, M.-L. (2013). Intra- and inter-rater reliability for judgement of cough following citric acid inhalation. *International Journal of Speech-Language Pathology, 15*(2), 209–215. https://doi.org/10.3109/17549507.2012.692812

Miles, A., Hunting, A., Mcfarlane, M., Caddy, D., & Scott, S. (2018). Predictive value of the New Zealand Secretion Scale (NZSS) for pneumonia. *Dysphagia, 33,* 1–8. https://doi.org/10.1007/s00455-017-9841-z

Neubauer, P. D., Rademaker, A. W., & Leder, S. B. (2015). The Yale Pharyngeal Residue Severity Rating Scale: An anatomically defined and image-based tool. *Dysphagia, 30*(5), 521–528. https://doi.org/10.1007/s00455-015-9631-4

Pitts, T., Bolser, D., Rosenbek, J., Troche, M., Okun, M. S., & Sapienza, C. (2009). Impact of expiratory muscle strength training on voluntary cough and swallow function in Parkinson disease. *Chest, 135*(5), 1301–1308. https://doi.org/10.1378/chest.08-1389

Plowman, E. K., Watts, S. A., Tabor, L., Robison, R., Gaziano, J., Domer, A. S., Richter, J., Vu, T., & Gooch, C. (2016). Impact of expiratory strength training in amyotrophic lateral sclerosis. *Muscle & Nerve, 54*(1), 48–53. https://doi.org/10.1002/mus.24990

Speed, L., & Harding, K. E. (2013). Tracheostomy teams reduce total tracheostomy time and increase speaking valve use: A systematic review and meta-analysis. *Journal of Critical Care, 28*(2), 216.e1-216.e10. https://doi.org/10.1016/j.jcrc.2012.05.005

Tzeng, A. C., & Bach, J. R. (2000). Prevention of pulmonary morbidity for patients with neuromuscular disease. *Chest, 118*(5), 1390–1396. https://doi.org/10.1378/chest.118.5.1390

Watts, S. A., Tabor, L., & Plowman, E. K. (2016). To cough or not to cough? Examining the potential utility of cough testing in the clinical evaluation of swallowing. *Current Physical Medicine and Rehabilitation Reports, 4*(4), 262–276. https://doi.org/10.1007/s40141-016-0134-5

Article Summary

Passy Muir Valve Tolerance in Medically Complex Infants and Children: Are There Predictors for Success?

Brooks, L., Figueroa, J., Edwards, T., Reeder, W., McBrayer, S., & Landry, A. (2019). Passy Muir Valve tolerance in medically complex infants and children: Are there predictors for success? *The Laryngoscope, 130*(11), E632–E639. https://doi.org/10.1002/lary.28440

This study investigated if there are predictors for success with using a Passy Muir Valve (PMV) with medically complex pediatric patients. In this investigation, the authors considered parameters that may influence the ability to use a speaking Valve. They found that transtracheal pressure measurements (TTP), presence of voicing, age (> 2 years), weight, and ventilator rate were all predictors of use. Since TTP is an indication of airway patency – the lower the pressure, then the more patent the airway, and the more successful the use of the Valve was. These findings were not dependent on whether the child was on the ventilator or off.

Passy Muir Valve Use and Early Mobility for the Pediatric Patient Requiring Extracorporeal Membrane Oxygenation (ECMO)

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What is ECMO?

Extracorporeal Membrane Oxygenation (ECMO) is a treatment for patients with severe respiratory failure or circulatory failure, who have failed maximal medical management. Many unique aspects to using ECMO in children exist, including indications, circuit configuration, and cannulation sites (Erdil et al., 2019). Common indications for ECMO in infants and children include patients with respiratory diagnoses (respiratory distress syndrome, pneumonia, congenital diaphragmatic hernia, meconium aspiration); cardiac diagnoses (congenital heart disease, myocarditis); or transplantation candidacy (heart, lung). ECMO utilizes a circuit that consists of a blood pump, either a centrifugal or roller head, and an artificial lung (oxygenator) to support the heart and lung function. Circuit configuration varies between ECMO programs (*see Figure 1*).

ECMO provides support to the patient with the oxygenator and blood pump. The oxygenator is where gas exchange occurs, removing carbon dioxide (CO_2) and diffusing oxygen (O_2). Gas exchange occurs via sweep rate (liters per minute) delivered via a blender, with a percentage of oxygen. Sweep rate is determined by the level of CO_2 the practitioner desires to maintain in the patient's arterial blood gas. The higher the sweep rate, the more CO_2 is removed. Additionally, the level of oxygen delivered to the oxygenator via sweep allows a paO_2 to be achieved as desired. The blood pump flow rate (liters per minute) allows this oxygenated blood to be returned to the patient via the venous or arterial system, therefore augmenting the heart and lung function. The higher the blood flow rate, the more oxygenated blood is delivered to the patient.

What are the differences between VV ECMO and VA ECMO?

The two main configurations of ECMO are based on cannulation sites: Veno-venous (VV) and Veno-arterial (VA). Simply stated, VV ECMO drains blood from the venous system and returns oxygenated blood from the ECMO circuit to the venous system. Veno-venous ECMO is primarily employed for respiratory failure, where hypoxia and/or hypercarbia are causing

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Figure 1: **1.** Venous drain (Deoxygenated blood) **2.** Membrane Oxygenator **3.** Arterial Filter **4.** Arterial return (Oxygenated blood) **5.** Continuous Kidney Replacement Therapy (CKRT) **6.** Blood pump

Image used with permission by © Kazandjian and Dikeman (2022) *Communication and Swallowing Management of Tracheostomized and Ventilator Dependent Individuals, 3rd Edition,* Eat Speak Breathe Publishing, NY. Chapter 9, Brooks, Pediatrics.

significant morbidity and may contribute to the patient's death. Veno-venous ECMO allows the oxygenated blood to be circulated through the heart to the lungs, allowing for normal physiological circulation (*see Figure 2*).

Veno-arterial ECMO drains blood from the venous system but returns the ECMO circuit blood to the arterial system and is often used to support primary or secondary cardiac failure in patients who are unable to maintain adequate circulation. Returning the oxygenated blood to the arterial system essentially bypasses the heart, with the blood delivered to the left side of the heart. In this way, the heart function is augmented with the ECMO blood flow. Finally, in pediatrics, patients can be too small for cannulation techniques to use VV ECMO and may require VA cannulation due to vessel size or lack of an appropriately sized dual-lumen catheter.

What are the different cannulation sites?

Cannulation sites for ECMO in pediatric patients vary based on the configuration of ECMO used and the size of the patient. Veno-venous ECMO may employ a single site by using a double-lumen cannula placed in the right internal jugular. Infants and toddlers use the Crescent RA Jugular Dual Lumen Catheter (Medtronic, Minneapolis, MN) or the Avalon Elite Dual Lumen Catheter (Getinge, Gothenburg, Sweden) which are placed into the right atrium, and larger patients may use the Crescent Jugular Dual Lumen Catheter or the Avalon Elite Catheter which terminate in the inferior vena cava. These single-site cannulas are usually placed percutaneously and allow simultaneous drainage of deoxygenated blood and return of oxygenated blood. The dual-lumen catheters are excellent for facilitating early mobility. Veno-venous access may also include the femoral veins, the saphenous veins, or the internal jugular vein with a single lumen catheter, or any combination of these sites to allow drainage of blood and return of oxygenated blood from the ECMO circuit (*see Table 1*).

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Figure 2

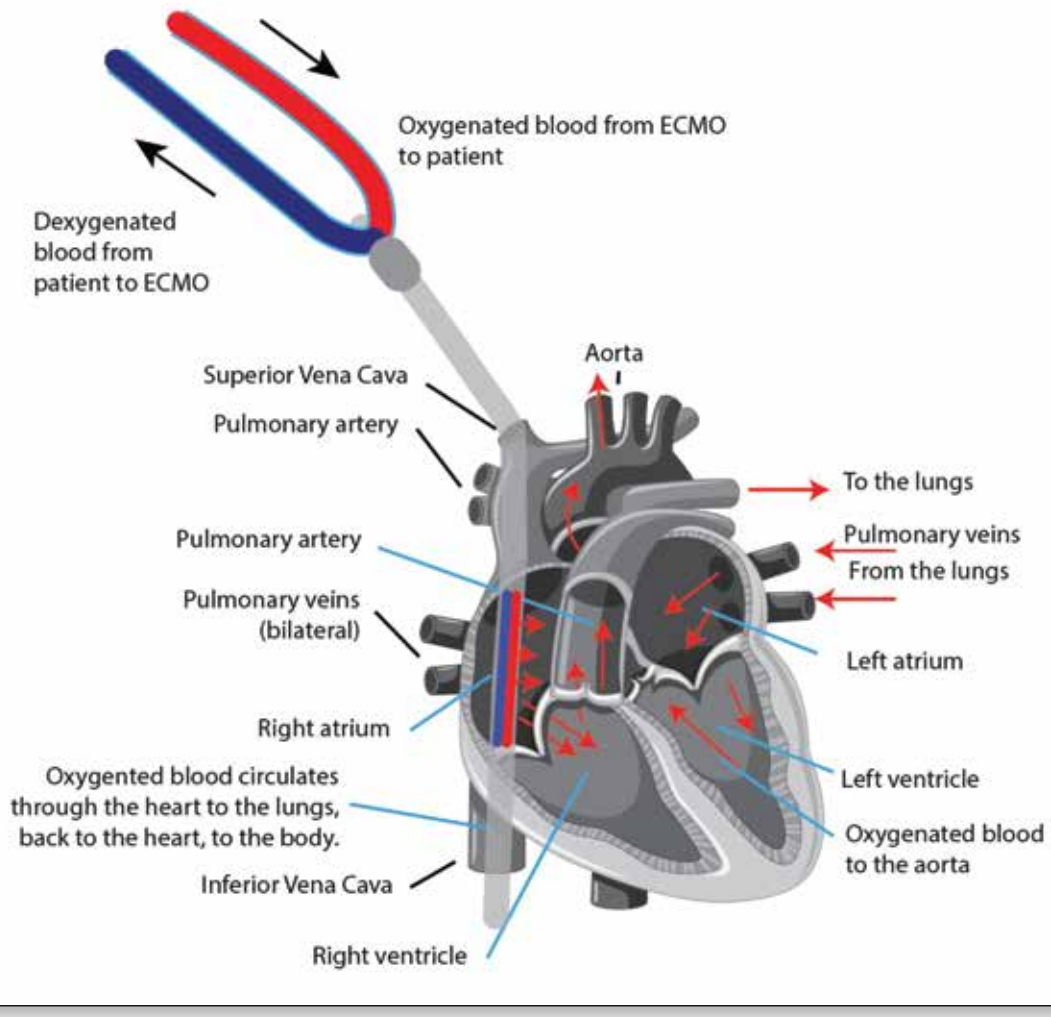

Figure 2: Image used with permission by © Kazandjian and Dikeman (2022) *Communication and Swallowing Management of Tracheostomized and Ventilator Dependent Individuals, 3rd Edition,* Eat Speak Breathe Publishing, NY. Chapter 9, Brooks, Pediatrics.

Table 1

Vein / Artery	Location	Purpose
Vein		
Femoral	Thigh	Moves blood from tissues of the lower leg to the heart
Saphenous	Superficial in leg	Sends blood from legs and feet to the heart
Internal Jugular	Each side of the neck	Collects blood from the brain and superficial regions of the face and neck to the right atrium of the heart
Artery		
Carotid	Each side of neck	Provides the brain's blood supply
Femoral	Top of thigh	Provides blood to lower extremities and anterior abdominal wall
Subclavian	Below clavicle	Supplies bilateral upper extremities and some contribution to head and neck

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Veno-arterial ECMO uses single catheters placed in veins as described above and then catheters are placed in an artery such as the right common carotid artery, femoral artery, or subclavian artery (*see Table 1*).

Additionally, central or transthoracic cannulation may be used in cardiac failure patients. Central cannulation is more invasive, requiring opening of the chest for access to the right atrium and aorta, and often in pediatric patients is used for patients who have previously undergone cardiopulmonary bypass for repair of congenital cardiac defects.

Passy Muir® Valve Benefits

The Passy Muir Tracheostomy & Ventilator Swallowing and Speaking Valve (PMV) is the only bias-closed, no-leak speaking valve due to the design of the membrane diaphragm. Exhaled air moves exclusively through the patient's upper airway. This maximizes the opportunity for voicing, sensation, managing secretions (by coughing or swallowing), improvement in swallowing function (particularly hyolaryngeal excursion), and weight shifting (Brooks, 2022; Hull et al., 2005; Sutt et al., 2015; Torres & Sirbegovic, 2004; Hoffman et al., 2008; Suiter et al., 2003; Hess & Altobelli, 2014; Watters, 2017; Massery, 2014; Massery et al., 2013; Brooks et al., 2020). Patients who are on ECMO and awake often experience anxiety that comes with feeling "air hunger" and reporting the sensation of "not (being) able to breathe." The PMV restores verbal communication for patients with a tracheostomy on mechanical ventilation, which is beneficial when navigating the complexities of ECMO and mobilization, particularly air hunger.

The PMV also assists with motor tasks during and outside of early mobility sessions.

When a tracheostomy tube is placed in the trachea, the respiratory system and intrathoracic (ITP) and intra-abdominal (IAP) pressures are diminished by having an open system (Massery, 2014; Massery et al., 2013). Airflow is redirected through the tracheostomy tube and the patient is no longer using the upper respiratory airway – airflow does not go through the upper airway and vocal cords. With an open tracheostomy tube and therefore, an open system, thoracic pressures cannot be increased, compromising sitting, pushing, and standing. For individuals without a tracheostomy, the glottis is engaged (vocal cords close) to restrict the expiratory lung volume to stabilize the chest and upper body (Massery, 2014; Massery et al., 2013). Placing a Passy Muir Valve on the tracheostomy hub or in-line with the ventilator circuit closes the system and restores a patient's ability to use the glottis to control expiratory flow and improve ITP and IAP. Additionally, patients on ECMO, who are candidates for lung transplant, often need to demonstrate the ability to walk a certain goal distance before they undergo a lung transplant. This underscores the importance of early mobility for the patients on ECMO, particularly those on mechanical ventilation.

Early Mobility for the Pediatric Patient on ECMO

Research in pediatric ECMO mobility is limited, but data in adult-focused studies show that early mobility with patients cannulated for VA or VV ECMO is safe and feasible with the appropriate members of an experienced, multidisciplinary team (Shkurka et al., 2022). Recommended personnel during ECMO mobility sessions include, but are not limited to, the ECMO physician (at a minimum, they are available on the unit), bedside nurse, ECMO Specialist, ECMO Primer (perfusionist), physical therapist, occupational therapist, and respiratory therapist (if an invasive airway is present). For patients with a tracheostomy, the speech-language pathologist can assist with PMV placement prior to mobilization and nonverbal communication for patients who are intubated. The child life specialist also has an important role in providing coping strategies to ease anxiety for patients who are moving while attached to many large, complex machines.

Progression of positions outside of supine may include ring sitting, short sitting, sitting edge of bed, standing, walking, and more (Shkurka et al., 2022). Upright positioning has many benefits including increased postural strength, improved pulmonary toileting, improved respiratory coordination, and increased engagement with the environment. As mentioned above, control of airflow by glottal structures is a primary determinant of thoracic pressure and may have a role in the control of postural stability (Massery, 2014; Massery et al., 2013). For patients with a tracheostomy, the use of a Passy Muir Valve during those tasks restores the ability to engage the glottis to control airflow and assist with early mobility.

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There are important considerations for rehabilitation clinicians when working with patients on VV and VA ECMO. A patient on VV ECMO should have arterial pressures that trend toward the normal range for the patient's age. However, they will also have arterial oxygen saturations of 80-95% because of mixing deoxygenated blood secondary to the disease state and status on ECMO. A patient on VA ECMO may have lower arterial blood pressures and normal saturations. Clinicians treating ECMO patients should be aware of arterial saturation and pressure goals as set by the medical team.

Prior to initiating an ECMO mobility session, safety and screening tools should be utilized. First, a physician order should be placed, outlining goals for the patient. These goals should be discussed with the team and a documented plan made. Second, an assessment of the cannulation sites should be undertaken to ensure the integrity of sutures, connections of circuitry tubing, and the ability to move the limb or neck. The session should begin with a baseline assessment of the vital signs, circuit readings, patient cognition, and patient willingness to participate. Monitoring these values while mobilizing will help to assess patient tolerance. The ECMO Specialist will provide immediate interventions on the ECMO system to increase support as needed. Collection of data from daily sessions, including mobility level achieved, how well it was tolerated, and any required interventions, will assist the team in future endeavors (*see Appendix A*).

Passy Muir Valve Candidacy

Despite the evidence supporting the benefits of speaking valve application, many patients are underserved due to a lack of clinician and physician consensus as to candidacy. Members of the medical team may consider the following questions: Is the patient too young? Is the patient too small? Is the patient too sick? Can the patient tolerate the speaking valve with any degree of airway obstruction or narrowing? Is the patient a candidate for PMV while on ECMO? (Brooks, 2012; Brooks et al., 2020). While further research is required to help answer many of these questions, the current literature does support speaking valve trials with medically complex pediatric patients under certain conditions (Brooks et al., 2020). However, it is critical to have a multidisciplinary team involved in determining candidacy by ensuring that no contraindications for speaking valve application exist and that the patient meets the criteria established by the facility. The multidisciplinary team for the patient requiring ECMO may include an otolaryngologist, pulmonologist, cardiologist, hospitalist, cardiologist, speech-language pathologist, and respiratory care practitioner.

With non-ECMO patients who require a tracheostomy due to lung compromise, physicians may be concerned that the application of a speaking valve will decrease the support provided by the ventilator due to the leak that occurs with cuff deflation. The concern is that the "leak" between the trach tube and the trachea will release too much pressure or volume support through the upper airway and not allow enough of the ventilator support into the lungs. When a patient is on ECMO and mechanical ventilation via a tracheostomy, the lungs are not responsible for oxygenation and ventilation. Therefore, the leak created with cuff deflation for PMV use is not a concern for the medical team. If the patient is not on ECMO but a Valve is to be used in-line with mechanical ventilation, the multidisciplinary team determines what ventilator adjustments may be needed to compensate for the leak and maintain good ventilation.

Case Study

We present a 17-year-old female with a recent history of orthotopic heart transplant (OHT) who was admitted to the Cardiac Intensive Care Unit (CICU) with viral symptoms in the setting of a recent COVID-19 diagnosis. She was well-known by the CICU staff due to her OHT, and it was felt that she would be best served in the CICU even with her primary diagnosis of respiratory failure. Despite maximal medical management, including progression from high flow nasal cannula (HFNC) during the day and continuous positive airway pressure (CPAP) via mask interface during sleep to BiPAP (bilevel positive airway pressure support), she ultimately required intubation and mechanical ventilation. She was febrile with chest pain, and the CT scan of her lungs was consistent with COVID-19 pneumonia. Her level of hypoxia and hypercarbia warranted ECMO cannulation with a 32fr (32 French) Avalon Dual Lumen Catheter placed in the right internal jugular.

Reason for tracheostomy. After a short period of stabilization on ECMO, she was re-awakened and extubated. She began early mobility with an HFNC, but she reported anxiety about her respiratory status on ECMO with the sensation and perception that she is not "breathing." Her anxiety and feeling of air hunger resulted in oxygen desaturations and increased work of breathing impacting her ECMO

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flow, and she was re-intubated. After endotracheal intubation, it was felt that she would benefit from a tracheotomy. A 6.0 cuffed adult Shiley tracheostomy tube was placed (Medtronic, Minneapolis, MN), and she remained on mechanical ventilation. Her first trach change was five days later, and she was ready to resume early mobility with physical therapy and occupational therapy.

Use of the Passy Muir Valve.

She also could have her first Passy Muir Valve trial in-line with mechanical ventilation with the speech-language pathologist (SLP) and respiratory therapist (RT). She remained on pressure control ventilation with the following settings: peak inspiratory pressure (PIP) 20 cmH_20 and positive end-expiratory pressure (PEEP) 10 cmH_20. For her initial PMV trial, the RT deflated her cuff, and the SLP placed the PMV in-line in her ventilator circuit using various adapters. An analog manometer was placed between the patient's trach and the PMV to measure trans-tracheal pressure (TTP) to determine airway patency. TTP was 10 cmH_20, which was consistent with the delivered PEEP of 10 cmH_2O indicating a patent airway.

When TTP is measured with a patient on mechanical ventilation, the manometer will not go to zero at end-expiration, instead, it will reflect the PEEP being delivered by the ventilator.

The patient was dysphonic (breathy vocal quality) but could verbally communicate. She presented with multiple cough events throughout the session after the PMV was placed which was expected as she was exhaling out her upper airway and sensing secretions that had been pooling. As she coughed up her secretions, she required less suctioning of her tracheostomy. She asked for small tastes of water and a popsicle and was cleared by the medical team, consuming without signs of dysphagia. She wore the PMV for 30 minutes with stable vital signs throughout the session. Physical therapy and occupational therapy arrived after the session, and the patient kept the PMV on during early mobility treatment given the strict 1:1 supervision. She started to take small PO trials of thin liquids via controlled single sips outside of her therapy sessions. Her vocal quality continued to improve over time with only mild breathiness and roughness. The SLP demonstrated to Mom and the nurse (RN) how to remove and re-insert the PMV in-line in the ventilator circuit. The mother independently demonstrated the placement and removal of the PMV. The patient transitioned to wearing the PMV during all awake hours as tolerated.

Conclusion

Patients with severe respiratory or circulatory failure who are tracheostomy and ventilator-supported and require ECMO may be a candidates for Passy Muir Valve use. PMV use in this population restores the use of the glottis (vocal cords) to assist in communication, swallowing, and early mobility (Ongkasuwan et al., 2014).

The optimal success of early mobility in pediatric patients requires a collaborative approach with a multidisciplinary team to ensure safety, provide effective patient care, and accomplish both patient and family goals.

References:

Brooks, L. (2022). CH.9 Management of the tracheostomized and ventilator dependent pediatric patient. In M. Kazandjian & K. Dikeman *Communication and Swallowing Management of Tracheostomized and Ventilator Dependent Individuals,* (3rd Edition, pp.237-277).

Brooks, L., Figueroa, J., Edwards, T., Reeder, W., McBrayer, S., & Landry, A. (2020). Passy Muir Valve tolerance in medically complex infants and children: Are there predictors for success? *The Laryngoscope, 130*(11), E632–E639. https://doi.org/10.1002/lary.28440

Erdil, T., Lemme, F., Konetzka, A., Cavigelli-Brunner, A., Niesse, O., Dave, H., Hasenclever, P., Hübler, M., & Schweiger, M. (2019). Extracorporeal membrane oxygenation support in pediatrics. *Annals of Cardiothoracic Surgery, 8*(1), 109–115. https://doi.org/10.21037/acs.2018.09.08

Hess, D. R., & Altobelli, N. P. (2014). Tracheostomy tubes. *Respiratory Care, 59*(6), 956–973. https://doi.org/10.4187/respcare.02920

Hofmann, L., Bolton, J., & Ferry, S. (2008). Passy Muir speaking valve use in a children's hospital: An interdisciplinary approach. *Perspectives on Voice and Voice Disorders, 1*(8), 76–77.

Hull, E. M., Dumas, H. M., Crowley, R. A., & Kharasch, V. S. (2005). Tracheostomy speaking valves for children: tolerance and clinical benefits. *Pediatric Rehabilitation, 8*, 214–219. https://doi.org/10.1080/13638490400021503

Massery, M. (2014). Expert interview: The role of the Passy-Muir valve in physical therapy. *Talk Muir,* 2-4.

Massery, M., Hagins, M., Stafford, R., Moerchen, V., & Hodges, P. W. (2013). Effect of airway control by glottal structures on postural stability. *Journal of Applied Physiology (Bethesda, Md. : 1985), 115*(4), 483–490. https://doi.org/10.1152/japplphysiol.01226.2012

Ongkasuwan, J., Turk, C. L., Rappazzo, C. A., Lavergne, K. A., Smith, E. O., & Friedman, E. M. (2014). The effect of a speaking valve on laryngeal aspiration and penetration in children with tracheotomies. *The Laryngoscope, 124*(6), 1469–1474. https://doi.org/10.1002/lary.24457

Shkurka, E., Child, H., Balls, J., Melkhuln, E., Carter, L., Compton, V., Marscheider, R., McConnell, R., Meenaghan, S., Milburn, N., Nugent, G., Peasbody, G., & Rimmer, L. (2022). Early rehabilitation and mobilisation of neonatal and paediatric extracorporeal membrane oxygenation patients: A UK and Ireland consensus document. *Perfusion, 39*(1), 174 – 181. https://doi.org/10.1177/02676591221132676

Suiter, D. M., McCullough, G. H., & Powell, P. W. (2003). Effects of cuff deflation and one-way tracheostomy speaking valve placement on swallow physiology. *Dysphagia, 18*(4), 284–292. https://doi.org/10.1007/s00455-003-0022-x

Sutt, A., Cornwell, P. L., Mullany, D., Kinneally, T., & Fraser, J. F. (2015). The use of tracheostomy speaking valves in mechanically ventilated patients results in improved communication and does not prolong ventilation time in cardiothoracic intensive care unit patients. *Journal of Critical Care, 30*(3), 491-494. https://doi.org/10.1016/j.jcrc.2014.12.017

Torres, L. Y., & Sirbegovic, D. J. (2004). Clinical benefits of the Passy-Muir tracheostomy and ventilator speaking valves in the NICU. *Neonatal Intensive Care,17,* 20–23.

Watters K. F. (2017). Tracheostomy in Infants and Children. *Respiratory Care, 62*(6), 799–825. https://doi.org/10.4187/respcare.05366

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Appendix A

CHILDREN'S HEALTHCARE OF ATLANTA
ECMO EARLY MOBILITY (EM) ACTION PLAN

Today's Date / Time of rounds:_____ Pt Name: _____

Diagnosis: _____

ECMO cann. date + type (VV/VA) + site:

_____

ECMO team today (MD, Primter, RN, RT):

_____

Rehab rep at round and Rehab team today:

_____

Anxiety support (fan, meds, breathing, etc.):

_____

Airway	Current: No support: _____ Intubated _____ NIPPV _____ Trach _____ Trach + vent _____	Change today?: No support: _____ Intubated _____ NIPPV _____ Trach _____ Trach + vent _____
Mobility level	Current: Level 1 (bed level) _____ Level 2 (↑in bed) _____ Level 3 (OOBed) _____	Goal for today: Level 1 (bed level) _____ Level 2 (↑in bed) _____ Level 3 (OOBed) _____
EM time	PT/OT Goal: _____ AM/PM SLP Goal: _____ AM/PM	Actual: _____ AM/PM Actual: _____ AM/PM
ΔO2 in prep	O2 change made: _____ Time: _____	Stable vitals: _____ O2 desat: _____ Other: _____
Δ ECMO in prep	Sweep change made: _____ _____ Time: _____	Pt response: _____ _____ _____
Feed hold time	Goal: 1 hr prior to mobility _____ AM/PM	Nausea: _____ No Complaints: _____ Emesis: _____ Other: _____
Blood gas	Pre EM: CO2: _____ CO2: _____ pH: _____	Post EM: CO2: _____ CO2: _____ pH: _____

Feeding Therapy Considerations for Rehabilitation in Infants Following Cardiac Surgery

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Overview of Risk Factors

Children requiring cardiac intervention due to congenital heart defects often require feeding therapy services throughout their pre-operative and post-operative course. Approximately 1.35 million newborns are born internationally with congenital heart disease (CHD) requiring medical support (van der Linde et al., 2011), making it the most common birth defect. Due to reduced blood flow, infants with CHD may experience changes in oxygenation and nutrition potentially resulting in delayed neurodevelopment. This population is at a heightened risk for white matter injury, stroke, and microcephaly (Desai & Lim, 2019). Additionally, it has been reported that up to 35% of infants with CHD also have an underlying genetic diagnosis that may influence development as well (Simmons & Brueckner, 2017). The most commonly associated genetic syndromes include Down syndrome, Turner syndrome, 22q11 deletion syndrome, Williams syndrome, and Noonan syndrome (Ko, 2015).

According to Akamagquna and Badaly (2019), infants who require surgery during infancy secondary to cardiac anomalies are at risk for additional developmental delays and cognitive impairments. Along with CHD, these infants may have additional pre-surgical and post-surgical pulmonary complications that may result in reduced cardiopulmonary stability creating delays in motor development and an exercise intolerance (Akamagquna & Badaly, 2019). Following surgery, infants are at risk for cardiac arrest, delayed sternal closure, pleural effusion, seizures, and prolonged post-surgical management, all of which may result in extended hospital stays (Desai & Lim, 2019). With improved viability of this patient population, infants with CHD require support to improve neurodevelopmental outcomes following their extensive medical interventions. The need for these infants to be provided with services through pediatric rehabilitation programs is vital to ensure optimal developmental outcomes.

Frequently, cardiac intervention needed to support infants with CHD is required within the first month of age.

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General Impact on Infant Feeding Development

In a review by Norman et al. (2022), feeding and swallowing disorders in infants and children with CHD were found to have over a 50% prevalence. Due to extensive surgical history, cardiac physiology, and reduced endurance, infants with cardiac defects often exhibit poor oral feeding that can progress into long-term feeding challenges (Medoff-Cooper & Ravishankar, 2013). Coordinated, efficacious sucking requires coordination of the oromotor system as well as the central nervous system and respiratory system to generate consistent, rhythmic suck bursts (McKean et al., 2017). According to Desai and Lim (2019), "the etiology of feeding dysfunction in infants with CHD is complex and multifactorial and includes a combination of hemodynamic status, prenatal neurological sequelae, and surgical consequences."

The development of adequate feeding skills occurs within critical developmental windows when neural plasticity is optimal for the development of certain skills. Frequently, cardiac intervention needed to support infants with CHD is required within the first month of age. During this time, infants learn the foundational skills for successful breast and bottle feeding. By missing these developmental windows, children with CHD are at heightened risk for delayed feeding acquisition without post-operative variables that may also complicate their clinical picture. If there is difficulty in the coordination of these functions due to endurance, oromotor discoordination, or pharyngeal structural deficits resulting in aspiration, oral feeding may be negatively impacted. Additionally, care of this population is made more complicated because successful pre-operative feeding skills do not predict successful post-operative feeding skills

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(Medoff-Cooper & Ravishankar, 2013). Surgical intervention often results in post-extubation laryngeal injury, post-operative vocal fold injury, and overall reduced acceptance of oral stimulation. Developing a negative association and adverse reaction to oral stimulation and natural protective mechanisms are risks potentially affecting feeding that are associated with this patient population.

Impact of Post-Operative Vocal Fold Immobility

A common result of cardiac surgery that impacts feeding participation is vocal fold immobility (VFI). It is recognized as a clinically important complication to determine because it may place the patient at risk for airway protection deficits, specifically aspiration (Sachdeva et al., 2007) and additionally, may result in protective responses including bottle refusal. Rodney et al. (2019) reported that vocal fold immobility occurs in 23% of infants following isolated patent ductus arteriosus (PDA) ligation [corrective surgery for when joining of the pulmonary artery and aorta does not close] and in 22% of infants following complicated aortic arch reconstruction. The incidence has been reported as up to 59% of infants following cardiac surgery with a rate of recovery ranging between 14%-84% (Barr et al., 2021). Barr et al. (2021) also found that the left recurrent laryngeal nerve and subsequently, the left vocal fold, were likely to be impacted during pediatric cardiac surgery. Their research also indicated the importance of routine follow-up following cardiac surgery as a reported 10% of the patients within their cohort did not have symptoms of VFI (Barr et al., 2021).

In terms of pharyngeal dysphagia, Leder et al. (2012) found that individuals with VFI were 2.5 times more likely to aspirate. This is suspected due to limited airway protection with impaired vocal fold adduction, decreased laryngopharyngeal sensation, and neuromuscular discoordination resulting in aspiration (Irace et al., 2019). Irace et al. (2019) also found that silent aspiration was more likely than overt aspiration in pediatric patients with unilateral vocal fold paralysis. Given the current body of research, vocal fold immobility is a significant comorbidity following pediatric cardiovascular surgery that must be considered. According to Irace et al. (2019), detection of vocal fold immobility is vital to prevent future morbidity associated with chronic aspiration, ensure proper nutrition and hydration through alternative means for adequate growth, and determine the need for compensatory techniques to improve swallow safety.

Considerations for Feeding Therapy in Rehabilitation Settings

The American Heart Association (2017) identified that infants with CHD are at risk for delays in cognitive skills, feeding development, speech and language skills, executive functioning, visuospatial deficits, and behavioral dysregulation. Additional complications often include frequent, extended hospital stays and limited participation in typical life experiences for their age due to medical complexity. The literature supports that those infants with CHD benefit from habilitation and rehabilitation services while medical management is being given between required surgeries. In the rehabilitation setting, infants are often admitted with the goals of medical management, rehabilitation, feeding optimization, and family education between necessary cardiac procedures. These infants participate in developmental speech and feeding interventions, occupational and physical therapy services, and recreation/child life services to allow for controlled developmental experiences with the support of medical professionals. The goals of rehabilitation in sub-acute and pediatric skilled nursing facilities align with the guidelines outlined by the American Heart Association of Cardiovascular Rehabilitation in which they recommend services that will manage physical health and promote socioemotional functioning (Akamagquna & Badaly, 2019).

Feeding therapy provided at this time requires close monitoring of the patient's physiological stability during therapeutic handling and monitoring of endurance. The ultimate goal is to progress to non-nutritive and nutritive stimulation. Often these sessions are diagnostic-based therapy sessions as post-operative changes may be present and require close monitoring during therapeutic intervention. Collaboration with physical and occupational therapy for appropriate handling dependent on cardiac physiology during post-surgical periods of recovery is key to improving tolerance to handling. Desai and Lim (2019) reported that improved stability during therapeutic handling can result in decreased oral aversions, strengthened positive social interactions, and increased motor learning for feeding. Tolerance to therapeutic handling is a key pre-feeding goal that, once achieved, can result in improved participation in non-nutritive stimulation via a pacifier.

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As the infant progresses to nutritive trials, the main goal continues to be physiological stability with nutritive presentations that are safe and infant driven. Desai and Lim (2019) noted that the use of infant-driven feeding methodology in medically complex infants was key in building positive associations during nutritive trials. This includes monitoring infant cues to initiate feeding opportunities, as well as modifying or discontinuing the presentation of nutritive trials when signs of stress occur. Signs of stress may include infant eye-widening, eyebrow furrowing, gaze aversion, cessation of sucking, increased heart rate, finger splaying, or gagging. Medoff-Cooper (2012) reported that holding, swaddling, and reducing stressful environmental stimulation during feeding could be used to improve participation during nutritive trials. Initial nutrition trials may include tastes of formula or breastmilk via swabs or pacifier dips to allow for controlled sensory experiences. Pacifier dips are a controlled way to provide taste and stimulation when infants require increased respiratory support during recovery (*see figure 1*).

Infants may require a slow, systematic introduction to bottle or breastfeeding given their medical complexity and specifically the impact of CHD on cardiopulmonary stability. According to Desai et al. (2023), the use of a slow-flow nipple paired with swaddling and a side-lying position can slow the flow of formula or breastmilk and allow for improved suck-swallow-breath coordination and pacing during feeding. The elevated side-lying position has also been noted in the literature to reduce variation in oxygen saturations during feeding, increase saturation in the middle of feeding, and allow for respiratory rates that are more consistent with baseline (Desai et al., 2023). Pacing during bottle feeding is additional support for the suck-swallow-breath coordination for improved efficiency and safety during bottle-feeding opportunities. For infants with CHD, using extended rest breaks with pacing can also be beneficial as it can complement the need for rest as feeding is a form of 'exercise' for infants.

Desai et al. (2023) also discussed that thickening is often another intervention for infants with dysphagia; however, one must proceed with careful consideration for infants who have CHD. This population, specifically, is at heightened risk for reduced swallow integrity resulting in aspiration due to fatigue as feeding progresses. Thickening to a viscosity that requires increased effort to extract may, in turn, increase fatigue and the likelihood of aspiration and energy expenditure (Desai et al., 2023). The use of tube feeding may be required throughout various points of medical intervention for infants with CHD. Maurer et al. (2011) reported that 22% of infants who required neonatal heart surgery required tube feeds and demonstrated developmentally inappropriate feeding behavior at two years of age. Due to their medical complexity, this population requires an individualized plan that balances safe oral feeding opportunities with adequate weight gain to allow for optimal neurodevelopment and recovery.

Summary

Successful feeding therapy in rehabilitation settings for infants with CHD requires a thorough evaluation, detailed chart review, and multidisciplinary communication between both the acute-care team and the receiving rehabilitation team. This population requires skilled intervention specifically as it relates to feeding due to the need for continued medical management during the critical periods of feeding skill development. Multidisciplinary partnership is crucial to facilitate optimal neurodevelopment for support of pre-feeding and subsequent oral feeding success. Additionally, assessment for post-operative changes and close monitoring for signs of decompensation during feeding resulting in potential airway protection deficit during nutritive trials are vital during oral feeding due to the high risk of aspiration in this patient population. By creating individualized feeding plans and fostering multidisciplinary management of this unique population, the incidence of delayed neurological development and long-term feeding difficulty may be improved.

Figure 1: Additional signs of stress that may be observed while monitoring an infant during feeding.

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References:

Akamagwuna, U., & Badaly, D. (2019). Pediatric cardiac rehabilitation: A review. *Current Physical Medicine and Rehabilitation Reports, 7*(2), 67–80. https://doi.org/10.1007/s40141-019-00216-9

Barr, J. M., Bowman, K., Deshpande, M., Dewey, E. N., Milczuk, H. A., Vo, J., Shen, I., & Muralidaran, A. (2021). Incidence and recovery of vocal fold immobility following pediatric cardiac operations. *World Journal for Pediatric and Congenital Heart Surgery, 12*(4), 535–541. https://doi.org/10.1177/21501351211015922

Desai, H., Jones, C. E., Fogel, J. L., Negrin, K. A., Slater, N. L., Morris, K., Doody, L. R., Engstler, K., Torzone, A., Smith, J., & Butler, S. C. (2023). Assessment and management of feeding difficulties for infants with complex CHD. *Cardiology in the Young, 33*(1), 1–10. https://doi.org/10.1017/S1047951122004024

Desai, H., & Lim, A. N. (2019). Neurodevelopmental intervention strategies to improve oral feeding skills in infants with congenital heart defects. *Perspectives of the ASHA Special Interest Groups, 4*(6), 1492–1497. https://doi.org/10.1044/2019_pers-sig13-2019-0017

Irace, A. L., Dombrowski, N. D., Kawai, K., Dodrill, P., Perez, J., Hernandez, K., Davidson, K., Hseu, A., Nuss, R. and Rahbar, R. (2019), Aspiration in children with unilateral vocal fold paralysis, SIG 13. *The Laryngoscope, 129,* 569-573. https://doi.org/10.1002/lary.27410

Ko J. M. (2015). Genetic Syndromes associated with Congenital Heart Disease. *Korean Circulation Journal, 45*(5), 357–361. https://doi.org/10.4070/kcj.2015.45.5.357

Leder, S. B., Suiter, D. M., Duffey, D., & Judson, B. L. (2011). Vocal fold immobility and aspiration status: A direct replication study. *Dysphagia, 27*(2), 265–270. https://doi.org/10.1007/s00455-011-9362-0

Maurer, I., Latal, B., Geissmann, H., Knirsch, W., Bauersfeld, U., & Balmer, C. (2011). Prevalence and predictors of later feeding disorders in children who underwent neonatal cardiac surgery for congenital heart disease. *Cardiology in the Young, 21*(3), 303–309. https://doi.org/10.1017/s1047951110001976

Marino, B. S., Lipkin, P. H., Newburger, J. W., Peacock, G., Gerdes, M., Gaynor, J. W., Mussatto, K. A., Uzark, K., Goldberg, C. S., Johnson, Jr, W. H., Li, J., Smith, S. E., Bellinger, D. C., and Mahle, W. T. (2012). Neurodevelopmental outcomes in children with congenital heart disease: Evaluation and management: A scientific statement from the American Heart Association. *Circulation, 126*(9), 1143 - 1172. https://doi.org/10.1161/CIR.0b013e318265ee8a

McKean, E. B., Kasparian, N. A., Batra, S., Sholler, G. F., Winlaw, D. S., & Dalby-Payne, J. (2017). Feeding difficulties in neonates following cardiac surgery: determinants of prolonged feeding-tube use. *Cardiology in the Young, 27*(6), 1203–1211. https://doi.org/10.1017/S1047951116002845

Medoff-Cooper, B., & Ravishankar, C. (2013). Nutrition and growth in congenital heart disease. *Current Opinion in Cardiology, 28*(2), 122–129. https://doi.org/10.1097/hco.0b013e32835dd005

Norman, V., Zühlke, L., Murray, K., & Morrow, B. (2022). Prevalence of Feeding and Swallowing Disorders in Congenital Heart Disease: A Scoping Review. *Frontiers in Pediatrics, 10,* 843023. https://doi.org/10.3389/fped.2022.843023

Rodney, J. P., Thompson, J. L., Anderson, M. P., & Burkhart, H. M. (2019). Neonatal vocal fold motion impairment after complex aortic arch reconstruction: What should parents expect after diagnosis? International *Journal of Pediatric Otorhinolaryngology, 120,* 40–43. https://doi.org/10.1016/j.ijporl.2019.02.006

Sachdeva, R., Hussain, E., Moss, M. M., Schmitz, M. L., Ray, R. M., Imamura, M., & Jaquiss, R. D. (2007). Vocal cord dysfunction and feeding difficulties after pediatric cardiovascular surgery. *The Journal of Pediatrics, 151*(3), 312–315.e3152. https://doi.org/10.1016/j.jpeds.2007.03.014

Simmons, M. A., & Brueckner, M. (2017). The genetics of congenital heart disease… understanding and improving long-term outcomes in congenital heart disease: A review for the general cardiologist and primary care physician. *Current Opinion in Pediatrics, 29*(5), 520–528. https://doi.org/10.1097/mop.0000000000000538

van der Linde, D., Konings, E. E. M., Slager, M. A., Witsenburg, M., Helbing, W. A., Takkenberg, J. J. M., & Roos-Hesselink, J. W. (2011). Birth prevalence of congenital heart disease worldwide. *Journal of the American College of Cardiology, 58*(21), 2241–2247. https://doi.org/10.1016/j.jacc.2011.08.025

Case Study 1

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MS, CCC-SLP, CLC, TSSLD

History

This 4-month-old male patient has a medical history significant for coarctation of the aorta requiring repair, IVC/RA [inferior vena cava/right atrial] thrombus, cellulitis wound, left vocal fold paresis, moderate protein malnutrition, history of neonatal respiratory distress syndrome, and chronic poor oral feeding requiring the need for supplemental nutrition and hydration via nasogastric tube (NGT). He was admitted to rehab for medical management following cardiac surgery and for feeding therapy with the goal of PO (per os/oral) optimization for NGT removal.

Prior to admission, a Modified Barium Swallow Study (MBS) was completed at an outside hospital (OSH) with a reported finding of silent aspiration with thin liquids via Dr. Brown's Level 1 and preemie nipple, as well as aspiration of mildly thickened liquids (reported mixture of 1.0 tsp of rice cereal per ounce) via Level 4. It was recommended that he continue to receive presentations of pacifier dips with the continuation of non-oral means of nutrition and hydration with consideration for long-term non-oral means. Upon admission, he consumed less than 10ml via PO with significant gagging and signs of stress during presentations of pacifier dips and conservative bottle-feeding trials.

Therapeutic Course of Stay

During his therapeutic course of stay, the patient was seen intensively for speech and feeding therapy. He was initially presented with pacifier dips; however, he continued to demonstrate significant neurological dysregulation, as well as changes in respiratory effort and the development of maladaptive behaviors. It was also observed that the patient benefitted from the use of a swaddled right side-lying position versus cradle position, potentially attributed to the history of left vocal fold paresis. With improvement in state regulation and acceptance of pacifier dips, PO trials of thickened liquids via bottle were initiated. Infant-driven feeding principles [use of developmental cues for feeding regulation] were utilized throughout his course, involving conservative presentations with discontinuation of PO with signs of stress.

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Nipple Flow Rates

He was trialed with various nipple flow rates and viscosities in a right, elevated, swaddled side-lying position. The trials included thin liquid via Ultra Preemie and Preemie nipple with strict pacing every 3 sucks, mildly thickened liquids via one Gelmix scoop per ounce with a 5-minute wait via Level 2 and Level 3, thickened liquids with the use of rice cereal via slightly thickened liquids (1 tsp of rice cereal) via Level 2, and mildly thickened liquids (1.5 tsp of rice cereal) via Level 3. Consistent acceptance was noted with the use of one Gelmix scoop to 45 ml (mildly thickened liquid).

Modified Barium Swallow Study Repeat

A repeat MBS was completed to rule out silent aspiration and determine the need for continued use of thickened liquids. During the MBS, the patient presented with moderate oral dysphagia with potential maladaptive overlay, as well as mild-moderate pharyngeal dysphagia. It was recommended that he continue to be presented with trials of mildly thickened liquids (one Gelmix scoop to 90ml, wait 5 minutes) via Level 2 nipple with therapeutic trials of mildly thickened liquids (one Gelmix scoop to 30ml, wait 5 minutes) via Level 3 nipple with external support to improve efficiency.

Discharge Recommendation

Given the recommendations from the swallow study, as well as bedside sessions, it was recommended upon discharge that the patient continue the use of PO with subsequent NGT to meet nutrition and hydration needs. Based on a visualization of slow bolus transit through the distal esophagus during the MBS and the clinical signs of discomfort during feeding opportunities at the bedside, it was recommended that the patient be seen by GI. A plan also for follow-up with the ENT was recommended to reassess vocal fold mobility due to a history of left vocal fold paresis. Education was provided consistently regarding the need for thickened liquid, negative outcomes for long-term NGT use, and the importance of infant-driven feeding.

It was recommended upon discharge that the patient continue to receive speech-language and feeding therapy targeting developmental feeding skills, monitoring PO intake via bottle for determination of NGT weaning, and monitoring of pre-linguistic language skills development.

Case Study 2

Stephanie Waters
MS, CCC-SLP, CLC, TSSLD

History

This 8-month-old female patient has a medical history of fetal IUGR [intrauterine growth restriction], patch closure of moderate VSD [ventricular septal defect], suture closure of muscular VSD, hypoplastic aortic isthmus, acute respiratory failure, relative microcephaly, left vocal fold paresis, oral aversion, chronic feeding disorder, congenital hypothyroidism, and clinical pneumonia. During the chart review, it was noted that the patient had a history of needing increased respiratory effort via high-flow nasal cannula (HFNC) with increased settings during the PO trial initiation. Due to this requirement, a Modified Barium Swallow Study (MBSS) was recommended; however, when completed, the patient exhibited absent participation without a functional latch or nutritive suck observed across multiple trials and consistencies. The patient was admitted to the rehabilitation facility with a continued need for HFNC and total nasogastric tube dependence.

Therapeutic Course of Stay

Throughout the therapeutic course of the patient's stay, persistent feeding difficulty with bottle presentations was observed even once HFNC was weaned. She was noted to have improved intensity and vocal quality and a repeat ENT assessment found improved vocal fold mobility. She was initially presented with pacifier dips with timely non-nutritive suck and without overt signs of airway protection deficit. With bottle feeding presentations, she was observed to have persisting overt signs of airway protection deficits.

continued next page

Case Study 2

Continued

Trials

She was trialed with thin liquids via Ultra-Preemie and Preemie nipple and mildly thickened liquids with the use of Gelmix as well as oatmeal via Level 1 and Level 2 nipple. The patient showed acceptance of limited volumes of moderately thickened liquids via Level 3 nipple with improved suck-swallow-breath coordination; however, with persisting gastrointestinal (GI) discomfort. With persisting GI discomfort during bottle presentations, the patient was observed to have developed maladaptive feeding behaviors (head turning, gagging) and stress cues during bottle feeding opportunities. The patient did not exhibit improvement despite external support, including trials of swaddled, elevated, side-lying position, external pacing, and changes in formula.

The patient was provided with an extended break from bottle presentations and a focus was placed on positioning in an upright position to prepare for early spoon and straw drinking introduction. With improved head control and acceptance of non-nutritive stimulation via spoon and straw, trace presentations of thickened liquids via spoon and straw were introduced. She was observed to have improved acceptance during presentations using a coated spoon. She also was presented with conservative boluses, straw use, and cup drinking to allow for the development of feeding skills fairly appropriate for her age. Limited volume was achieved; however, she had improved participation in feeding with reduced maladaptive behaviors to her PO opportunities. The patient was also noted to maintain respiratory status on room air during presentations of PO with a spoon and honey-bear straw bottle (HBSB). The patient was discharged with a plan to prepare for a repeat objective assessment with new skills acquired with consistency of acceptance. Due to the patient's need for extended NGT use and persisting discomfort with tube feeds, consideration for long-term means in collaboration with feeding therapy to target developmental feeding skills was recommended following collaboration with the multidisciplinary team.

Discharge Recommendation

It was recommended upon discharge that the patient continue to receive speech-language and feeding therapy targeting developmental feeding skills, monitoring of PO intake via spoon, and use of a straw for the progression of developmental feeding skills. Recommendations also included consideration for determining NGT weaning and continued follow-up with ENT, as well as GI, due to persisting difficulty with trials of thin versus thickened liquids. Strong consideration for a repeat MBS with the acquisition of new feeding skills was recommended due to a history of cardiac issues, vocal fold paresis, and the need for increased respiratory support associated with PO feeding. Prior to discharge, education was provided regarding improved comfort with thickened liquid via spoon and straw, potential negative outcomes associated with long-term NGT use, and the importance of infant-driven feeding principles during developmental feeding opportunities.

Incidence of Tracheostomy in the Pediatric Cardiac Patient Population

Kristin A. King, PhD, CCC-SLP

Airway abnormalities occur in patients with congenital heart disease (CHD). Due to the increased associated risks with airway compromise in patients with CHD, Foz et al. (2021) investigated the incidence and associated factors. They found that the coexistence of airway abnormalities is most likely in premature patients, weight < 10 kg, and with specific cardiac lesions and concomitant genetic syndromes (Foz et al., 2021). Having an airway abnormality perioperatively or airway manipulation during and postoperatively increases the possibility of a tracheostomy. The incidence of tracheostomy in pediatric patients undergoing cardiac surgery varies depending on the population studied, the type of cardiac defects, and the institutional practices. Mastropietro et al. (2016) reported an increase in the occurrence of tracheostomies from 0.1% to 0.76% in pediatric patients undergoing cardiac surgery. Puchi et al. (2023) analyzed the incidence of tracheostomy in the patient population with CHD and found a high mortality rate associated with age at the time of tracheostomy and the presence of tracheomalacia. These rates, though low, reflect the severity and complexity of the conditions in these patients. Children with CHD often have comorbidities such as pulmonary hypertension, respiratory muscle weakness, or airway abnormalities, which increase the likelihood of respiratory failure and the need for prolonged mechanical ventilation.

Risk Factors for Tracheostomy

Several risk factors have been identified as contributing to the need for tracheostomy in pediatric patients following cardiac surgery. These include:

Complex Congenital Heart Disease: Children with more complex cardiac defects, such as single-ventricle physiology or hypoplastic left heart syndrome, are at higher risk for respiratory complications (Rusin et al., 2021). These conditions often require extensive surgical repair, which can lead to longer postoperative recovery and an increased need for respiratory support.

The duration of mechanical ventilation postoperatively is a strong predictor of tracheostomy

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Prolonged Mechanical Ventilation: The duration of mechanical ventilation postoperatively is a strong predictor of tracheostomy. Children who require prolonged ventilation due to inadequate respiratory function or failure to wean are more likely to undergo tracheostomy. De Araujo et al. (2022) found that the underlying severity of the disease that caused a need for mechanical ventilation was more indicative of a tracheostomy than the length of time of ventilation. They did find that earlier tracheostomy was linked to reduced time on mechanical ventilation and a shorter length of hospital stay but had no effect on mortality.

Postoperative Respiratory Complications: Complications such as diaphragmatic paralysis (Alcántara-Noguez et al., 2023), pulmonary hypertension (Song et al., 2024), and bronchopulmonary dysplasia (Song et al., 2020) are associated with a higher likelihood of requiring a tracheostomy. These conditions exacerbate respiratory insufficiency, making extubation difficult.

Surgical Factors: The type and duration of cardiac surgery also play a role. More complex surgeries that involve longer cardiopulmonary bypass times or multiple procedures can lead to increased respiratory complications.

Patient-Specific Factors: Prematurity, low birth weight, genetic syndromes, and pre-existing respiratory conditions are significant patient-specific factors that increase the risk of requiring a tracheostomy (Foz et al., 2021).

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Outcomes and Prognosis

The decision to perform a tracheostomy in pediatric cardiac patients is often made when it becomes clear that prolonged mechanical ventilation is necessary. Similar to what is seen in adult literature on the impact of a team, Hansen et al. (2021) found that having a multidisciplinary chronic lung disease team in the neonatal intensive care unit (NICU) was associated with an increased survival rate for infants with tracheostomies. While a tracheostomy may be lifesaving, it is associated with both short- and long-term complications. These include tracheal stenosis, infection, and the potential need for long-term respiratory support. Despite these risks, tracheostomy can lead to improved outcomes in selected patients by facilitating weaning from mechanical ventilation, improving oral feeding, and allowing for discharge from the hospital, especially if the patient is able to use a speaking valve.

The placement of a tracheostomy tube and prolonged mechanical ventilation with an inflated cuff causes a disconnect between the upper and lower airways. The lack of airflow through the upper airway can often lead to multiple negative changes affecting speech and swallowing: reduced subglottic pressure (Gross et al., 2003; Gross et al., 2006); decreased sensation (O'Connor et al., 2019); reduced laryngopharyngeal reflex (Dai et al., 2022); decreased ability to manage secretions, requiring more frequent suctioning (Siebens et al., 1993; O'Connor et al., 2019); decreased sense of taste and smell (O'Connor et al., 2019); inability to vocalize; increased aspiration risk; and muscle disuse and atrophy (Henningfeld et al., 2020). A disconnect between respiration and swallowing also may negatively impact the ability to coordinate breathing and swallowing. For pediatrics, long-term tracheostomy placement also has been associated with delayed acquisition of language, delayed social development, and risk of impaired parent-child bonding (Lieu et al., 1999; Cowell et al., 2013).

A primary means for closing the system to restore more normal physiology and pressures for patients with tracheostomies is the use of a bias-closed position, no-leak valve. When a patient has a tracheostomy, airflow is directed in and out through the tracheostomy tube and bypasses the upper airway. The Passy Muir® Valve works by closing at the end of inspiration, which redirects 100% of airflow upwards through the vocal cords and upper airway. Research has shown that this redirection of airflow assists with improving secretion management, increasing sensory awareness, improving swallowing, and restoring natural physiologic PEEP (positive end-expiratory pressure), among other benefits (O'Connor et al., 2019). Brooks et al. (2019) found that in medically complex infants and children, not only was using a Valve beneficial but there are predictors of success related to the age and weight at the time of tracheostomy, transtracheal pressure measurements, voicing, and ventilator rate.

The long-term prognosis for pediatric patients who undergo tracheostomy after cardiac surgery varies. Using a Valve has been shown to increase the rate of success with feeding and swallowing (Henningfeld et al., 2019) and lead to earlier decannulation (Fuller, Wineland, & Richter, 2021). Some children may eventually be decannulated and achieve normal respiratory function, while others may require long-term tracheostomy care. The presence of underlying conditions, such as chronic lung disease or neurologic impairment, significantly influences long-term outcomes.

> *Knowing when to use a speaking valve, healthcare providers can improve the quality of care for children.*

Conclusion

The incidence of tracheostomy in pediatric patients undergoing cardiac surgery, while relatively low, reflects the complexity and severity of this population. Identifying risk factors and optimizing management is essential for reducing the need for tracheostomy and improving outcomes or for providing better plans of care should the patient need a tracheostomy. Refining criteria for tracheostomy in this patient population, as well as developing strategies to minimize respiratory complications, will enhance recovery following pediatric cardiac surgery. Through a better understanding of these factors, and knowing when to use a speaking valve, healthcare providers can improve the quality of care for children with congenital heart disease, ultimately leading to better long-term outcomes.

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References:

Alcántara-Noguez, C., García-Lemus, N., Bolio-Cerdán, A., Ruíz-González, S., & Romero-Cárdenas, P. (2023). Frequency and treatment of diaphragmatic paralysis after cardiac surgery in pediatric patients. *Cirugía Cardiaca e México, 8*(3), 70-74.

Brooks, L., Figueroa, J., Edwards, T., Reeder, W., McBrayer, S., & Landry, A. (2019). Passy Muir Valve tolerance in medically complex infants and children: Are there predictors for success? *The Laryngoscope, 130*(11), E632–E639. https://doi.org/10.1002/lary.28440

Cowell, J., Schlosser, D., & Joy, P. (2013). Language outcomes following infant tracheostomy. *Asia Pacific Journal of Speech, Language, and Hearing, 5*(3), 179-186. https://doi.org/10.1179/136132800805576942

Dai, Y., Qiao, J., Ye, Q-P., Li, X-Y., Hu, J-H., & Dou, Z-L. (2022). Exploring the influence of dysphagia and tracheostomy on pneumonia in patients with stroke: A retrospective cohort study. *Brain Sciences, 12*(12), 1664. https://doi.org/10.3390/brainsci12121664

de Araujo, O. R., Azevedo, R. T., de Oliveira, F. R. C., & Colleti Junior, J. (2022). Tracheostomy practices in children on mechanical ventilation: a systematic review and meta-analysis. *Jornal de Pediatria, 98*(2), 126–135. https://doi.org/10.1016/j.jped.2021.07.004

Foz, C., Peyton, J., Staffa, S. J., Kovatsis, P., Park, R., DiNardo, J. A., & Nasr, V. G. (2021). Airway abnormalities in patients with congenital heart disease: Incidence and associated factors. *Journal of Cardiothoracic and Vascular Anesthesia, 35*(1), 139-144. https://doi.org/10.1053/j.jvca.2020.07.086

Fuller, C., Wineland, A. M., & Richter, G. T. (2021). Update on pediatric tracheostomy: Indications, technique, education, and decannulation. *Current Otorhinolaryngology Reports, 9*(2), 188–199. https://doi.org/10.1007/s40136-021-00340-y

Gross, R., Mahlmann, J., & Grayhack, J. P. (2003). Physiologic effects of open and closed tracheostomy tubes on the pharyngeal swallow. *Annals of Otology, Rhinology & Laryngology, 112*(2), 143-152. https://doi.org/10.1177/000348940311200207

Gross, R., Steinhauer, K., Zajac, D., & Weissler, M. (2006). Direct measurement of subglottic air pressure while swallowing. *The Laryngoscope, 116*(5), 753-761. https://doi.org/10.1097/01.mlg.0000205168.39446.12

Hansen, T. P., Noel-MacDonnell, J., Kuckelman, S., Norberg, M., Truog, W., & Manimtim, W. (2021). A multidisciplinary chronic lung disease team in a neonatal intensive care unit is associated with increased survival to discharge of infants with tracheostomy. *Journal of Perinatology, 41,* 1963–1971. https://doi.org/10.1038/s41372-021-00974-2

Henningfeld, J., Lang, C., & Goday, P. (2019). Feeding disorders in pediatric tracheostomy. *American Journal of Respiratory and Critical Care Medicine, 199,* A3583. https://doi.org/10.1164/ajrccm-conference.2019.199.1_MeetingAbstracts.A3583

Lieu, J. E., Muntz, H. R., Prater, D., & Stahl, M. B. (1999). Passy-Muir valve in children with tracheotomy. *International Journal of Pediatric Otorhinolaryngology, 50*(3), 197-203. https://doi.org/10.1016/s0165-5876(99)00245-1

Mastropietro, C. W., Benneyworth, B. D., Turrentine, M., Hornik, C. P., Jacobs, J. P., & Jacobs, M. L. (2016). Tracheostomy after operations for congenital heart disease: An analysis of the Society of Thoracic Surgeons Congenital Heart Surgery Database. *The Annals of Thoracic Surgery, 101*(6), 2285 – 2292. https://doi.org/10.1016/j.athoracsur.2016.01.046

O'Connor, L., Morris, N., & Paratz, J. (2019). Physiological and clinical outcomes associated with use of one-way speaking valves on tracheostomised patients: A systematic review. *Heart & Lung, 8*(4), 356-364. https://doi:10.1016/j.hrtlng.2018.11.006

Puchi, C., Lavin, J., Eltayeb, O., & Billings, K. R. (2023). Outcomes of pediatric tracheostomy after surgery for congenital heart disease: A 20-year experience. *Laryngoscope Investigative Otolaryngology, 8*(4), 1124–1130. https://doi.org/10.1002/lio2.1100

Rusin, C., Acosta, S., Vu, E., Ahmed, M., Brady, K. M., & Penny, D. J. (2021). Automated prediction of cardiorespiratory deterioration in patients with single ventricle. *Journal of American College of Cardiology, 77* (25) 3184–3192. https://doi.org/10.1016/j.jacc.2021.04.072

Song, H., Cao, L., Wang, X., & Zhang, H. (2024). Comparative analysis of treatment strategies for postoperative pulmonary hypertensive crisis in congenital heart disease. *The Heart Surgery Forum, 27*(7), E757-E767. https://doi.org/10.59958/hsf.7621

Song, W. S., Kim, C. Y., Lee, B. S., Kim, E. A., Kim, K., & Jung, E. (2020). Morbidity and mortality of very low birth weight infants with congenital heart disease. Korean Circulation Journal, 50(12), 1113 – 1123. https://doi.org/10.4070/kcj.2020.0135 post- tracheostomy care. *Respiratory Care, 62*(2), 137-143. https://doi:10.4187/respcare.04878

Article Summary

Decrease in Respiratory Related Hospitalizations in Tracheostomy-DependentChildren who Tolerate Passy Muir Valve Use

Li, L., Wikner, E., Behzadpour, H., Perez, G., & Mudd, P. (2021). Decrease in respiratory related hospitalizations in tracheostomy-dependent children who tolerate Passy-Muir Valve use. *The Annals of Otology, Rhinology, and Laryngology, 130*(6), 623–628. https://doi.org/10.1177/0003489420966612

This paper is a retrospective study of pediatric patients who received a tracheostomy at one facility from 2012-2018 to determine the effect of Passy Muir Valve (PMV) use on respiratory illness and respiratory-related hospital admissions. This study investigated 262 patients with tracheostomies. Particularly, these authors sought to add to the body of literature regarding PMV use in pediatrics by providing a study to highlight improvements in respiratory outcomes. Slightly more than half (51.5%) of the patients received a PMV, and of those using a Valve, 78.5% wore the PMV for at least an hour each day. Results revealed that when separated by age, children < 2 years of age have an overall higher rate of respiratory-related hospitalization pre- and post-PMV placement compared to older children, but there was a statistically significant lower rate of respiratory-related hospitalizations following PMV placement within the age group. The authors determined their findings supported the early use of PMV in children < 2 years of age to improve consistency with use and to increase benefits to respiratory function and outcomes such as hospitalization rates.

PMV® 2001 (Purple Color®)

Measuring Transtracheal Pressure During Passy Muir Valve Application: Impact on Patient Outcomes

Laura Brooks, MEd, CCC-SLP, BCS-S

Introduction

The Passy Muir® Valve (PMV®) is the only bias-closed, no-leak speaking valve, which means that it is the only valve that allows for 100% of the exhalation to return through the patient's upper airway when the Valve is placed on a tracheostomy tube hub or in-line in the ventilator circuit. While other speaking valves have a leak and may still allow a patient to vocalize, the design of the Passy Muir Valve has been shown to restore subglottic pressure for glottic or vocal cord closure (Gross et al., 2003; Gross et al., 2006). This restoration of subglottic pressure not only provides benefits to the patient (coughing, swallowing, bearing down, and restoring intrathoracic pressure), it also allows the clinician to gain insight into the pressure within the trachea when the Passy Muir Valve is applied. It is critical to know this measurement, as any obstruction compromising the exhale may increase the pressure within the trachea, also known as transtracheal pressure (TTP).

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Airway Patency

The airway is separated into the upper and lower airways. The upper airway includes the oral cavity (lips, tongue, jaw, palate), nasopharynx, pharynx, and larynx (glottis). The supraglottis is the area above the vocal cords, the glottis area is the true vocal cords, and the subglottis is the area below the vocal cords. The lower airway includes the trachea and the lungs *(see Image 1).*

Image 1

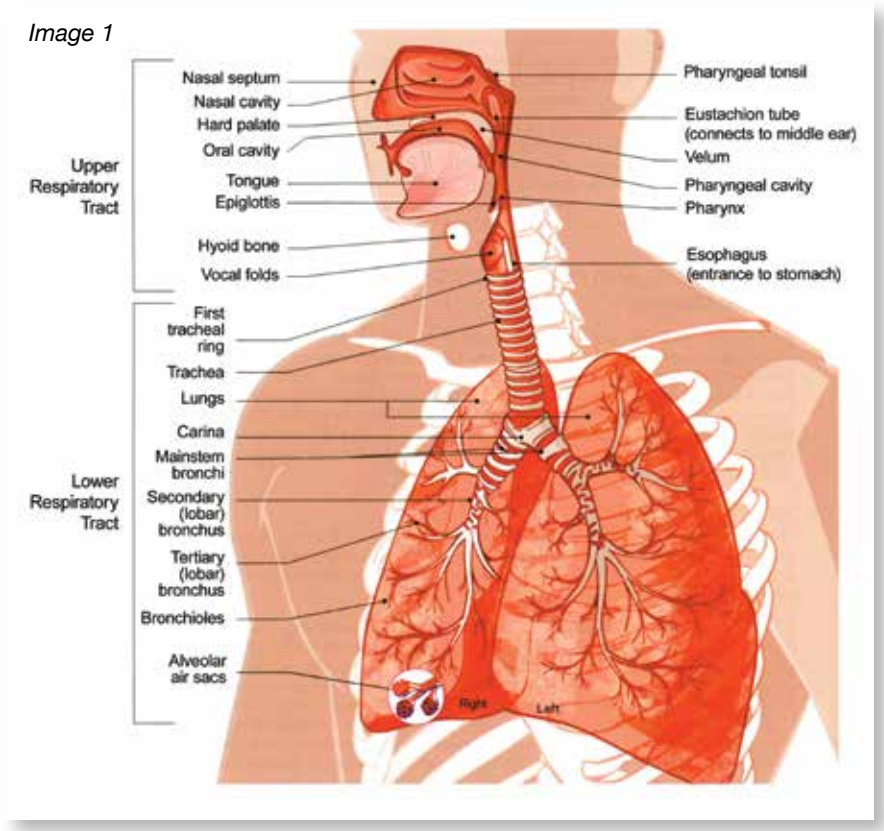

Image: © Kazandjian and Dikeman (2022) *Communication and Swallowing Management of Tracheostomized and Ventilator Dependent Individuals, 3rd Edition,* Eat Speak Breathe Publishing, NY. Used with permission.

When the PMV is placed on a tracheostomy tube hub or in-line in the ventilator circuit, it can be difficult to determine if the patient can adequately exhale, particularly for infants or nonverbal patients. Stress signs, whoosh after removal, and coughing with placement of the PMV are subjective signs and are often misleading. The clinician needs to ensure airway patency or opening of the trachea, before any negative outcomes, such as oxygen desaturation or bradycardia, are associated with poor tolerance. Measuring transtracheal pressure with PMV application is an objective way to ensure that the pressure intended to remain in the airway, the positive end-expiratory pressure (PEEP), remains the same with the use of the PMV. If the airway is not patent, and there is some level of obstruction at the level of the tracheostomy tube or above, the patient may not be able to tolerate the speaking valve. Measuring the TTP has the following benefits including, but not limited to:

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1. Ensuring airway patency when applying the PMV and ensuring patient safety (Brooks et al., 2020, Utrarachkij et al., 2005).
2. Guiding workup for the causes of high pressures: downsizing the tracheostomy tube if the tracheostomy tube is too large, repeating DLB [direct laryngoscopy and bronchoscopy] for airway evaluation to assess the presence of unknown upper airway obstruction with a need for intervention.
3. Determining readiness for capping trials.
4. Determining readiness for possible decannulation (Young, 2024).
5. Identifying complete tracheostomy tube obstruction or complete mucous plug, prompting urgent tracheostomy tube exchange.

These benefits will be illustrated in the following case studies.

Case Study #1

CS1 is a 16-year-old male admitted on 2/10/2024 in respiratory distress in the setting of rhino/enterovirus and pneumonia and with a history of Pompe Disease and restrictive lung disease (decrease in volume of air the lungs can hold). He was intubated for hypercapnic (elevated CO_2) and hypoxemic (low-level O_2) respiratory failure. He underwent a tracheotomy on 3/5/2024, and his first tracheostomy change was on 3/11/2024. His tracheostomy tube was a Shiley 7.0. He was on a Trilogy ventilator with the following settings: mode of AVAPS [average volume-assured pressure support]; PEEP of 7 cm H_20; tidal volume (TV) 530 ml; measured peak inspiratory pressure (PIP) 25 cm H_20. He was referred for a PMV trial on 3/11/ 24. His cuff was deflated on arrival, and the PMV was placed in line by the speech-language pathologist (SLP) and respiratory therapist (RT). Transtracheal pressure was consistent with his PEEP at 7 cm H_20, indicating a patent airway. He wore the PMV for 45 minutes. Two months later during his admission, he was off the ventilator during awake hours. The PMV was placed on his tracheostomy tube hub with the manometer. His TTP was 0 cm H_20

Image 2: Manometer with resting breaths.

Image 3: Manometer with vocalization.

when off the ventilator (see Image 2). To ensure that the manometer was working properly, the SLP cued the patient to vocalize, and the pressure increased as expected (*see Image 3*).

Teaching points for Case Study #1

Pompe disease. A genetic condition that causes severe muscle weakness and respiratory insufficiency.

Indication for a Tracheostomy. The indication for the tracheostomy always needs to be considered when performing a Passy-Muir Valve assessment and trial. CS1 had a baseline musculoskeletal weakness. Given his inability to successfully extubate, and his deconditioning following prolonged admission and intubation, he required a tracheotomy. The tracheostomy would allow for continued rehabilitation and weaning of support over time.

PMV Trial. His Passy Muir Valve trial was conducted on the day of his first tracheostomy change. (*See Appendix A for an example of PMV Protocol*).

Cuff Types. Shiley cuffs are inflated with air; these tracheostomy tubes tend to be used for older pediatric patients, although there are exceptions based on patient factors and/or physician preference. Bivona cuffs are inflated with water; these tracheostomy tubes tend to be used for infants and younger pediatric patients.

AVAPS. A relatively new mode of noninvasive positive pressure ventilation (NIPPV), AVAPS can also be used for invasive mechanical ventilation. AVAPS ensures delivery of a constant tidal volume, as it gradually adjusts the patient's spontaneous breaths to the target tidal volume of airflow with pressure support ventilation. This mode of ventilation is potentially advantageous over standard spontaneous or timed modes because it ensures delivery of a constant tidal volume that may prevent fluctuations in CO_2.

AVAPS is the term used with a Trilogy ventilator; other ventilators have different terms for a similar mode.

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Ventilator settings. PEEP 7 cm H_20, TV 530 ml, PIP 25 cm H_20. See Appendix A for ventilator setting recommendations for a PMV trial. In this mode, volume (TV) is set and pressure is variable, i.e. measured PIP. There is a maximum pressure and minimum pressure setting.

PMV In-line. For ventilator-dependent patients, the PMV is placed in-line (in the ventilator circuit) with the manometer to measure airway patency. *See Image 4* for where to place the PMV and manometer. The adapters may vary depending on the ventilator circuit.

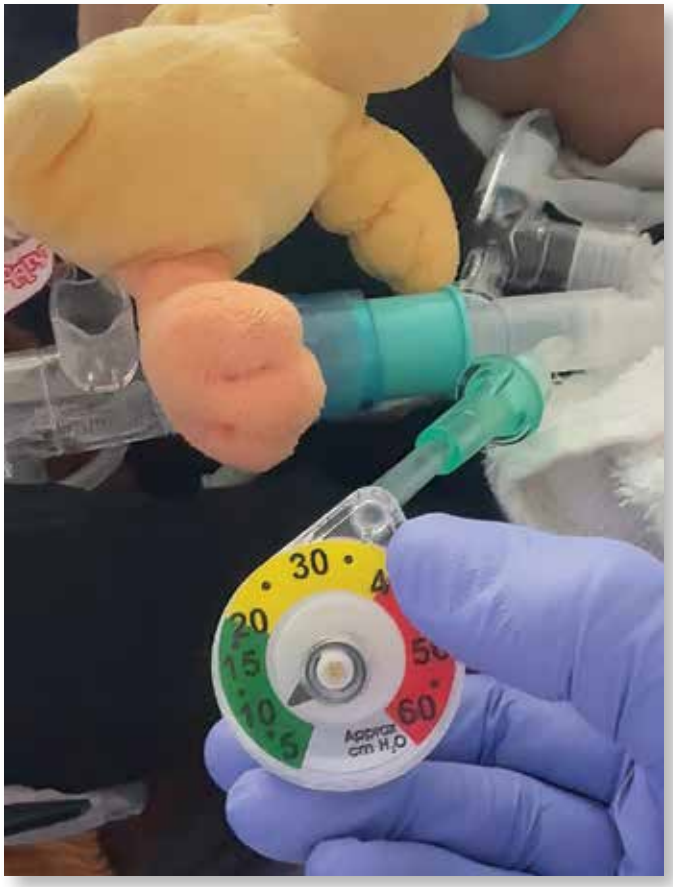

Image 4: Manometer + PMV in the ventilator circuit.

Transtracheal pressure. Transtracheal pressure is the pressure within the trachea at the end of the exhale. For a patent (open) airway without obstruction, when a patient is on the ventilator, the TTP should read close to the set and delivered PEEP. In this case, his delivered PEEP was 7 cm H_20. Because the PMV allows the patient to receive support "one-way," during inhalation, the PEEP that was delivered from the ventilator reached the patient's airway with the PMV in-line. Therefore, the intended set PEEP from the ventilator, in this case 7 cm H_20, was close to the pressure that was measured within the trachea for a patent airway. If the airway was not patent, the TTP would increase because the patient was unable to exhale adequately, and the manometer would reflect a number at the end of the exhale that was higher than the intended PEEP. Off the ventilator, the pressure should ideally read 5 cm H_20 or less. In this case, it was 0 cm H_20. The manometer needle did not move, which was expected for a patient with a patent airway. If there was a little resistance, the manometer might read between 0 and 5 cm H_20 and the patient may still comfortably wear the PMV. TTPs that are higher than 5 cm H_20 may indicate some degree of obstruction, as the inability to adequately exhale increases the pressure within the trachea.

When the PMV is placed on a tracheostomy tube (no ventilator) and the TTP is 0 cm H_20 (the analog manometer needle does not move), the clinician should test the manometer by asking the patient to cough or vocalize and see if the needle moves, which demonstrates that the manometer is working (*see Images 2 and 3*).

If the clinician needs to obtain the exact pressure measurement, a digital manometer is recommended (*see Image 5*). This is connected to the adapters in the same way the analog manometer is connected.

Image 5: Digital manometer

Case Study 2

CS2 is a 17-year-old female admitted on 2/5/2024 for altered mental status, shock, and respiratory failure in the setting of Candida urinary tract infection. She has a past medical history of Hennekam lymphangiectasia-lymphedema syndrome (HKLLS1), obstructive sleep apnea with BiPAP at night, low flow nasal cannula (LFNC) during the day, retrognathia [retracted mandible], chronic kidney disease secondary to membranous nephropathy (hemodialysis dependent), and restrictive lung disease. She continued to have dyspnea (shortness of breath),

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For patients on a ventilator, it is helpful for the clinician to begin the assessment by placing the manometer in-line without the PMV. The manometer reflects the ventilator support that the patient is receiving, such as the PIP, PS, and PEEP. Then, the PMV is placed in the ventilator circuit, with the manometer between the PMV and the tracheostomy tube hub (*see Image 4*).

If the airway is patent and the patient demonstrates resting breaths, the manometer reflects values similar to the previous measurement when the PMV was not in-line. If the airway is not patent, the manometer will reflect an increase in end-expiratory pressure that is inconsistent with the PEEP.

For patients off the ventilator, the manometer is placed between the tracheostomy tube hub and the PMV. Note that patients off the ventilator who are receiving FiO_2 greater than 21% can continue to receive the O_2 support with an oxygen adapter (PMA® 2000 O_2 Adapter for use with the PMV 2000 and PMV 2001 valves) (see Image 6). If the adapter is unavailable in your facility, the tracheostomy collar/mask may be added to the Optiflow circuit allowing O_2 support during PMV use.

Image 6

PMA® 2000 Passy Muir Valve O_2 adapter

Children's Healthcare of Atlanta Institutional Review Board approved this project, IRB number STUDY00002271

respiratory acidosis (high CO_2), hypoxemia (low-level O_2), and persistent pleural effusions (fluid in space surrounding the lungs). Given the inability to successfully extubate her, she underwent a tracheotomy on 3/4/2024. She had her first tracheostomy tube change on 3/11/2024 with a 6.0 cuffed TTS (tight to shaft) Bivona tracheostomy tube placed. She was on a Servo ventilator with pressure-regulated volume control (PRVC), PIP range of 25-35 cm H_20, and TV of 160 ml.

She was referred for a PMV trial after her first tracheostomy change. The cuff was deflated, and the PMV was placed in-line while using the manometer. It was difficult to measure her TTP because she was highly anxious, compromising the TTP reading with resting breaths. She did voice with the PMV application which indicated that some air was moving through the upper airway. She requested the removal of PMV and continued on the ventilator with her cuff deflated for another 10 minutes. She continued in her speech therapy sessions to trial the PMV for only a few minutes at a time due to anxiety and reported difficulty breathing when the PMV was placed in-line. TTP continued to be higher than the PEEP, but the clinician was unsure if she truly could not exhale around the tracheostomy tube and through the upper airway or if she was too anxious and pushing or bearing down.

Two months later during her admission, she was off the ventilator during the day and exhibited less anxiety with her PMV trials. Her TTP was 10-12 cm H_20 indicating the possibility of some level of obstruction. The otolaryngologist (ENT) performed a DLB on 6/7/2024 with the following results: supraglottis, normal; vocal cords, normal; subglottis, normal; trachea, normal; no granulation tissue; and a small space around the 6.0 tracheostomy tube with the cuff down. It was recommended to consider downsizing her tracheostomy tube, if appropriate from a ventilation standpoint. The pulmonologist was hesitant to downsize due to ongoing issues with CO_2 retention (65 mm Hg). Several weeks later, CS2 reported difficulty talking on the ventilator and difficulty breathing off the ventilator, so the team agreed to downsize to a 5.0 Bivona. She still had a cuff, but her cuff was deflated and TTS. TTP improved following tracheostomy change to 7 cm H_20. Prior to discharge two weeks later, her tracheostomy tube was changed to a 5.0 cuffless Bivona, with a TTP < 5 cm H_20 indicating a patent airway. She reported easy breathing and wanted to wear the PMV during awake hours. CO_2 at the time of discharge was 47.9 mm Hg.

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Teaching points for Case Study #2

Bivona TTS 6.0. Tight to Shaft (TTS) cuffs rest tight to the tracheostomy tube shaft when deflated, allowing for more space in the trachea. Bivona cuffs are inflated with water.

Servo. A hospital-grade ventilator. These ventilators are more precise than home ventilators and indicate that the patient is likely still in the intensive care unit.

Pressure-regulated volume control (PRVC) (including a PIP range 25-35 cm H_20, and TV 160 ml). This mode was used on her Servo ventilator (other ventilators have this mode, but it may be called something different). The ventilator adjusts the pressure delivered during each breath to ensure a target volume. Tidal volume is set; pressure is variable.

Tidal Volume. The TV range for adults is typically between 6-8 ml/kg. The average TV for adult females is 400 ml and for adult males 500 ml. CS2 is 17 years old, but weighed 28 kg on admission; therefore, her TV was set at 160 ml initially in the pediatric intensive care unit (PICU).

Voicing with PMV trial. May be predictive of PMV tolerance (Brooks et al., 2020) but does not necessarily ensure airway patency.

High TTP. When TTPs are high, there are usually two possible main causes. The first is the tracheostomy tube might be too large in diameter, and there is not enough leak or space between the tracheostomy tube and the tracheal walls. The second is upper airway obstruction, which can be nasal, oral, pharyngeal, or laryngeal (supraglottis, glottis, or subglottis).

Critical Points

It is critical that the TTP is measured with resting breaths. When the cuff is deflated and the PMV is placed, the air is redirected entirely through the upper airway which can feel very different for the patient. In response to that sensation, patients may cough, vocalize, or bear down, which compromises the TTP reading. If the clinician is not sure that the TTP is being measured with resting breaths, it is not a "pass" or a "fail," and the clinician needs to continue to measure over subsequent sessions.

CO_2 goal range is 35-45 mm Hg. CS2 had a CO_2 on admission of >130 mm Hg. By discharge, it was 47.9 mm Hg. Arterial blood gas is used to measure and monitor CO_2, O_2, and pH balance.

Case Study #3

CS3 is a 14-year-old male presenting on 10/20/2023 with a gunshot wound to the face and neck with bilateral mandible fractures and nasal bone fractures. He went to the operating room for a tracheotomy, performed by ENT, and a maxillomandibular fixation (oral maxilla facial surgery (OMFS)). Following the OMFS, the ENT ordered a PMV trial. The patient did not require mechanical ventilation. He wore the PMV for only 2 minutes, but the SLP removed the Valve due to an increased TTP to 8-9 cm H_2O, possibly associated with upper airway swelling. Three days later, his TTP was < 5 cm H_2O and he wore it for 2 hours. The next day his TTP was 0 cm H_2O. SLP cued him to verbalize and cough for a TTP manometer check, but it did not move despite the pressure. The SLP changed the manometer, but the pressures never elevated with vocalizing or coughing. The SLP reported this to Pulmonology and ENT. The ENT scoped the patient at the bedside and found that his tracheostomy tube was completely occluded by a mucous plug. His tracheostomy was changed, and his TTP continued to be < 5 cm H_20. Prior to discharge, he was capped and decannulated.

Teaching points for Case Study #3

TTP. His TTP improved over only a few days as his swelling was reduced. Any diagnosis or procedure that may cause temporary upper airway swelling (i.e. free flap for head and neck tumors) may have a similar TTP change in just a few days.

Pressure. The pressure on the manometer should always increase with coughing or vocalizing. The lack of movement alerted the SLP to report urgently to the ENT. The SLP hypothesized that the manometer did not move because the tracheostomy tube was completely obstructed, so the manometer could not read any change in pressure. The hypothesis was confirmed with the ENT scope. In his case, he had enough of a leak that the mucous plug did not compromise his breathing, in a sense he was "successfully capped," which is why he was able to be decannulated soon after the tracheostomy tube exchange. For another patient without a large leak, mucous plugs can lead to serious respiratory distress.

The pressure on the manomter should always increase with coughing or vocalizing.

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Case Study #4

CS4 is a 21-month-old male who was born at 24 weeks gestation. His past medical history included severe bronchopulmonary dysplasia (BPD), chronic lung disease (CLD), and tracheostomy with ventilator dependence, and he was briefly admitted for G-tube dislodgement. His LTV ventilator settings were as follows: mode, SIMV, PC/PS; and settings, PIP 18 cm H_20, PEEP 9 cm H_2O, PS +8 cm H_20, and tidal volumes ranged 85-110 ml. His tracheostomy tube was a 4.0 cuffed Bivona inflated with 2 ml water. He was referred for a PMV trial. The PMV was placed in-line, and his TTP increased with every breath up to 30 cm H_20 after < 30 seconds, so the SLP removed the Valve. He was in a calm state and his TTP was measured with resting breaths. This indicated likely some upper airway obstruction compromising his ability to exhale with the PMV in-line.

Three months later, he had a direct laryngoscopy bronchoscopy and ENT found a completely obstructive suprastomal granuloma which was then removed. He was seen one month later for a Videofluoroscopic Swallow Study. The pulmonologist agreed to have the SLP retest TTP with the PMV. There was an improvement in TTP to 15 cm H_20 but still higher than his PEEP indicating some level of obstruction. He could not be cleared for PMV use at that time, but ENT planned to take him back to the OR for a repeat DLB in a few months. PMV trials were ongoing at outpatient pulmonology clinic visits and with SLP visits.

Teaching points for Case Study #4

Vent. LTV ventilator is a home ventilator.

Ventilator settings. Mode of SIMV PC/PS and settings of PIP 18 cm H_20, PEEP of 9 cm H_2O, PS +8 cm H_20, and tidal volumes ranging 85-110 ml. His mode of ventilation was SIMV, pressure control and pressure support. Synchronized Intermittent Mandatory Ventilation with Pressure Support (SIMV/PS) tends to be a very comfortable mode for patients. The ventilator delivers a predetermined number of breaths per minute, and pressure support can be provided during spontaneous breathing. In pressure control mode, the pressure is set (PIP = 18 cm H_20) and the volume is variable (TV range 85-110 ml). Pressure support is the support that the ventilator provides when the patient takes a breath, and his peak inspiratory pressure (PIP) is the PS value + PEEP value, in his case a PS of 8 cm H_2O and PEEP of 9 cm H_2O equaled a PIP of 17 cm H_20. Note that his PIP (PS+ PEEP) for his spontaneous breaths is close to his set PIP for his ventilator breaths: 17, 18 respectively.

TTP on the ventilator. Should be consistent with the set PEEP if the airway is patent. A discrepancy between his TTP and his PEEP indicated some level of obstruction. This could be due to upper airway obstruction (oral, nasal, pharyngeal, laryngeal) or at the level of the tracheostomy tube. The ENT would consider downsizing if the DLB did not reveal any other upper airway obstruction. In his case, his ENT planned to take him back to the OR for a DLB in a few months.

Summary

These case studies illustrate the benefits of objectively measuring transtracheal pressure to ensure airway patency for tracheostomy-dependent patients on and off the ventilator. Measuring TTP when using the PMV has the potential to positively impact patient outcomes and safety.

References:

Brooks, L., Figueroa, J., Edwards, T., Reeder, W., McBrayer, S., & Landry, A. (2020). Passy Muir valve tolerance in medically complex infants and children: Are there predictors for success? *The Laryngoscope, 130*(11), E632-E639.

Brooks, L. (2022). CH.9 Management of the tracheostomized and ventilator dependent pediatric patient (pp. 237-277) in *Communication and Swallowing Management of Tracheostomized and Ventilator Dependent Individuals,* Kazandjian & Dikeman, 3rd Ed.

Gross, R., Mahlmann, J., & Grayhack, J. P. (2003). Physiologic effects of open and closed tracheostomy tubes on the pharyngeal swallow. *Annals of Otology, Rhinology & Laryngology, 112*(2), 143-152. https://doi.org/10.1177/000348940311200207

Gross, R., Steinhauer, K., Zajac, D., & Weissler, M. (2006). Direct measurement of subglottic air pressure while swallowing. *The Laryngoscope, 116*(5), 753-761. https://doi.org/10.1097/01.mlg.0000205168.39446.12

Utrarachkij, J., Pongsasnongkul, J., Preutthipan, A., & Chantarojanasri, T. (2005). Measurement of end-expiratory pressure as an indicator of airway patency above tracheostomy in children. *Journal of Medical Association of Thailand, 88*(7), 928-933.

Young, A., Walsh, K., Ida, J., Thompson, D. M., & Hazkani, I. (2024). Transtracheal pressure for evaluation of decannulation readiness. *The Laryngoscope, 134*(7), 3377-3383. https://doi.org/10.1002/lary.31280.

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Appendix A

Brooks Ch. 9 in Kazandjian and Dikeman (2022) Communication and Swallowing Management of Tracheostomized and Ventilator Dependent Individuals, 3rd Edition, Eat Speak Breathe Publishing, NY. Used with permission.

Sample Passy Muir® Speaking Valve Best Practice Protocol

Speaking Valve Protocol/Guideline

I. Clinical benefits of the PMV include:

A. Swallowing
B. Secretion management
C. Decannulation
D. Infection control – eliminates finger occlusion
E. Speech and language production/development
F. Weight shifting and bearing down

II. Candidacy for a PMV include:

A. The patient must have an MD order
B. The patient must tolerate cuff deflation. Set the patient up for success by slowly deflating the cuff. Some patients may even require deflation to take place over several minutes to adjust to the change in airflow
C. PMV in the pediatric population should be trialed following patient's first trach change. The first trach change is often done by the surgeon as the immature stoma poses some risk for damage.
D. The patient must be hemodynamically stable.
E. Patients with the following ventilator settings (parameters may vary based on institution)
    - FiO2 <50%
    - PEEP= 10 cm H_2O or less
    - PIP/PAP= <40cm H_2O

III. Contraindications for PMV application include:

A. Significant upper airway obstruction (e.g grade 4 subglottic stenosis)
B. Presence of laryngeal stents
C. Thick secretions
D. Foam filled cuff, as these cuffs cannot be safely deflated
E. With the Trilogy ventilators: If the patient is on Volume Control mode and has a passive circuit, the ventilator may deliver higher volume than necessary and the mode may need to be changed to pressure control. RT should monitor the ventilator closely with first PMV trial if the patient is on a Trilogy ventilator.
F. The PMV is not intended to be used during sleep.

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Appendix A *(continued)*

IV. Application of PMV for patients who are on a ventilator

A. MD to order 1) Passy Muir Valve trial 2) SLP consult with comment for PMV trial. SLP to conduct bedside evaluation in conjunction with bedside RT or Respiratory Educator.

B. Supplies for in-line placement -aqua PMV OR purple PMV + in-line silicone adaptor, blue 15, 22 adaptors, omni flex. Adaptors will vary depending on the patient's circuit

C. Pressure testing supplies- Washington tee piece, manometer, and oxygen tubing

D. Position patient upright.

E. Observe baseline vitals.

F. Oral care/suction

G. RT to suction trach

H. RT to slowly deflate cuff.

I. RT to suction trach after cuff deflation, mouth as needed.

J. Observe changes in vitals, color, work of breathing, and signs of stress.

K. Proceed if tolerating above steps.

L. Apply Passy Muir Valve and pressure manometer in line of circuit (not directly on trach to avoid torque) with adaptors and pressure testing supplies.

M. Monitor trans-tracheal reading/pressure testing, record end-expiratory pressure with resting breaths.

V. Application of PMV for patients with tracheostomy only

A. MD to order Passy Muir Valve trial (Respiratory order) and SLP consult with comment for PMV trial. SLP to conduct Bedside evaluation in conjunction with bedside RT or Respiratory Educator for initial placement.

B. Pressure testing supplies- Washington tee piece, manometer, and oxygen tubing (*see Image 4*)

C. Position patient upright.

D. Observe baseline vitals.

E. Oral care/suction.

F. RT to suction trach

G. Slowly deflate cuff.

H. Suction trach again, suction mouth again as needed.

I. Observe changes in vitals, color, work of breathing, and signs of stress.

J. Support trach flange with one hand and gently apply PMV + pressure manometry to trach with the other hand adding a gentle quarter turn twist to the right to seat the valve. To remove, support flange and turn to the right while using a pulling-off motion.

K. Monitor trans-tracheal reading/pressure testing, which measures end-expiratory pressure.

L. Monitor stability.

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Appendix A *(continued)*

VI. Signs that patient has not tolerated the Valve

A. Change in vitals with cuff deflation or Valve placement.

B. Stress signs, changes in color, increased work of breathing

1. High pressure testing
2. If a "whoosh" sound is heard when the Valve is removed, could indicate pressure buildup/ breath stacking

If the patient is ON a ventilator			
Likely to pass: Resting TTP ≤ 10 cm H_2O (consistent with PEEP delivered).	TTP 10-14 borderline – may tolerate PMV but will be patient specific.	TTP 15-20 likely to be too high but patient specific.	Likely to fail: resting TTP > 20 cm H_20.
Action: Proceed with PMV trial.	• Start with SLP as tolerating. • Closely monitor for work of breathing or stress signs.	• Strict monitoring by SLP • Closely monitor for work of breathing or stess signs. • May need cuffless tracheostomy tube or downsizing of tracheostomy tube.	• Review possible confounding effects, such as obstruction, large tracheostomy tube, and more. • Consider contacting ENT. • Next steps may include assessment of upper airway, downsizing tracheostomy tube.
If the patient is OFF the ventilator			
Likely to pass: Resting TTP ≤ 5 cm H_2O	TTP 5-10 borderline – may tolerate PMV but will be patient specific.	TTP 10-15 likely to be too high but patient specific.	Likely to fail: resting TTP > 15 cm H_20.
Action: Proceed with PMV trial.	• Start with SLP as tolerated. • Closely monitor for work of breathing or stress signs.	• Strict monitoring by SLP • Closely monitor for work of breathing or stess signs. • Contact ENT. Next steps may include assessment of upper airway (DLB), downsizing tracheostomy tube, or changing to cuffless tracheostomy tube.	• Review possible confounding effect, obstruction, large tracheostomy tube. • Contact ENT. • Next steps may include assessment of upper airway, downsizing tracheostomy tube, or changing to cuffless tracheostomy tube.

Filtration: Added Protection for Both Pediatric and Adult Patients with Tracheostomies

Kristin A. King, PhD, CCC-SLP

Tracheostomy

Why would a patient with a tracheostomy be more at risk for disease exposure? Not only does the patient with a tracheostomy have co-morbidities that increase their risk of contracting disease, but they also have a higher risk of spreading viral and bacterial contagions because the open airway is often a forgotten source. A physiologic consequence of a tracheostomy is a change in the direction of airflow for the patient. Since the tracheostomy tube is placed in the trachea and provides an access point for airflow to the lower respiratory system at that point of entry, this placement bypasses the natural mechanisms of filtration, ciliary clearance, warming, and humidification of the air that are usually provided by the nose and oral cavity. Thus, a patient, adult or pediatric, with a tracheostomy may experience increased cough, pulmonary infections, and drying of pulmonary secretions. Respiratory gases inhaled through a tracheostomy bypass a patient's nasal passage, thus entering and exiting the upper airway and lungs in an unfiltered state. As a result, patients with tracheostomies have an increased risk of exposure to bacterial, viral, and particulate matter and are more likely to contaminate others. Personal protective equipment may be used with these patients to protect them from these exposures.

Disease Exposure

Considering that COVID-19 became a pandemic worldwide and still exists, the current influenza season already has approximately 35 million cases per the CDC, whooping cough and similar respiratory diseases are on the rise, and even the common cold (rhinoviruses and enteroviruses) is on the rise, understanding what the risks are for patients with tracheostomies and how to protect their respiratory system is essential (CDC, 2024a; CDC, 2024b; CDC, 2024c). A range of 3% to 17% of patients who contract COVID-19 develop Acute Respiratory Distress Syndrome (ARDS); however, most remain mild and manage their illness at home (Guan et al., 2020). Among all patients who develop the severe classification of the COVID-19 disease, the average time to dyspnea (shortness of breath) is 5 to 8 days and to develop ARDS is a median of 8 to 12 days (Lauer et al., 2020). Concurrent risk factors for developing ARDS also include respiratory viral infections, such as influenza and cold viruses.

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Why is this significant? Well, when a patient progresses to ARDS, this level of disease often requires intubation and may lead to a tracheostomy. If the patient already has a tracheostomy and the severity of the disease increases, or they contract a new disease, their potential recovery and progress may be negatively impacted. Pre-existing conditions influence the severity of illnesses, and patients with tracheostomies have the significant factor of an already compromised respiratory system. Adding a viral or bacterial infection raises the risk significantly with some reporting a mortality rate of 31% in critically ill patients who contract COVID-19 (Cascella et al., 2023).

Image 1: Patients with tracheostomies have a higher risk of exposure to disease due to the open tube.

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Another consideration that moved to the forefront of medical care during COVID-19 is the recognition that producing droplets through cough and throat clear during a procedure is then an aerosol-generating procedure (AGP). If a patient has a tracheostomy, airflow from the tracheostomy site or nose and mouth during an AGP increases the risk. Covering the mouth and nose is typically managed with a face mask; however, the patient with a tracheostomy has the added area of the tracheostomy site – an opening into the airway that is both a risk for inhaling viral and bacterial loads and exhaling them during breathing, coughing, sneezing, and more. Because of the risk with AGPs and the potential spread of COVID-19 or other viruses, in general, patients with tracheostomies have additional risks for exposure to any virus around them or to others. With the use of proper personal protective equipment (PPE), the risk for and from these patients is reduced.

Personal Protective Equipment

In the earlier phases of COVID-19, the use of personal protective equipment (PPE) changed. David, Russell, El-Sayed, and Russell (2020) reported on the use of both contact and airborne precaution-level PPE for patients with tracheostomies. Viral load and reduction were managed with a time-based strategy instead of PPE, such as extended intubation times and staff limitations, to limit viral shedding. During this time, PPE for staff often included a gown, N95 mask, gloves, goggles, shoe covers, and at times, a powered air purifying respirator (PAPR). Currently, many of these precautions are still in place, especially during APGs. For patients, they are often isolated in their rooms when in a facility. If at home, they are confined to a bedroom or designated space to limit others from being exposed.

The use of PPE is for the protection of both healthcare professionals and patients. However, for a patient with a tracheostomy proper protection is limited. This patient population breathes through the tracheostomy site, limiting the options for providing filtration to either placing a face mask over the tracheostomy site or using an off-label device, such as placing a filter made for mechanical ventilation onto the tracheostomy tube hub. These are usually large and have some weight as they are not designed for direct patient placement, when off the ventilator.

For a patient with a tracheostomy proper protection is limited.

Image 2: The patient uses a mask over both the face and tracheostomy, but this is cumbersome.

Filters

Previously, available filters have been intended for use with ventilators, anesthesia machines, and open-flow systems where filtration of inspired and expired gases is desired. The open flow system terminology indicates a breathing system that does not control the inhaled or exhaled gases of a patient. The bacterial and viral filter used for anesthesia machines has been shown to reduce the risk of viral and bacterial cross-contamination between patients or between staff and patients, even when used for non-ventilated patients (De Seta et al., 2020). These filters are often developed in combination with a heat moisture exchanger (HME) 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 heat moisture exchanger (HME) devices are designed for placement on the hub, this 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. This electrostatic filter uses a polypropylene media with a pleated design to increase surface area without increasing size. This media is used to improve safety, effectiveness, and efficiency as compared to paper or foam. The PM-APF15 maintains an open flow system via the tracheostomy tube, allowing the patient to continue inhaling and exhaling at the site of the tracheostomy tube. This device has a bacterial filtration efficiency of >99.9%, viral filtration efficiency of >99.9%, and other particulate matter at a filtration efficiency of > 99.0%. It is intended to fit onto the

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15mm hub of a tracheostomy tube and is easy to apply and remove with a gentle twist motion. This filter provides much-needed protection for patients with tracheostomies for both inspiratory and expiratory risks.

Having a high viral filtration efficiency provides a superior filtration performance and protection factor for patients. Meister et al. (2020) conducted a state-of-the-art review for safety recommendations following tracheostomy in the presence of COVID-19 (or other viral and bacterial matter). The authors also addressed that a primary area of concern is transporting patients and the need for a viral filter to lower transmission risk during transport. The PM-APF15 can be used during transport.

A filter also should be used to prevent irritation of the airways, due to dust or harmful substances contained in the air as a patient breathes. Another component of tracheostomy care is to have proper humidification and suctioning as these are essential to reduce the risk of crusting, mucus plugs, and tube blockage due to dryness (Watters, 2017). While HMEs (heat moisture exchangers) may be used to assist with humidification and secretion management (Lawrence et al., 2021), none of the current ones on the market are rated with a filtering capacity for viral and bacterial particulates.

Filter Placement

The PM-APF15 filter is designed with a standard conical connector, fitting on the 15 mm hub of a tracheostomy tube. This design is consistent with current HMEs and speaking valves which are placed and used independently by patients. The PM-APF15 filter is designed to be used in the same manner for placement and removal.

Martin et al. (2021) reported on patient independence with speaking valve use and found that patients could independently manage their speaking valves without safety concerns. Research also has reported that patients' independence for the use of speaking valves and care significantly improves their psychological state and quality of life (O'Connor et al., 2019). It is common practice to teach patients independence in the care of their tracheostomy, including removal and insertion of the tracheostomy tube, and placement and removal of accessories, such as HMEs, speaking valves, suction lines, and more. Having a patient trained for independence increases care and safety. Placement and removal of a filter by the patient would be a standard of care that is currently observed with other accessories that have 15 mm connectors. The process for placement and removal of HMEs, speaking valves, and the PM-APF15 filter would be the same. Russell et al. (2022) reviewed tracheostomy care in a community setting and reported that the aim of teaching independence is to "enhance patient and carer confidence, and thereby promote independence, safety, and quality of life."

Image 3: Using a filter on the tracheostomy tube for higher filtration of viral, bacterial, and particulate matter offers significantly improved protection and ease of use.

Summary

Meister et al. (2020) conducted a State-of-the-Art review for safety recommendations following tracheostomy in the presence of COVID-19 (and other viral and bacterial matter). The authors found that having a heightened awareness of protective equipment and care protocols with patients increased safety and mitigated transmission risks, including the use of a filter that would be specific to viral and bacterial matter. Providing a patient who has a tracheostomy with access to a filter that has a high filtration efficiency not only protects the patient but also offers caregivers and healthcare professionals lower risks of exposure. In a patient population with an already compromised respiratory system, reducing the risk and co-morbidities by providing appropriate personal protective equipment enhances the quality of life and may lower the risks of mortality.

Passy Muir Tracheostomy Viral & Bacterial Airway Protection Filter (PM-APF15)

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References:

Cascella, M., Rajnik, M., Aleem, A., Dulebohn, S. C., & Di Napoli, R. (2023). Features, evaluation, and treatment of Coronavirus (COVID-19) [Updated 2023 Aug 18]. NIH: National Library of Medicine. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing. https://www.ncbi.nlm.nih.gov/books/NBK554776/

Centers for Disease Control and Prevention, National Center for Immunization and Respiratory Diseases (NCIRD). (2024a). Weekly U.S. influenza surveillance report. Retrieved from https://www.cdc.gov/flu/weekly/index.htm#:~:text=CDC%20estimates%20that%20there%20have,important%20for%20higher%20risk%20patients

Centers for Disease Control, Whooping Cough (Pertussis). (2024b). About whooping cough outbreaks. Retrieved from https://www.cdc.gov/pertussis/outbreaks/index.html#:~:text=Pertussis%20(whooping%20cough)%20is%20common,on%20the%20rise%20in%202024

Centers for Disease Control, The national respiratory and enteric virus surveillance system (NREVSS). (2024c). Interactive dashboard. Retrieved from https://www.cdc.gov/nrevss/php/dashboard/index.html

David, A. P., Russell, M. D., El-Sayed, I. H., & Russell, M. S. (2020). Tracheostomy guidelines developed at a large academic medical center during the COVID-19 pandemic. *Head & Neck, 42*(6), 1291–1296. https://doi.org/10.1002/hed.26191

De Seta, D., Carta, F., & Puxeddu, R. (2020). Management of tracheostomy during COVID-19 outbreak: Heat and moisture exchanger filter and closed suctioning system. *Oral Oncology, 106,* 104777. https://doi.og/10.1016/j.oraloncology.2020.104777

Guan, W. J., Ni, Z. Y., Hu, Y., Liang, w, Ou, C., He, J., … Zhan, N. S. (2020). Clinical characteristics of coronavirus disease 2019 in China. *New England Journal of Medicine, 382,* 1708 – 1720. https://doi.org/10.1056/NEJMoa2002032

Lauer, S. A., Grantz, K. H., Bi, Q., Jones, F. K., Zheng, Q., Meredith, H. R., Azman, A. S., Reich, N. G. & Lessler, J. (2020). The incubation period of Coronavirus Disease 2019 (COVID-19) from publicly reported confirmed cases: Estimation and application. *Annals of Internal Medicine, 172* (9), 577 – 582. https://doi.org/10.7326/M20-0504 Evidence-based care of children with tracheostomies: Hospitalization to home care. *Rehabilitation Nursing, 46*(2), 83-86. https://doi.org/10.1097/RNJ.0000000000000254

Martin, K. A., Cole, T., Percha, C. M., Asanuma, N., Mattare, K., Hager, D. N., Brenner, M. J., & Pandian, V. (2021). Standard versus accelerated speaking valve placement after percutaneous tracheostomy: A randomized controlled feasibility study. *Annals of the American Thoracic Society, 18*(10), 1693 – 1701. https://doi.org/10.1513/AnnalsATS.202010-1282OC

Meister KD, Pandian V, Hillel AT, et al. (2021). Multidisciplinary Safety Recommendations After Tracheostomy During COVID-19 Pandemic: State of the Art Review. *Otolaryngology–Head and Neck Surgery, 164*(5), 984-1000. https://doi.org/10.1177/01945998820961990

O'Connor, L. R., Morris, N. R., & Paratz, J. (2019). Physiological and clinical outcomes associated with use of one-way speaking valves on tracheostomised patients: A systematic review. *Heart & Lung, 48*(4), 356-364. https://doi.org/10.1016/j.hrtlng.2018.11.006

Russell, C., MacGinley, K., & Meads, C. (2022). Tracheostomy care in community settings. *Primary Health Care, 29* (4), 40 – 49. https://doi.org/10.7748/phc.2019.e1548

Watters, K.F. (2017). Tracheostomy in infants and children. *Respiratory Care, 62* (6), 799 – 825. https://doi.org/10.4187/respcare.05366

Article Summaries

Tracheostomy-Related Swallowing Issues in Children

Raynor, E. M. & Wohl, D. (2024). Tracheostomy-related swallowing issues in children. *Otolaryngologic Clinics of North America, 57* (4), 649 – 655. https://doi.org/10.1016/j.otc.2024.02.017

This review of current literature synthesized information regarding dysphagia characteristics and management in pediatrics with tracheostomies. This article was not a clinical research study but instead provided clinical protocols and relevant information related to patient care. The paper highlighted specific dysphagia characteristics such as prolonged swallow timing, decreased laryngeal elevation, decreased sensitivity, and decreased subglottic pressure. The authors noted that the use of the Passy-Muir Valve (PMV) may improve residue, sensation, subglottic pressure, and risk of aspiration. They also reported that PMV use and early intervention by speech-language pathology should be utilized as part of the plan of care for improving outcomes for pediatric patients with tracheostomies.

Tolerance of One-Way In-Line Speaking Valve Trials in Ventilator Dependent Children

Althubaiti, A. Worobetz, N., Inacio, J. Lukens, J., Mousset, M., Onwuka, A., Stevens, M., Justice, L., Shepherd, E., & Wiet. G. (2022). Tolerance of one-way in-line speaking valve trials in ventilator dependent children. *International Journal of Pediatric Otorhinolaryngology, 157,* 111131. https://doi.org/10.1016/j.ijporl.2022.111131

A retrospective cohort study was conducted at a large, tertiary care children's hospital to evaluate the outcomes of in-line speaking valve (ISV) trials from 2009 to 2019. This study investigated 89 patients with tracheostomies. Eighty-nine patients were included, and 76 (85%) patients completed an ISV assessment and trial successfully during their hospitalization. Children who underwent tracheotomy for airway obstruction were more likely to fail. The authors concluded that children with tracheostomy, mechanical ventilation, and complex comorbidities demonstrate excellent tolerance of in-line speaking valves.

Akangire, G., & Manimtim, W. (2023). Tracheostomy in infants with severe bronchopulmonary dysplasia: A review. *Frontiers in Pediatrics, 10.* https://doi.org/10.3389/fped.2022.1066367

Althubaiti, A. Worobetz, N., Inacio, J. Lukens, J., Mousset, M., Onwuka, A., Stevens, M., Justice, L., Shepherd, E., & Wiet. G. (2022). Tolerance of one-way in-line speaking valve trials in ventilator dependent children. *International Journal of Pediatric Otorhinolaryngology, 157.* https://doi.org/10.1016/j.ijporl.2022.111131

Barnes, G. & Toms, N. (2021). An overview of tracheostomy tubes and mechanical ventilation management for the speech-language pathologist. *Perspectives of the ASHA Special Interest Group, 6*(4), 885-896. https://doi.org/10.1044/2021_PERSP-20-00105

Böschen, E., Wendt, A., Müller-Stöver, S., Piechnik, L., Fuchs, H., Lund, M., Steindor, M., Große-Onnebrink, J., Keßler, C., Grychtol, R., & Rothoeft, T. (2023). Tracheostomy decannulation in children: a proposal for a structured approach on behalf of the working group chronic respiratory insufficiency within the German-speaking society of pediatric pulmonology. *European Journal of Pediatrics, 182*(7), 2999-3006. https://doi.org/10.1007/s00431-023-04966-6

Botsch, M.L. (2021). An investigation of speech-language pathologists' and parents' perceptions of the counseling techniques provided by speech-language pathologists to pediatric patients with tracheostomies and their families. Senior Independent Study Theses. https://openworks.wooster.edu/independentstudy/9611

Brooks, L., Figueroa, J., Edwards, T., Reeder, W., McBrayer, S., & Landry, A. (2019). Passy muir valve tolerance in medically complex infants and children: Are there predictors for success? *The Laryngoscope, 130*(11), E632–E639. https://doi.org/10.1002/lary.28440

Brooks, L., Raol, N., Goudy, S., & Ivie, C. (2021). Pediatric medullary stroke, severe dysphagia, and multimodal intervention. *Dysphagia, 36*(5). https://doi.org/10.1007/s00455-021-10376-3

da Cunha de Lima, J.A., Collet, N., Baggio, M.A., & de Almeida, A.M. (2021). Breastfeeding based on the experience of mothers of tracheostomized children and the use of the Passy-Muir® Valve. *Anna Nery School Journal of Nursing, 25*(3), 1-7. https://doi.org/10.1590/2177-9465-EAN-2020-0290

Eichar, B., Kaffenberger, T., McCoy, J., Padia, R., Muzumdar., H., & Tobey, A. (2024). Effects of speaking valves on tracheostomy decannulation. *International Archives of Otorhinolaryngology, 28*(1). https://doi.org/10.1055/s-0043-1767797

Fuller, C., Wineland, A. M., & Richter, G. T. (2021). Update on pediatric tracheostomy: Indications, technique, education, and decannulation. *Current Otorhinolaryngology Reports, 9*(2), 188-199. https://doi.org/10.1007/s40136-021-00340-y

Goode-Roberts, M., Bickel, S. G., Stout, D. L., Calvery, M. L., Thompson, J. E., & Behrman, A. L. (2021). Impact of activity-based therapy on respiratory outcomes in a medically complex child. *Children, 8*(1), 36. https://doi.org/10.3390/children8010036

Henningfeld, J., Lang, C., Erato, G., Silverman, A. H., & Goday, P. S. (2021). Feeding disorders in children with tracheostomy tubes. *Nutrition in Clinical Practice, 36*(3), 689-695. https://doi.org/10.1002/ncp.10551

Kam, K., Patzelt, R., & Soenen, R. (2022). Pediatric tracheostomy speaking valves: A multidisciplinary protocol leads to earlier initial trials. *Journal of Child Health Care.* https://doi.org/10.1177/13674935211070416

Kennedy, A., Hart, C. K., de Alarcon, A., Balakrishman, K., Boudewyns, A., Chun, R., Fayouix, P., Goudy, S. L., Hartnick, C., Hsu, W., Johnson, R. F., Kuo, M., Peer, S., Pransky, S. M., Rahbar, R., Rickert, S., Roy, S., Russell, J., Sandu, K., Sidell, D., Smith, R., Soma, M., Spratley, J., Thierry, B., Thompson, D., Trozzi, M., Watters, K., White, D., Wyatt, M., Zalzal, G., Zdanski, C., Zur, L., & Rutter, M. J. (2021). International pediatric otolaryngology group (IPOG) management recommendations: Pediatric tracheostomy decannulation. *International Journal of Pediatric Otorhinolaryngology, 141*, 110565. https://doi.org/10.1016/j.ijporl.2020.110565

Kolb, C. M., Halbert, K., Xaio, W., Strang, A. R., & Briddell, J. W. (2021). Comparing decannulation failures and successes in pediatric tracheostomy: An 18-year experience. *Pediatric Pulmonology, 56,* 2761–2768. https://doi.org/10.1002/ppul.25170

Li, L., Wikner, E., Behzadpour, H., Perez, G., & Mudd, P. (2021). Decrease in respiratory related hospitalizations in tracheostomy-dependent children who tolerate Passy-Muir Valve use. *The Annals of Otology, Rhinology, and Laryngology, 130*(6), 623–628. https://doi.org/10.1177/0003489420966612

Lloyd, A. M., Behzadpour, H. K., Rana, M. S., & Espinel, A. G. (2024). Time considerations and outcomes in pediatric tracheostomy decannulation. *International Journal of Pediatric Otorhinolaryngology, 179.* https://doi.org/10.1016/j.ijporl.2024.111934

Rao, F., Garuti, G., Vitacca, M., Banfi, P., Racca, F., Cutrera, R., Pavone, M., Pedemonte, M., Schisano, M., Pedroni, S., Casiraghi, J., Vianello, A., & Sansone, V. A. (2021). Management of respiratory complications and rehabilitation in individuals with muscular dystrophies: 1st Consensus Conference report from UILDM - Italian Muscular Dystrophy Association (Milan, January 25-16, 2019). *Acta Myologica,* 8–42. https://doi.org/10.36185/2532-1900-045

Raynor, E. M. & Wohl, D. (2024). Tracheostomy-related swallowing issues in children. *Otolaryngologic Clinics of North America.* https://doi.org/10.1016/j.otc.2024.02.017

Sohn, E. Y., Peck, K., Kamerman-Kretzmer, R., Kato, R., Keens, T. G., & Davidson Ward, S. L. (2021). Comparison of SIMV+ PS and AC modes in chronically ventilated children and effects on speech. *Pediatric Pulmonology, 56*(1), 179–186. https://doi.org/10.1002/ppul.25102

St-Laurent, A., Zielinski, D., Qazi, A., AlAwadi, A., Almajed, A., Adamko, D. J., Alabdoulsalam, T., Chiang, J., Derynck, M., Gerdung, C., & Kam, K. (2023). Chronic tracheostomy care of ventilator-dependent and-independent children: clinical practice patterns of pediatric respirologists in a publicly funded (Canadian) healthcare system. *Pediatric Pulmonology, 58*(1), 140-151. https://doi.org/10.1002/ppul.26171

Featured Authors

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JoAnn Beck Cabacungan, MS, CCC-SLP, CBIS

JoAnn Beck Cabacungan received her BS in Human Communication Sciences at Northwestern University and her MS in speech-language pathology at the University of Washington. JoAnn is an experienced medical SLP in acute care, inpatient rehabilitation, skilled nursing facilities (SNF), and home health (HH) settings. She is passionate about patient advocacy, dysphagia, and upper airway disorders. JoAnn has guest lectured at local universities and presented at AMRPA, OSLHA Learning Academy, and the American Speech-Language-Hearing Association (ASHA) convention. She also has been a guest speaker on the Conversations on Aerodigestive Management podcast by Passy-Muir. JoAnn initiated the development and serves as co-chair of the interdisciplinary tracheostomy team at Cleveland Clinic Rehabilitation Hospital, Edwin Shaw.

Laura Brooks, MEd, CCC-SLP, BCS-S

Laura Brooks, MEd, CCC-SLP, BCS-S received her undergraduate degree from the University of Florida and her master's degree from the University of Virginia. She has been a speech-language pathologist since 1999 and has been board-certified in swallowing disorders since 2012. She is a clinical specialist at Children's Healthcare of Atlanta working with pediatric patients in the intensive and acute care units. She specializes in the management of pediatric dysphagia and patients with tracheostomy and ventilator dependence. She has published research, journal articles, case studies, and textbook chapters related to pediatric dysphagia and patients with tracheostomy/ventilator dependence. She serves on the Bioethics Committee, Global Tracheostomy Committee, and ICU Liberation/Early Mobility Committee at Children's Healthcare of Atlanta.

Colby Davis, RRT, MHA

Colby Davis received both a BS in respiratory management and a Master of Health Administration from Independence University. With 17 years of experience as an RRT, he serves as the Senior Respiratory Therapy Manager for Select Medical's Inpatient Rehabilitation Division and was a Market Respiratory Manager for Cleveland Clinic Rehabilitation Hospitals. He has been a champion in collaborative care between respiratory and other therapy departments. Colby has presented at the OSLHA Learning Academy and the American-Speech-Language-Hearing Association convention

Tara Hall, OTR/L

Tara Hall, OTR/L has been an occupational therapist for six years. She earned her undergraduate degree at the University of Georgia and her master's degree in occupational therapy from Augusta University in 2017. She has been working at Children's Healthcare of Atlanta since that time. Tara works in pediatric acute care with a primary focus on treating in the Pediatric Intensive Care Unit (PICU) and serving as the OT representative on the ICU Liberation Team. She is a Certified Brain Injury Specialist and has her Neonatal Touch and Massage Certification.

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Contribute to an Upcoming Issue:

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

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*.

Jessica Rindone, PT/DPT

Jessica Rindone, PT/DPT has been a physical therapist for seven years. She earned her undergraduate degree at the University of Georgia and her Doctor of Physical Therapy degree from Mercer University in 2016 and has been working at Children's Healthcare of Atlanta since that time. She works primarily in the intensive care units and serves as the cardiac physical therapy lead.

Kelsey Titgen, PT/DPT

Kelsey Titgen, PT/DPT received her undergraduate degree from the University of South Carolina and her doctorate from Emory University. She has been a physical therapist at Children's Healthcare of Atlanta since 2018, specializing primarily in the cardiac ICU. She is one of the rehab team leaders that has continued to progress ECMO mobility in both the PICU and CICU.

Stephanie A. Waters, MS, CCC-SLP, CLC, TSSLD

Stephanie A. Waters, MS, CCC-SLP, CLC, graduated from SUNY Geneseo with a BS in Speech and language disabilities and from New York Medical College with an MS in speech-language pathology. She is a Certified Lactation Counselor and works at St. Mary's Hospital for Children specializing in pediatric feeding disorders, airway management, and augmentative and alternative communication. She has written articles to share clinical protocols and considerations for special patient populations and has been a speaker at national conferences. She regularly has been an invited guest lecturer for both graduate and post-graduate courses.

Micheal Heard, RN, FELSO

Micheal Heard, RN, FELSO has been a practicing 'ECMOlogist' for over 30 years, having started the ECMO programs at Miami Children's Hospital and the University of Virginia, and being instrumental in the program growth and development of Children's Healthcare of Atlanta's ECMO Center. She is a charter member of the Extracorporeal Life Support Organization. She has been involved in many research projects including the use of inhaled nitric oxide, tidal flow ECMO, and the use of Venovenous ECMO in pediatric patients. She has presented at multiple conferences on a variety of subjects related to ECMO, as well as presented numerous times regarding ECMO therapies, technology, and education. She has written chapters and co-edited (4th Edition) for the ELSO ECMO Specialist Training Manuals. She has written a chapter on Nursing Care of the Pediatric Patient on ECMO for the 5th Edition of the ELSO Red Book and is a co-author of Management of Children with Respiratory Failure for the 6th Edition of the ELSO Red Book. Finally, Micheal is a co-founder of the Award for Excellence in Life Support Committee and continues to serve as a co-chair.

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