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Welcome to *Aerodigestive Health*: Addressing Use of the Passy Muir® Tracheostomy and Ventilator Swallowing and Speaking Valve with the Pediatric Population

Welcome to *Aerodigestive Health*, formerly known as *Talk Muir*. This publication has been renamed but is continuing the restructuring that occurred with the last issue. The focus of this publication is to provide a clinical research perspective for the safe and effective use of the PassyMuir® Tracheostomy and Ventilator Swallowing and Speaking Valve (PMV®). Each edition of *Aerodigestive Health* will focus on specific topics relating to the care of patients who are tracheostomized or mechanically ventilated. It is the Editor's objective that the publication will provide readers with clinical perspectives and cutting edge research to address specific questions raised by practitioners relating to the use of the PMV.

In this new format, you will find key elements:

- Editor's Commentary – An overview of the newsletter theme topic or question
- Physician's Corner – Editorial from a physician's perspective
- Clinicians' Perspectives – Articles by respiratory therapists and speech-language pathologists on clinical issues
- Peer-Reviewed Published Research Studies – Top studies with summaries of each featured article
- Research Bibliography – A bibliography of the top articles for the issue's theme topic
- Clinical Take-home Boxes – Take-home clinical suggestions/therapy recommendations by respiratory therapists and speech-language pathologists
- Hot Topic Box – Addressing and answering key clinical questions that have been hot topics from our tech calls or clinicians

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For this issue, the selected topic is: *Addressing Use of the Passy Muir Tracheostomy and Ventilator Swallowing and Speaking Valve with the Pediatric Population*. Working within the field of pediatrics, special issues arise when considering the use and assessment of a speaking valve. Because of the anatomical and physiologic changes that are occurring secondary to growth, and the wide developmental considerations that are age related, this population has needs that are not common when working with older children or adults.

A tracheostomy in a developing infant or toddler can impact speech and language development and have an impact on fine and gross motor development. When a tracheostomy is placed, the patient transitions from having a closed respiratory system with end expiratory pressure (pressure remaining in the lungs after expiration) to an open system with a loss of pressures. Our bodies function with a pressurized system that assists with trunk support and postural stability. In infants and toddlers, this is particularly important as the gross motor development of trunk control for sitting, crawling, standing, and walking has a direct correlation with self-feeding and advancement of oral intake. Because of these potentially negative effects on crucial development, it is imperative to provide the pediatric population with a closed system that normalizes the physiologic considerations with their development.

A primary means for closing the system is to use the Passy Muir Tracheostomy and Ventilator Swallowing and Speaking Valve, 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. Using the Valve allows a patient to breathe in through the tracheostomy tube and out through the upper airway (mouth and nose). The Valve works by closing at the end of inspiration, which redirects 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.

However, infants, toddlers, and young children are more difficult to assess than adults because of their limited ability to participate in the evaluation by following commands and volitionally vocalizing. This issue of *Aerodigestive Health* is dedicated to addressing these concerns by providing the perspectives of several professionals and sharing the latest research, which provides additional evidence-based support for use of a one-way speaking valve with the pediatric population.

Justin 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/ventilator, and pre-term birth. Doctor 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.



About the Cover:

This issue's cover is comprised of over 2,100 images of actual pediatric tracheostomy patients and is dedicated to the millions of children who have had their voices restored through the tireless efforts of dedicated clinicians and the use of the Passy Muir® Valve.

Upcoming Issues:

If you have an interest in submitting or writing for one of our upcoming issues, please contact me at aerodigest@passymuir.com. The upcoming topics include: home health care, communication and ethics, dysphagia, and therapeutic interventions (including early intervention and mobilization); however, we are open to accepting articles on other topics related to use of the Valve for patients with tracheostomy and ventilators.



Physician's Corner

Having a Protocol for Clinical and Research Use of the Passy Muir® Speaking Valve

Melodi Pirzada, MD, FCCP
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St. Mary's Healthcare System for Children is an organization that provides intensive rehabilitation, specialized care, post-acute care, and education for children with life-limiting and medically complex conditions. Established more than 140 years ago, St. Mary's Hospital for Children is a 97-bed inpatient facility, located in Queens, New York. With a family-centered approach, this facility provides medical daycare to children and young adults. It also provides early education for medical conditions, a multi-disciplinary feeding disorder program, and a K-12 public school, which provides ongoing education to its long-term inpatients who may be admitted for several months or even years. The feeding program is designed for both inpatient and outpatient cases. Additionally, the hospital's home care program reaches nearly 2,000 medically fragile children each day throughout New York City and Long Island, making St. Mary's Hospital for Children one of the largest providers of long term home healthcare for children in the state of New York.

One specialty group within the hospital that requires a multidisciplinary approach is children who undergo a tracheotomy. More than 50% of the children at St. Mary's Hospital for Children receive a tracheostomy and suffer from chronic respiratory failure. Because of the tracheostomy, these children lose access to their voice as a means for communication. The procedure of a tracheotomy places a tracheostomy tube in the anterior of the neck, providing access for an artificial airway. Because a tracheostomy tube redirects airflow, the child has little to no airflow moving upwards through the vocal cords and out through the mouth and nose. Several disadvantages occur secondary to the tracheostomy. One of the disadvantages is losing the ability to vocalize because of the redirected airflow. Therefore, the Passy Muir® Tracheostomy and Ventilator Swallowing and Speaking Valve (PMV®) is used on all patients at St. Mary's Hospital for Children who meet criteria for wearing it.

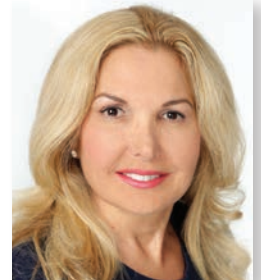
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Placement of the PMV occurs either in-line with ventilators or directly on the hub of the tracheostomy tube for spontaneous breathers. Use of the PMV not only helps with vocalization, but research also has shown that its use improves swallow function, respiratory secretion management, and expedites decannulation, among other benefits. Use of the PMV is initiated in patients where there is an air leak around the tracheostomy tube and relatively intact upper airway anatomy to allow the air to travel through the vocal cords.

Because our hospital staff and multidisciplinary team have seen the benefits of using the Valve with patients who have a tracheostomy, policies and protocols have been put in place to establish best practice for our facility. Hospital protocol requires clearance and physician order by an ENT or a pulmonary specialist, prior to initiation of the PMV assessment. Then, a multidisciplinary team approach, including a respiratory therapist, pulmonary attending, nurse, and a speech pathologist, provides a well-rounded assessment of the patient's abilities and needs.

We continue to see the benefits of using the PMV® with our patients both in practice and in research.

Prior to the initial trial use of the PMV[®], a transtracheal pressure (TTP) measurement is done while the patient is awake. If the measured pressure is less than 10 cmH₂O, then the PMV is placed and the patient's vital signs (i.e. O₂ Sats, HR, and RR) are monitored for five minutes. Once the patient tolerates the Valve for five minutes with TTP below 10 cmH₂O, the pulmonologist clears the patient, and the nurses and speech pathologist follow the protocol for Valve use. After the initial assessment, the goal is to reach PMV use for all waking hours. Use during waking hours provides the patient with more opportunity to access the benefits related to secretion management, upper airway use, sensory stimulation of the upper airway, swallowing, voicing, and more.

At this time, the hospital protocol covers waking hours because the PMV is not recommended or approved for use during sleep. Because of the lack of research related to use of the Valve at night, a team of researchers from St. Mary's Hospital for Children and Winthrop University Hospital began investigating the use of the Valve at night. Researchers established a clinical study that was registered with the FDA. Results of the initial study were published in 2014 and entitled "The safety of tracheostomy speaking valve use during sleep in children: A pilot study" in the *American Journal of Otolaryngology* (Bazarrá, et al., 2014).

At St. Mary's Hospital for Children, we aim to provide state of the art care for our patients. As a physician, I seek to provide evidence based practice, even conducting research to support our ongoing policies and protocols for PMV use. We continue to see the benefits of using the PMV with our patients both in practice and in research. As a physician, it is very gratifying to see my patients able to manage their secretions better. However, most significant in my daily medical practice, is being able to see them with a big smile on their face when they first hear their own voice. That moment is priceless.

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Speaking Valve Use: Troubleshooting Tips

Kristin King, PhD, CCC-SLP
 Gail M. Sudderth, RRT
 Linda Dean, RRT

Problem	Troubleshooting Tips
Honking noise with Valve use:	<ol style="list-style-type: none"> 1. Clean the Valve according to manufacturer's instructions. 2. If no improvement, work with the patient on how they are breathing with the Valve. Work on controlled exhalations, respiratory support for breathing and speech, relaxation techniques, or other methods to assist with normalizing respirations. 3. Intermittent honking may require an ENT evaluation to check for vocal fold dysfunction or other airway anomaly below the vocal folds. 4. Discuss with the team tracheostomy tube size and consider potential need for downsizing. 5. If honking occurs after extended use of the Valve and cleaning does not work, consider replacing the Valve.



PMV[®] 2001 (Purple Color[™])

Assessment Considerations for PMV® Candidacy in the Pediatric Population

Jessica Shaw, MS, CCC-SLP

Premature birth is defined as birth before 37 weeks gestation and is the leading cause of death in babies in the United States. According to the March of Dimes, for the first time in eight years, the preterm birth rate in United States has increased to 9.63% as reported by the National Center for Health Statistics (NCHS) (2016 Premature Birth Report Card, 2016). These premature infants often face health issues such as respiratory complications, jaundice, retinopathy of prematurity, developmental delays, and gastrointestinal complications, among others. The National Academy of Medicine reports that preterm birth costs \$26 billion dollars annually. Due to advances in medical technology and scientific innovation, more micro-preemies, those born at less than 26 weeks gestation or less than 800g, and those with congenital abnormalities are surviving, but not without frequently facing prolonged medical challenges.

Due to the underdevelopment of the respiratory system and risk for development of Bronchopulmonary Dysplasia (BPD), respiratory support via mechanical ventilation is imperative for children who survive early birth. Bronchopulmonary Dysplasia is a form of chronic lung disease that can develop in preterm infants who have been treated with oxygen or positive pressure ventilation. Symptoms of BPD include tachypnea (increased respiratory rate), tachycardia (increased heart rate), frequent desaturations, and increased respiratory effort. Increased respiratory effort may be evidenced by any of the following: retractions, grunting, or nasal flaring. This is despite the introduction of surfactant therapy and increased use of noninvasive positive pressure ventilation (Overman, et al., 2013). Many of these infants will require tracheostomy placement due to the need for prolonged mechanical ventilation or the presence of upper airway abnormalities which prohibit successful extubation. Supportive research has stated that early tracheostomy has reduced the occurrence of associated subglottic and tracheal stenosis for children who have had prolonged intubation (Overman, et al., 2013).

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Impact of a Tracheostomy

Tracheostomy is the outcome of the tracheotomy procedure that creates an artificial airway in the trachea and redirects airflow, bypassing the patient's upper airway. This procedure is performed by a pediatric surgeon or otolaryngologist. One method for this procedure is to have a vertical or horizontal incision made below the level of the vocal folds over the 3rd-4th cartilage ring (Alladi, et al., 2004), creating a stoma wherein a tracheostomy tube is placed to create the artificial airway. Indications for tracheostomy placement include the need for long-term mechanical ventilation, upper airway obstruction, poor pulmonary hygiene, and poor secretion management (Abraham, 2003). When looking at the reasons for tracheostomy in 184 infants, 78.8% of those born at extremely low birth weight had more than one reason for tracheostomy placement, including diagnoses such as bronchopulmonary dysplasia, congenital heart defect, subglottic stenosis, respiratory failure, and laryngeal orotracheomalacia (Overman, et al., 2013). While tracheostomy placement is often lifesaving, the placement of tracheostomy is not without secondary complications.

Documented complications of tracheostomy placement include tracheal infections, accidental decannulation, obstruction, reduced or absent airway protection, reduced secretion management, swallowing deficits, and reduced ability to produce voice (Abraham, 2003). In children who undergo tracheostomy prior to the development of speech during infancy or early childhood, the development of oral communication and verbal interaction with their environment may be

delayed. Use of a Passy Muir® Tracheostomy and Ventilator Speaking and Swallowing Valve (PMV®) can aid in the ability to restore airflow through the upper airway, which would allow a child to produce a cry or voicing and normalize aspects of language development.

Additionally, the use of the PMV has been documented to improve secretion management, aid in weaning of respiratory support, and improve airway protection responses in both adults and children due to the restoration of upper airway sensation (Sutt et al., 2015; Blumenfeld et al., 2011). It has been stated that use of PMV in appropriate candidates less than two years of age has resulted in more normal acquisition of vocal exploration and speech development (Engleman & Turnage-Carrier, 1997; Jiang & Morrison, 2003). Considering the positive outcome with PMV use, clinicians working with the pediatric population with tracheostomies should aim to establish PMV use as soon as medically and clinically appropriate.

Assessment For Passy Muir® Valve Use In Children

Assessment for PMV use in children can create additional challenges for the clinician when compared to evaluation for use in adults. Children, specifically infants and those under the age of two years or those with developmental delays, are not able to voice on command which would typically be a method used with older children or adults during assessment of upper airway patency. When initially assessing with digital occlusion, voicing or attempting to voice is generally used to look for an ability to pass air around the tracheostomy tube and up through the vocal cords. Very young children also cannot articulate feelings of discomfort during PMV trials. Furthermore, in young children who have had a tracheostomy for the majority of their life, they may not be able to complete a more normalized exhalation process and may not be able to coordinate exhalation with phonation. Because volitional voicing may not be possible with infants and young children, other considerations must be used during assessment and treatment. A clinician may have to target this coordination with therapeutic interventions until true voicing can be heard. This is different when compared to an older child or an adult patient with a tracheostomy who has had prior experience of vocalizing and speaking without the presence of the artificial airway.

Clinical assessment considerations

When moving toward assessment of the nonverbal or young child, the first step is to complete a thorough review of their medical history and discuss it with the child's medical team to rule out any contraindications for PMV use. Contraindications for PMV use may include severe subglottic stenosis, severe tracheomalacia, tracheal edema, bilateral vocal fold paralysis in the adducted position, severely reduced lung compliance, or the presence of an inflated cuff or foam-filled cuff tracheostomy tube.

Due to the small size of the pediatric trachea, there is a greater risk of airway obstruction. The airway diameter in infants less than six months of age is approximately 4 mm and grows to 8-11 mm by the time a child is approximately 10 years of age. Considering this small tracheal size, even slight congenital or inflammatory obstruction can lead to increased risk of airway obstruction (Alladi, et al., 2004). Therefore, the proper sizing of the diameter of the tracheostomy tube in relation to the size of the child's airway is crucial to adequate airflow through the upper airway and for successful usage of a PMV.

In the pediatric population, both pediatric and neonatal tracheostomy tubes may be used. The difference between the two is length, with the pediatric tube being longer than the neonatal tube but the inner diameter remaining the same. It is the inner diameter of the tracheostomy tube that is often described when the question is asked, "what size tracheostomy tube do they have?" Throughout the time that a child may remain tracheostomized, the size and length of the tracheostomy tube requires modification to accommodate changes in airway due to growth or respiratory support needs. A pediatric otolaryngologist can assess the airway and tracheostomy by direct laryngoscopy to determine appropriate size and length. Because of these potential changes, the clinician must continually monitor and evaluate the needs of the child.

Another variable to consider that affects the tracheostomy and potential obstruction in a child's trachea is the presence or absence of a cuff. Placement of the PMV requires full deflation of the cuff, yet having the added circumference of the deflated cuff material present can reduce airflow and affect the ability to use the Valve. When working as part of an interdisciplinary team, it is beneficial to attempt to transition a child to a cuffless trach as soon as medically appropriate, to reduce its impact on the child's transition to Valve use.

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Airway Assessment: Digital Occlusion

Successful use of the PMV is directly related to the amount of air that will flow around the tracheostomy tube and up through the larynx, nose, and mouth. Variables affecting this airflow include tracheostomy tube size in relation to patient's tracheal diameter, as well as the presence or absence of any anatomical or structural narrowing (i.e. subglottic stenosis). One way that assessment of airway patency can be completed is via bronchoscopy; however, this is an invasive procedure that is unable to be conducted in a wide variety of environments and involves many disciplines (Utrarachkij, et al., 2005).

Current standard practice for bedside evaluation of PMV candidacy in pediatrics is to assess upper airway patency via digital occlusion of the tracheal hub. The clinician occludes the hub by lightly placing a gloved fingertip over the end of the trach tube hub. After digital occlusion and with close clinical monitoring, the clinician then waits to hear voicing or listens for upper airway breath sound, via stethoscope, or by assessing for airflow out through the nose and mouth (e.g. use of a mirror under the nose to look for fogging). While these assessment measures will demonstrate a clinical measure of airflow, it does not give information to the clinician regarding the amount of exhaled air that is moving up and out through the mouth and nose. Use of spirometry has been documented as an objective measure of upper airway patency; however, the use of spirometry continues to depend on the child's ability to follow commands and coordinate breathing into the spirometer, which can be difficult for some younger or developmentally disabled patients (Utrarachkij, et al., 2005). The added medical complexity and cognitive limitations of this younger population may make identification of successful and unsuccessful PMV trials difficult to distinguish from each other.

Prior to placement of the PMV, the clinician should note the baseline measurements for the infant or child. These would include heart rate, respiratory rate, and oxygen saturations. The clinician also should acquire a good indication of skin color and respiratory pattern through observation. Once baseline measurements are obtained, one indicator of successful PMV use is with observed adequate voicing. With an infant or young child this may include crying, cooing, babbling, or any other vocalizations. Moreover, the child should be comfortable, without changes in respiratory pattern or increased respiratory effort.

Utilization of the PMV is often seen as the first step towards removal of the tracheostomy in a patient who is deemed a candidate for eventual decannulation by their medical team.

During this time, the clinician should not only be monitoring for impact on respiratory function but should be observing the overall state of the child and monitor for changes in physiological or autonomic indicators such as heart rate, oxygen saturation, and respiratory rate. Furthermore, clinical observations should be taken in relation to the child's coloring, looking for signs of perioral cyanosis and other indicators of decompensation (becoming flushed, sweating, etc.).

Utilization of the PMV is often seen as the first step towards removal of the tracheostomy in a patient who is deemed a candidate for eventual decannulation by their medical team. When a patient achieves wearing the PMV for all waking hours and is on a weaning protocol, the next step is capping of the tracheostomy tube. During capping trials, a solid cover is placed on the tracheostomy hub which completely closes off the tracheostomy and normalizes the use of patient's upper airway. As part of the medical team, the clinician will assess tolerance of tracheostomy by capping, utilizing a similar protocol as for the PMV assessment. Once a patient is wearing a cap during all waking hours, the patient may then be referred to their otolaryngologist or pulmonologist for consideration for decannulation. In some facilities, this may involve repeat bronchoscopy or an overnight sleep study to assess respiratory readiness for decannulation.

Airway Assessment: Transtracheal Pressure Measurement

As we move towards more objective and data driven clinical practice, the question is asked: how can we more instrumentally and objectively assess the status of a child's upper airway when they are non-verbal at the time of evaluation? There is documentation in the literature to support the use of end expiratory pressure (EEP) or transtracheal pressure (TTP) during passive exhalation to non-invasively assess upper airway patency as part of the assessment procedures in the pediatric patient for PMV use (Utrarachkij, et al., 2005). This is accomplished using a manometer attached to the PMV via connection tubing and a

Washington Tee adapter, or similar adapter that is then placed onto the tracheal hub. The manometer provides a reading of pressure at the level of the tracheostomy at the end of the exhalation. Research has shown a positive relationship between children who demonstrate a clinical inability to wear the PMV as judged by change in heart rate, oxygen saturation, report of respiratory difficulties (chest tightness or coughing), or abnormal breathing patterns during a five minute PMV trial and higher TTP measurements of greater than 10 cmH₂O (Utrarachkij, et al., 2005). Furthermore, TTP of < 6 cmH₂O was associated with observed clinical tolerance and easier transition of children to PMV wearing schedules (Buckland, et al. 2012; Abraham, 1997, 1995). Research has shown that TTP up to 10 cmH₂O is consistent with successful PMV wearing (Buckland, et al., 2012). It is important to note that these TTP measures are to be completed during passive exhalation, such as resting breaths; coughing and other more forceful exhalations will result in increased numbers in TTP and will skew the readings. These measurements also must be taken when a child is calm and quiet, as play and other activities may increase the numbers. Therefore, when air is purposefully expelled with increased force in order to produce voice, in an attempt to clear the airway, or increased due to play or other activities, the manometer pressure reading is not accurate.

Behavioral Factors

An additional factor in PMV usage in children is a behavioral response to the placement of the PMV during assessment and ongoing trials. Children who have undergone tracheotomy at a very early age are often hypersensitive to the feeling of upper airflow through their nose and mouth. For infants and many young children, this may be something that they have not experienced in their lifetime. Due to this lack of experience, children may demonstrate various clinical presentations that appear as respiratory difficulties but require behavioral adjustments. A child may exhibit blowing off the PMV or breath holding, which otherwise may be interpreted as clinical intolerance. The difficulty a clinician faces is determining if these observed symptoms are behavioral or due to reduced upper airway patency or airflow. The presentation of the two may look very similar to the naked eye of the clinician. Monitoring TTP can help determine the etiology of the observed behaviors; whereas, if the TTP is < 6 cmH₂O then research has shown it is less likely that the clinical presentation is due to a structural or anatomical issue.

If it is determined to be behavioral in nature, clinicians working with a pediatric population should engage the child in some desensitization and use distraction or play therapy during PMV trials. Often with young children, the clinician will institute these techniques prior to the initial assessment in order to set the child up for success. By doing so, the clinician may elicit a period of time that a child can demonstrate passive exhalations while wearing the PMV by helping the child become more comfortable and relaxed during the assessment. As previously discussed, transtracheal pressures are most accurately and reliably measured during passive exhalation. By achieving adequate and accurate TTP measurements, the clinician will have a better clinical assessment for use of the PMV.

Troubleshooting

If a child demonstrates elevated TTP, further assessment completed by a physician and the clinical team to evaluate airway management may assist with improving upper airway patency and use of the PMV. Elevated TTP, in conjunction with laryngoscopy demonstrating poor tracheal lumen fit (tracheostomy tube size within the diameter of the trachea), provides sufficient clinical information to support the need for a change in tracheostomy tube size. Changing the tracheostomy tube size may allow for improved upper airflow in those children without identified structural or anatomical etiology. Reducing the outer diameter of the tracheostomy tube and increasing the space in the tracheal lumen can improve airflow through the upper airway. This, in turn, can improve use of the PMV and improve clinical tolerance for wearing the Valve secondary to the increased room surrounding the cannula for airflow to move around the tracheostomy tube and into the upper airway.

Post-Assessment

After assessment of the pediatric patient is completed, if a child demonstrates clinical tolerance of the Valve as evidenced by all physiologic parameters remaining stable and TTP pressure of no greater than 10 cm H₂O during passive exhalations, the patient should be started on a wearing schedule based on their behavioral tolerance. This wearing schedule should be advanced until the child reaches the goal of wearing their PMV during all waking hours. During the advancement of the PMV schedule, these children are participating in speech and language therapy with the clinician. Goals of therapy are often focused

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on advancing language skills, improving functional vocalizations, or cognitive therapy, based on the child's current and premorbid functioning. Additionally, while research has mixed data on the effects of reducing laryngeal penetration or aspiration in children with tracheostomies (Ongkasuwan, et al., 2014), due to the restoration of upper airflow and improved airway protection via improved cough that is linked to PMV placement (Suiter, et al., 2003), clinicians may consider addressing PMV placement prior to initiating therapeutic feeding goals.

If initial assessment does not indicate that a child is a candidate for Valve use at the time of evaluation, the reason for the difficulty should be considered. If it is due to change in any physiologic parameters previously mentioned or the TTP is consistently above 10 cmH₂O, then the medical team must further assess the options. Another consideration is to monitor for increasing TTP with each exhalation. Changes in physiologic parameters or TTP being high may involve a referral to a pediatric otolaryngologist to assess the airway for any signs of stenosis or narrowing and for consideration for reduction in the size of the tracheostomy tube.

Summary

Pediatric tracheostomy placement is occurring with greater incidence due to the advancements in medical interventions and the increased survival rate of infants who are premature and those with congenital abnormalities. Long term tracheostomy placement has been associated with delayed acquisition of language and social development (Cowell, et al., 2013). Additionally, long term tracheostomy can impact parent-child bonding and the ability of the child's family to know their wants and needs due to the communication impairment (Lieu, et al., 1999). Assessment and usage of PMV is important for the normalization and development of the social and language development of these children and can be seen as a first step towards decannulation. Due to the limited volitional participation of infants and young children, the clinical assessment of pediatric use of the PMV presents with specific challenges that are unlike those observed in the adult population. Airway patency is directly related to the successful wearing of a PMV but is difficult to assess objectively through clinical judgement alone. The use of transtracheal pressure monitoring through manometry is a great asset to the evaluation for PMV use in the pediatric population.

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Speaking Valve Use: Troubleshooting Tips

Kristin King, PhD, CCC-SLP | Gail M. Sudderth, RRT | Linda Dean, RRT

Problem	Troubleshooting Tips
Excessive coughing:	<ol style="list-style-type: none">1. Use slow cuff deflation.2. Cue patient to clear secretions orally or suction again.3. Remove Valve and check for complete cuff deflation when working with cuffed tubes.4. Check tracheostomy tube alignment and body positioning to enhance breath support.5. Consider tracheostomy downsize or different tracheostomy tube type.6. Introduce Valve slowly – seconds of wear at a time.7. If coughing persists, consider ENT evaluation.
Limited or strained voicing, with decreased airflow through upper airway:	<ol style="list-style-type: none">1. Remove the Valve and assess factors affecting airway patency.2. If the tracheostomy tube is cuffed, ensure cuff is completely deflated.3. Check tracheostomy tube alignment and body positioning to enhance breath support.4. Suction again, if needed.5. Discuss with the team consideration for tracheostomy tube downsize or different tracheostomy tube type.6. Consider ENT consult.
Air leak around stoma during valve use:	<ol style="list-style-type: none">1. Consider silicone stoma pad.2. Consider a hydrophilic dressing.
Good airway patency but difficulty saturating:	<ol style="list-style-type: none">1. Consult your respiratory care practitioner.2. Discuss with team consideration for adding low flow supplemental oxygen via humidified nasal cannula.
Patient with mechanical ventilation who still needs a cuffed tube:	Consider a TTS (tight to shaft cuff) tracheostomy tube.

Candidacy for Passy Muir® Valve Placement in Infants and Young Children: The Airway Assessment

Suzanne Abraham, PhD, CCC-SLP



Assessment of the upper airway is a critical component for a comprehensive evaluation of any infant or very young child who has a tracheostomy. It is the analysis and interpretation of the data collected during the airway assessment that guides the decision-making regarding two critical quality of life issues for very young patients with tracheostomies and their families: (1) the route for nutritional intake and (2) candidacy for Passy Muir® Valve placement and wear time. Use of the Passy Muir Valve not only addresses neurodevelopment but also health-related quality of life.

When we examine the airway of a baby with a tracheostomy, the primary goals are to determine the baby's *baseline respiratory status and upper airway patency*. To meet the goals, these two variables must be examined under two different clinical conditions: (1) the tracheostomy tube in the *open mode* and (2) the tracheostomy tube in the closed mode. The data collected under condition 1 and condition 2 are subsequently subjected to comparative analysis in the decision-making process of candidacy for Passy Muir Valve placement.

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Airway Assessment

I. Clinical Condition 1: Tracheostomy Tube in the *Open Mode*

I. a. *Respiratory Criterion in the Open Mode*

- No evidence of respiratory distress (RD) in the open mode
- No evidence of increased work of breathing (WOB) in the open mode
 - No retractions in the region of the chest wall or chest cavity: suprasternal, substernal, intercostal, subcostal, or clavicular
 - No nasal flaring
 - No head bobbing
 - No aberrant respiratory cycling

I. b. *Airway Patency Criterion in the Open Mode*

- No evidence of airway obstruction in the open mode
 - No noisy breathing
 - No obstructive sounds associated with inspiration or expiration through the open tube
 - **Precaution:** baseline breathing that produces an audible, dry sound can be a red flag

I. c. *Secretion Criterion in the Open Mode*

- No evidence of copious secretions in the open mode
 - Check at the level of the oral cavity, larynx, or trachea



If the baby with a tracheostomy does not meet the above criteria for tracheostomy tube in the *open mode*, then do NOT continue on to Clinical Condition 2.

If the baby with a tracheostomy meets criteria for the trach tube in the *open mode*, then continue on to Clinical Condition 2: the "Tracheostomy Tube in the *Closed Mode*".



II. Clinical Condition 2: Tracheostomy Tube in the Closed Mode

II. a. Transtracheal Pressures (TTP)

- **Used to Measure**
 - End expiratory pressures (in centimeters of water pressure) during quiet breathing
 - An indicator of airway patency at the level of the cannula
- **Equipment**
 - Closed system, coupling the Passy Muir® Valve to a manometer



Example using a portable manometer

- **Patient Requirements for TTP Procedure**
 - Quiet breathing only
 - No audible tracheal secretions
 - No crying
 - No vocal behaviors
 - No forced expiratory airflow, e.g., a reflexive or volitional cough
- **What to Monitor During TTP: Data & Analysis**
 - Complete 3 to 4 trials while maintaining quiet breathing
 - With TTP in place, monitor the pressure that is registering on the manometer
 - Each trial = 2 to 3 respiratory cycles as tolerated
 - Calculate the average & range of TTPs across trials
- **TTP Criterion in the Closed Mode**
 - Average TTP in quiet breathing should be 6 cmH₂O or less

II. b. Tracheostomy Occlusion Trials

- **What It Measures**
 - An indicator of airway patency above the cannula
- **Equipment**
 - Gloved index finger
- **How to Measure**
 - Finger occlude the hub of the tracheostomy tube completely and consistently by a gloved finger for the inspiratory and the expiratory phases throughout consecutive respiratory cycles



- **Patient Requirements for Tracheostomy Occlusion Procedure**
 - Compliant for complete occlusion of the hub of the tracheostomy tube
- **What to Monitor During Tracheostomy Occlusion Trials: Data & Analysis**
 - Tolerance for the number of respiratory cycles of consistent and complete occlusions of the tracheostomy tube
 - Observe for respiratory distress signs and increased WOB across respiratory cycles in closed mode
 - Listen for any obstructive sounds, which can be wet or dry
 - Determine the presence or absence of airflow from mouth and nose in the closed mode
- **Trach Occlusion Criteria in the Closed Mode**
 - Tolerance for a minimum of 10 consecutive respiratory cycles in the closed mode
 - During consistent, complete occlusion of the tube:
 - Confirm inspired & expired airflow from the mouth or nasal passage(s)
 - Observe no evidence of respiratory distress or WOB
 - Hear no audible obstructive sounds
 - Observe no build-up of secretions at the oral, nasal, or laryngotracheal level

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The data collected under condition 1 and condition 2 are subsequently subjected to comparative analysis in the decision-making process of candidacy for Passy Muir® Valve placement. If the infant or very young child with a tracheostomy meets respiratory, airway patency, and secretion criteria in the open mode (condition 1) and meets criteria for TTPs, trach occlusion trials, and associated respiratory, airway patency, and secretion criteria in the closed mode (condition 2), then advancing the tracheostomized baby to initial wear time trial of Passy Muir Valve placement is indicated. If the baby does not meet criteria for condition 1 or 2, then candidacy for PMV placement should continue, albeit with the addition of appropriate medical and clinical collaborative problem-solving.

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Speaking Valve Use: Troubleshooting Tips

Kristin King, PhD, CCC-SLP
Gail M. Sudderth, RRT
Linda Dean, RRT

Problem	Troubleshooting Tips
Back pressure noted with Valve removal:	<ol style="list-style-type: none">1. Stop Valve use and reassess airway patency.2. Consider measuring tracheal pressure with manometry to evaluate airway patency.3. Assess patient for anxiety, stress, and tension as potential causes.4. Discuss with team consideration for tracheostomy downsize or different tracheostomy tube type.5. If no improvement - consult ENT to evaluate for upper airway obstruction.

Keys to Success: A Pediatric Respiratory Therapy Case Study

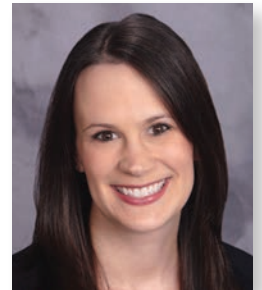
Lyndsi Yarkosky, RRT

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Throughout infancy and childhood, gross and fine motor development progresses in a typical pattern and timeline which impacts many aspects of a child's life. However, when infants and children are tracheostomized at a young age, this developmental process is negatively impacted. Placement of a tracheostomy tube in the child's airway opens a previously closed system. While the tracheostomy is necessary to improve the respiratory status of the child, having a tracheostomy tube in place changes the dynamics of the aerodigestive system. The child now breathes through the tracheostomy tube and cannot use the upper airway effectively, especially if the tracheostomy tube cuff is inflated. This loss of airflow through the upper airway diminishes stimulation of the upper airway, causing changes in sensation, loss of subglottic pressure, negative impact on secretions and secretion management, changes in swallow function, loss of voicing, and other negative changes to functions. In addition, having an open system has been shown to have a negative effect on trunk support and core stability for mobility (Massery, 2014, 2006; Massery, Hagins, Stafford, Moerchen, & Hodges, 2013). It also reduces their ability to communicate and eat safely. Early intervention is imperative, as a disruption during this critical period may have significant impact on patients' development, in particular to language and speech (Stevens, Finch, Justice, & Geiger, 2011). The sooner the clinical team is able to intervene, the risk for long term delays is decreased (Hofmann, Bolton, & Ferry, 2008).

Application of the Passy Muir® Tracheostomy and Ventilator Swallowing and Speaking Valve provides opportunities to close the system and restore airflow to the upper airway. The Passy Muir® Valve is a bias-closed position no-leak speaking valve that closes at the end of inspiration and remains closed throughout the expiratory cycle. By doing so, it allows a patient to breathe out through the mouth and nose, returning airflow to the upper airway. This assists in returning functions that were compromised when a tracheostomy tube is placed. Two of those functions critical to development for a young child are vocalizing and a typical swallowing pattern.

As a respiratory therapist (RT), it is wonderful to work with these children to enable them to eat and communicate again, but the primary focus of the RT is: (1) how can we wean this patient; and (2) where do we begin? At our pediatric rehabilitation hospital, we have had much success using the Passy Muir Valve as a weaning tool and resource for patients with a tracheostomy and on ventilators. Within The Children's Institute of Pittsburgh, the respiratory therapists have seen use of the Passy Muir Valve assist with decreasing ventilator settings, decreasing or eliminating oxygen use, increasing trials off the ventilator, and as a stepping stone towards the discontinuation of mechanical ventilation in the decannulation process. Use of the Passy Muir Valve involves written policies, procedures, and guidelines. In addition, the clinical approach and techniques used by the multidisciplinary team are key contributions to successful weaning.

We have had much success using the Passy Muir® Valve as a weaning tool and resource for patients with a tracheostomy and on ventilators.

The respiratory system of the human body is intended to be a closed system that works on a pressure gradient. Many functions within the human body occur because of how these pressure gradients change. However, when a tracheostomy is placed, the system becomes open and pressure is lost. Typically, exhalation occurs against resistance through the upper airway and glottis, which provides for physiologic Positive End Expiratory Pressure (PEEP). PEEP is the amount of pressure that remains in the lungs at the end of exhalation and provides ventilation to the alveoli to assist with proper gas exchange. A tracheostomy tube places an opening within the airway which punctures the naturally closed and pressurized system. With an open system, the body cannot maintain a strong, natural PEEP. This pressure is important to sustain as it improves oxygen saturation levels, improves gas exchange, and restores Functional Residual Capacity (FRC – the normal volume of gas left in the lungs after exhalation) (Vanderford, 2002).

When a patient is on a ventilator, the ventilator may be used to supplement physiologic pressures by setting a PEEP on the ventilator (normal PEEP is 3-5 cmH₂O) (Deakins & Myers, 2007). If a patient has a tracheostomy tube and is off the ventilator, then the ability to sustain sufficient PEEP is compromised and may impact oxygenation. In addition to changes in PEEP, an open system impacts the ability to have an effective cough. A more effective cough is produced with a closed system, which also facilitates secretion management.

Applying the bias-closed position, no-leak, one-way Passy Muir Valve to a tracheostomy tube closes the system, which returns the lungs to a more normal physiologic process (Sutt, Caruana, Dunster, Cornwell, Anstey, & Fraser, 2016). Using the Valve enables the patient to breathe through the upper airway during exhalation, which returns the respiratory system to a more normalized physiologic process and allows the patient to have restored physiologic PEEP by using the normal resistance of the vocal cords and upper airway. In order to restore this more naturalized system, patients with tracheostomies must first be evaluated for Passy Muir Valve candidacy.

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Closing The System: Evaluation

Every tracheostomy patient who is admitted into our facility is evaluated immediately by the speech-language pathologist (SLP) and RT for Valve use. If the patient is on a ventilator, the RT evaluates for stable ventilator settings, such as $\text{FiO}_2 < 60\%$, $\text{PEEP} < 10 \text{ cmH}_2\text{O}$, and Peak Inspiratory Pressure (PIP) $< 40 \text{ cmH}_2\text{O}$. The first parameter assessed is the medical stability of the patient, with the team considering if the patient is stable and appropriate to consider cuff deflation and potential Valve use. The patient also should be awake, alert, and attempting to communicate. Next, if the patient has a cuffed tracheostomy tube, tolerance of cuff deflation is assessed. After oral and tracheal suctioning, the RT uses slow cuff deflation, allowing the upper airway to become acclimated to the different sensations as airflow is returned to the upper airway (Hess & Altobelli, 2014). The next critical step is ascertaining that the upper airway is patent. Airway patency may be evaluated in one of two ways if the patient is on the ventilator: (1) by checking that airflow is going around the tracheostomy tube, up through the vocal folds, and out the nose and mouth by feeling for airflow or hearing a cough, throat clear, or vocal sound; and (2) checking for a change in the PIP. If PIP decreases, this decrease indicates a leak through the upper airway. Once a Valve is placed in-line, tidal volume (V_T) can be used to slowly return the patient to their pre-cuff deflation PIP by increasing V_T in small increments until at pre-cuff deflation PIP. If all of these factors are positive, then the team begins looking at the application process.

Keys to Successful Application

Step One: Building Trust

A key first step in the approach to placing a Passy Muir Valve, whether the patient is on or off the ventilator, is building trust. Throughout the course of a typical hospital stay, a child interacts with many team members coming in and out of the room, performing different procedures or introducing new treatments. It can be overwhelming for the parents or caregivers and intimidating to the children. Bonding and building a relationship with the family sets everyone up for success. When the child sees that their parent or caregiver is comfortable and trusting of a new face, the child is less likely to be anxious or fearful.

Building trust may take time and should be approached with both the child and the parent or caregiver. Depending on the age of the child, this may require a play-based approach, education at an age-appropriate level, and a slow approach to change. The parent or caregiver will need education and quality information to help them understand what is happening with their child. They also will need to understand the role of the team members. Establishing rapport and a level of trust among all of the participants is critical to a successful approach.

Step Two: Providing Education

Another crucial step in the key to success is education; making sure the parent or caregiver is on board and understands the benefits of the Passy Muir Valve. In addition to speech and swallowing, education about the additional benefits, such as secretion management and restoring physiologic pressure should be provided. Everyone should have a good understanding of what steps will be taken during the assessment. If the child is too young to understand what will be occurring, establishing rapport and comfort will assist with making the evaluation process more of a success.

Various techniques for providing education may be used. Education should occur with both the child and the parent or caregiver and may be provided by various clinical team members. Specialized pediatric clinical practitioners may be involved in providing education because those working in pediatrics will have specialized experience and training in child development and are familiar with techniques specific to emotional support and coping strategies. Any member of the team, from the SLP to the RT, will be involved in education. Resources specific to pediatrics and the Passy Muir Valves are available through the Toby Tracheosaurus™ Program from Passy-Muir, Inc. and the TRACHTOOLS™ App. These provide different methods to approach education, from using a stuffed animal with a tracheostomy to patient videos.

Step Three: Use of Distraction

The final key to success used with the pediatric population when placing a Passy Muir Valve is distraction. At times, when a child is stressed or anxious, being able to provide a distraction from the intended plan may assist with improving participation and increase success rate. The use of distraction often requires the team to get creative with children and find age-appropriate activities or ideas that interest them.

Any member of the team, from the SLP to the RT, will be involved in education.

The distraction helps to take their mind off the “new procedure,” decreasing fear and anxiety. Another option for distraction is to take the child out of the current setting. If a hospital patient room has been the only environment, the child may benefit from going to the gym or to an outside area to experience new scenery. Another aspect related to distractions is to limit extraneous stimuli, such as noises, lights and interruptions, which also may help to improve the child’s ability to participate.

One Child’s Story

Our multidisciplinary team consists of respiratory therapists, speech-language pathologists, recreational therapists, nurses, and physicians. We also consider the patient, family, and parent or caregiver an integral part of the team. In addition to the combined clinical skills of the multidisciplinary team, we focus on using the three keys to success: trust, education, and distraction. Usage of these techniques played a significant role in treating and weaning one of our recent challenging patients who was dependent on a tracheostomy and ventilator.

Noah is a 12 year old male who presented to the emergency department on May 31, 2016 with weakness. He suffered a spinal cord stroke, with fluid pinching his spinal cord, preventing blood flow to his brain. The fluid accumulation stemmed from his underlying birth diagnosis of Chiari Malformation, a structural defect in the cerebellum at the level of the foramen magnum. Noah also had a history of migraines, asthma, and anxiety. He was admitted to the hospital, and surgery was performed to remove the fluid and decompress the spinal cord, but he remained paralyzed from the neck down as a result of the stroke.

During his hospital stay, Noah was tracheostomized on June 6, 2016 with a #4 Shiley Disposable Cuffed Tracheostomy Tube. In need of intense rehabilitation, Noah was referred to The Children’s Institute of Pittsburgh and transferred to the pediatric rehabilitation hospital on June 29, 2016. The team at The Children’s Institute established several primary goals: (1) to wean him from his ventilator; (2) to provide education; (3) to train the patient and his mother; and (4) to initiate extensive therapies in the disciplines of physical therapy, occupational therapy, speech-language pathology, and respiratory therapy.

At the time when the RT and SLP began working with Noah, he was on the Trilogy Ventilator with settings of: SIMV/PC, PC 22 cmH₂O (centimeters of water pressure), RR 16 bpm (breaths per minute), PEEP 8 cmH₂O, PS 8 cmH₂O and 2l pmO₂. SIMV (Synchronized Intermittent Mandatory Ventilation) is a common mode of ventilation that ensures the patient is getting the minimum set ventilation but also allows the patient to take spontaneous breaths. This mode is a moderate support mode and is typically comfortable for the patient. Pediatric patients are normally ventilated with set pressures to achieve desired volumes, instead of set volumes, in order to help prevent barotrauma to the lungs (Dahlem & Randolph, 2015). At the time of admission to our facility, Noah was on a Pressure Control (PC) of 22 cmH₂O, which is a normal inspiratory pressure for the lungs and his Respiratory Rate (RR) was set at 16 bpm. If he took additional breaths on his own above what the ventilator was supplying, we had a Pressure Support (PS) of 8 cmH₂O set to help give his spontaneous breaths a boost. So, if Noah was breathing 20 bpm, 16 of those breaths were at the PC 22 cmH₂O and the other 4 were at a PS of 8 cmH₂O. His PEEP was set at 8 cmH₂O and he was receiving 2 liters of oxygen via the ventilator. The initial goal of therapy was to deflate the tracheostomy cuff and wean the ventilator settings with consideration for Passy Muir Valve use.

Due to the patient’s underlying issues with anxiety, the initial stages of cuff deflation and vent weaning presented a huge challenge. With the cuff still inflated, Noah was unable to vocalize and did not have an easy method to communicate with staff or family, which added to his frustration. Whenever a member of the team would try to work with him, his respiratory rate and heart rate would increase as he would become tearful and anxious with possible change.

Our unspoken motto in the facility is “slow and steady wins the race.” We needed to set Noah up for success. It was very clear from the beginning of working with Noah that we needed to approach his care with a variety of methods and instituting our keys to success. To increase our chances of success, we began by building trust, explaining the plan, and letting him begin to know the team members. Another consideration was to have his mother become involved with the therapies to help with his anxiety. Having his mother educated on the plan and providing support was a key element to success.

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During this step, it was essential to maintain a consistent team, which would assist with building trust. We integrated his speech, respiratory, and recreational therapy into interdisciplinary sessions, while pursuing cuff deflation and ventilator weaning. The team spent time taking Noah outside, and therapy began with sitting and talking about cars and some of his other interests. Once he became comfortable sitting outside, we would SLOWLY deflate his cuff and let him acclimate to the sensation of air moving through his nose and mouth – something he had not felt in a while. Typically, with patients, cuff deflation would occur over a minute or two to avoid a huge rush of air to a sensitive area. However, with Noah, it took approximately 10 minutes to get the cuff fully deflated. We did this twice a day for three days, until he was comfortable with the change in the feeling and with the team members working with him.

After we had successful tracheostomy cuff deflation, it was time to introduce the bias-closed position no-leak Passy Muir Tracheostomy & Ventilator Swallowing and Speaking Valve (PMV). Noah's ventilator settings were stable, he wanted to eat and speak again, and we had confirmed his upper airway was patent by hearing whispers of speech after his cuff deflation. However, the team met with similar obstacles when using the PMV as they had with cuff deflation. Noah was hesitant and anxious about something new, which would cause a change in his breathing.

The first time we placed the PMV in-line with the ventilator, Noah agreed to use it for 10 minutes. Another consideration for success with children is to have them invested in the therapy; have them agree and assist with planning the goals. While there was much hesitation from Noah, having him assist with the plan, understand it, and using distraction while providing encouragement helped to motivate his use for 10 minutes. While it was not the easiest 10 minutes, Noah enjoyed having his voice back and being able to try tastes of Nutella. The ventilator settings for the initial Valve use were: SIMV/PC, PC 22 cmH₂O, PEEP 8 cmH₂O, PS 8 cmH₂O, RR 8 bpm. Alarms were set at low minute ventilation 0.5 l/min and circuit disconnect 5 seconds (high and low pressures are automatically set at 5 above and below in SIMV/PC mode). Due to the Trilogy Ventilator leak compensating in pressure modes, no changes were made to the settings or alarms.

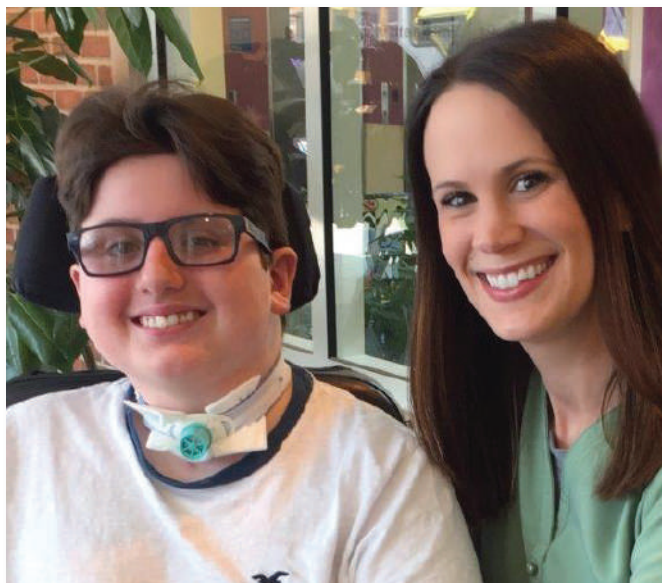
Over the next week, Noah's use of the Valve steadily increased until he was using it all day. By this point, Noah also tolerated his tracheostomy cuff being deflated around the clock, 24 hours a day. He was medically stable and appropriately ventilated with the tracheostomy cuff deflated because of the leak compensation with the Trilogy ventilator. To increase the space around his tracheostomy tube within the diameter of the trachea and avoid unnecessary complications of the tracheostomy cuff, he was transitioned to a cuffless tracheostomy tube as soon as possible. The change introduced a Shiley cuffless tracheostomy tube (4 DCFS). Again, the Trilogy ventilator leak compensates when in pressure modes, so when the cuff is deflated or a valve is placed in-line, the Trilogy ventilator automatically adjusts to continue to deliver the set pressure. If the patient uses a different mode or a different ventilator, adjusting the pressure or volumes to pre-cuff deflation values will assist in compensating for the air leak. While this may be especially advantageous with pediatric patients, when working with older or anatomically larger patients, the ventilator may require a switch in mode and settings to provide compensation for the leak.

As Noah wore the PMV, his ventilator settings were reduced over the next two weeks to BiPAP settings (a spontaneous, weaning mode). Once Noah had been comfortable on the BiPAP settings, it was decided to trial the tracheostomy mask. The RT removed him from the vent and placed him on a room air tracheostomy mask with humidification. Within one minute, Noah's SpO₂ dropped from 98 to 87% and he struggled to breathe. After the RT bagged him and returned his SpO₂ to baseline, he was placed back on the ventilator. After several minutes on the ventilator, Noah calmed down and was able to catch his breath. He stated that the feeling was so different off the ventilator, and he was scared because he could not talk.

We explained that we took him from a closed system (because he had the PMV in-line with the ventilator) to an open system, and his lungs lost a lot of pressure that the ventilator was previously providing him. As a result of Noah being scared during his first trial off the ventilator, it was a few weeks before he agreed to try again. The initial unsuccessful trial caused a setback for his weaning process.

When he finally became comfortable with the idea being off the ventilator again (still on BiPAP settings), we presented him with a new plan. We would remove him from the ventilator and place him on his PMV immediately, skipping the tracheostomy mask. We explained the reasons to him. First, being the most important to him was that he would be able to talk, which would assist with being less anxious. The second main reason to place the PMV immediately was so that his lungs did not lose pressure. As previously discussed, the lungs operate with PEEP under a closed system. When Noah was trialed with a tracheostomy mask and no PMV, he had an open system and could not sustain his own natural physiologic pressures. His oxygenation dropped, and he felt his breathing was compromised. The plan this time was to use the Passy Muir Valve immediately with removal of ventilation, so that a closed system would be maintained. Noah was in agreement to let us remove him from the ventilator and to place the PMV.

Upon doing this, the team anticipated his typical anxious reaction; however, his response was surprising and instead he voiced, "I feel fine." The team was so excited – this was a successful trial! He was able to be off the ventilator and use the PMV for 15 minutes during his first trial. Over the next month, we were able slowly to build his strength and endurance, and Noah was off the ventilator for 2.5 hours, twice a day, at the time of discharge home. He was happy that he did not have to use his ventilator while at school.



Noah with Lyndsi Yarkosky, RRT

Achieving Success

Success with this patient did not come easily or quickly, but by implementing our techniques of building trust, providing education, and using distraction techniques, our efforts with Noah were successful. It took extra patience and creativity on our end (which is typical when working in pediatrics) and a lot of trust and patience on Noah's end. Understanding from the beginning that we needed to be aware of our approach and take our time, helped us all in the long run. We also will now consider our best practice of "tracheostomy mask trials." Working with Noah demonstrated to the team the need to have a closed system to establish use of a more natural physiologic PEEP, and return a patient's ability to use their upper airway and sustain their oxygenation when transitioning off the ventilator. Transitioning from ventilator to tracheostomy mask has its own complications to consider and implementation of the PMV to maintain a closed system appears to assist with both patient comfort and improved respiratory support. It not only made a difference in how the patient felt, but it improved how his lungs responded to the change and weaning process.

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Mobility and Postural Stability

Critical development of anatomy, physiology, swallowing, mobility, and other skills begin in utero and continue from birth through childhood. Immediately after birth, speech, language, and cognition are added to the many areas of development that a child is undergoing. It is well documented that primary speech and language development occurs from birth to age three and during this same timeframe, infants and toddlers are making vast changes in gross and fine motor development. These skills continue to develop throughout childhood but at a slower pace than initially seen in infancy and early childhood. When this process is complicated by medical conditions requiring a tracheostomy, the manner in which the systems interact for development are compromised even further.

When a tracheostomy tube is placed in the trachea, the respiratory system and intrathoracic and intra-abdominal pressures are diminished by having an open system (Massery, 2014). 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 glottis (vocal cords). Use of the upper airway and glottis typically provides restrictions that allow for control of exhalation and assists with controlling expiratory lung volumes (Massery, 2014). This loss of pressure may impact gross motor function for mobility and postural stability.

Use of the Passy Muir® Valve during physical therapy helps restore the pressure support in the trunk, allowing for natural increases in intrathoracic pressure (ITP) and intra-abdominal pressures (IAP) in response to increased postural demands. With an open tracheostomy tube and therefore, an open system, thoracic pressures cannot be increased or sustained as airflow passes through the tracheostomy tube and bypasses the upper airway. This difficulty would be observed when a patient needs to crawl, sit, push, or stand up. The typical means of gross motor movement for mobility is to engage the glottis (vocal cords) to restrict the expiratory lung volume in order to stabilize the chest and upper body (Massery, 2013). Placing a Passy Muir Valve on the tracheostomy tube closes the system and restores a patient's ability to use the upper airway to control expiratory flow and improve ITP and IAP.


Consider that with infants and young children, a tracheostomy could limit or diminish gross motor development. During infancy and early development, children are progressing through the stages of head control, trunk control, sitting, reaching, standing, and walking. Without good ITP and ITA, these functions could be significantly impacted and even delayed. A vicious cycle may begin as fine motor skills related to feeding, self-feeding and other levels of function are directly linked to gross motor development. These delays and limitations can be mitigated by using a bias-closed position no-leak speaking valve to return the young child to a more normalized use of the upper airway with control of expiratory lung volumes and improved trunk control and postural stability.

Massery, M. (2014). Expert interview: The role of the Passy-Muir valve in physical therapy. *Talk Muir* (3 Feb. 2014): 2-4.

Massery, M., Hagins, M., Stafford, R., Moerchen, V., and Hodges, P.W. (2013). Effect of airway control by glottal structures on postural stability. *Journal of Applied Physiology*, 115(4), 483-490.

Current Research Related to Speaking Valve Use with the Pediatric Population

Jessica Nourse, SLP.D, CCC-SLP

 Ongkasuwan, J., Turk, C.L., Rappazzo, C.A., Lavergne, K.A., Smith, E.O., and Friedman, E.M. (2014). The effect of a speaking valve on laryngeal aspiration and penetration in children with tracheostomies. *Laryngoscope*, 124, 1469-1474.

Current research documents that use of a Passy Muir® Valve during eating and drinking decreases laryngeal penetration and aspiration in adults (Muz et al., 1989; Stachler et al., 1996; Dettelback et al., 1995; Suiter, McCullough, & Powell, 2003; Elpern et al., 2000). Improvements in oropharyngeal functioning for patients with tracheostomies can result in improved outcomes related to morbidity and accrued healthcare related expenses.

The investigators of this study conducted research on the effect of the Passy Muir Valve on swallowing in pediatric patients with tracheostomies. Twelve patients were identified for inclusion in the study, all of whom could tolerate a speaking valve for the purpose of phonation and for whom modified barium swallow studies were indicated. Each participant wore two valves during the study, a Passy Muir Valve and a sham valve, and was trialed with two consistencies of liquids and solids. Two speech-language pathologists, who were unaware of the valve status, rated the modified barium swallow study results with the Rosenbeck 8 Point Penetration and Aspiration Scale (PAS).

Findings of the study were inconclusive regarding the effect of the Passy Muir Valve on penetration and aspiration, however, five patients out of the 12 participants demonstrated improvements in PAS with the Passy Muir Valve in place. A significant difference was noted with the presence of the Passy Muir Valve in the decrease of pyriform sinus residue across all patients. Overall, patients who underwent tracheotomy due to respiratory failure or prematurity demonstrated more improvement in their pharyngeal functioning with use of the Passy Muir Valve as compared to patients with upper airway obstructions.

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 Stevens, M., Finch, J., Justice, L., and Geiger, E. (2011). Use of the Passy Muir Valve in the neonatal intensive care unit. *Neonatal Intensive Care*, 24(7), 22-23.

Previous research has demonstrated that vocal exploration and social interaction is essential for normal speech and language development, which can be limited with the presence of a tracheostomy tube (Kalson & Stein, 1985; Simon, Fowler, & Handler, 1983). Supporting attainment of developmental outcomes for infants and children with tracheostomy tubes, while acknowledging the medical fragility and comorbidities that often accompany the need for treatment within the neonatal intensive care unit remains an area of concern.

In this article, the authors document a protocol for use of Passy Muir® Valve within a neonatal intensive care unit (NICU). The authors identified a need for a systematic, team-based approach to assessing speaking valve readiness and tolerance for both non-mechanically ventilated and mechanically ventilated neonatal patients. Their protocol was formalized in 2010 and is used by the multidisciplinary team of neonatologists, ENT nurse practitioners, speech-language pathologists, and respiratory therapists.

The protocol implementation resulted in an increased number of referrals for speaking valve trials with neonatal patients, as well as an improvement in quality of patient care. The authors identified two possible future uses of their protocol: (1) measurement of caregiver/infant bonding pre- and post-speaking valve use; and (2) measurements of weaning from mechanical ventilation with use of the Passy Muir Valve with neonatal patients.



Hofman, L., Bolton, J., and Ferry, S. (2008). Passy Muir Valve use in a children's hospital: An interdisciplinary approach. *SIG 3 Perspectives on Voice and Voice Disorders*, 18, 76-86. doi: 10.1044/vvd18.2.76

Speaking valves can be an integral part of advancing language growth in pediatric patients with tracheostomies (Lewis & Carron, 2003). Respiratory therapy and speech-language pathology goals are often intertwined when working with patients with tracheostomies, making interdisciplinary coordination of care essential (Torres & Sirbegovic, 2004).

The authors of this article document the interdisciplinary protocol for Passy Muir Valve use within their hospital, including measures of patient candidacy and exclusion criteria. A critical aspect of their protocol was the emphasis on the interdisciplinary team developing individualized treatment plans to improve consistency of speaking valve wear, thereby increasing length of tolerance. Through interdisciplinary collaboration and standardization of care, pediatric patients received the optimal benefit of speaking valve use within a systematic and safe framework.

NEW Pediatric Anatomical Demonstration and Teaching Model

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Hull, E.M., Humas, H.M., Crowley, R.A., and Kharasch, V.S. (2005). Tracheostomy speaking valves for children: Tolerance and clinical benefits. *Pediatric Rehabilitation*, 8(3), 214-219. doi: 10.1080/13638490400021503

Previous research studies consistently and effectively demonstrated the negative effect of tracheostomy placement on the expressive language skills of infants and children (Karlson & Stein, 1985; Hill & Singer, 1990; Singer et al., 1991; Ross, 1982; Simon, Fowler, & Handler, 1983; Kaman & Watson, 1991). Limited research has been available regarding expressive language development through use of speaking valves targeting restoration of voicing in infants and children with tracheostomies.

Investigators of this study identified that pediatric patients with tracheostomies often spend prolonged periods within healthcare settings (hospitals, rehabilitation centers), during which a collaborative, team-based approach for speaking valve use would be beneficial. The researchers conducted a retrospective evaluation of inpatient pediatric tracheostomy cases to determine the percent of patients able to tolerate the Passy Muir Valve, whether phonation was achieved with the Valve and which secondary benefits (improved secretion management, restoration of coughing ability, and improvements in feeding and swallowing) were observed. Twelve cases were reviewed, with 10 children able to tolerate Valve placement during initial evaluation and three subsequent trials. All of the 10 children were able to achieve phonation by the completion of the trials, and significant improvement in vocal quality was noted for the six children who demonstrated hydrophonic vocal quality during the initial Valve placement. A productive cough was noted for all children, and one of the two children who were noted to have secretion management concerns, demonstrated significant improvement with decreased oral pooling of secretions.

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