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Assessing and Managing Medically Fragile Children: Tracheostomy and Ventilatory Support

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Over the past decade, the rate of premature births has increased more than 9%, and 11.6% of all babies born in the United States in the year 2000 were preterm (March of Dimes, 2003). Children who survive premature birth often present with complex medical conditions (Andrews, 1999; Jackson & Albamonte, 1994; Simon & Silverman McGowan, 1989). Some of these children are dependent on tracheostomies and ventilators (Jackson & Albamonte, 1994; Simon & Silverman McGowan, 1989; Stanton & Murry, 1998). Children with tracheostomies constitute a diverse population from many standpoints, including underlying medical diagnoses, health issues, developmental status, and communication needs. Many require assistance from speech-language pathologists (SLPs) to establish effective communication. However, SLPs treating these children may have limited background information to prepare them for assessing and managing the communication needs of this population (Manley, Frank, & Melvin, 1999).

ABSTRACT: Over the past decade, there has been an increase in premature births. Children born prematurely often present with complex medical conditions; some require a tracheostomy. Although many children with tracheostomies require assistance to achieve effective communication, speech-language pathologists may have limited information with respect to the medical issues and communication needs of this population.
The purpose of this article is twofold. First, a review of basic information on tracheostomy and ventilatory support in the pediatric population is provided. Second, information on the assessment of communication skills and intervention specific to voice for the child with a tracheostomy is detailed. Two case studies are presented. The case studies illustrate the diversity and medical complexity common to this population and provide practical information for the clinician working with a child with a tracheostomy.

KEY WORDS: tracheostomy, children, voice, speaking valve, ventilator, pediatric

This article provides an overview regarding tracheostomy and ventilatory support in the pediatric population as well as information on the assessment of communication skills and intervention specific to voice for the child with a tracheostomy. Two case studies are presented as a means of explaining the management of voice problems associated with tracheostomies. The case studies also illustrate the diversity and medical complexity common to this population.

PEDIATRIC TRACHEOSTOMY

A tracheostomy, or external opening into the trachea, may be necessary when a child experiences respiratory difficulties secondary to obstruction of the upper airway, has problems managing secretions, and/or requires mechanical ventilation for adequate respiration (Simon & Handler, 1991; Stanton & Murry, 1998). A tracheostomy is the end result of a surgical procedure called a tracheotomy. With children, this surgery involves making a vertical incision into the trachea below the level of the larynx, between the second and fourth tracheal rings (Bissell, 2000). An opening, or stoma, is created, and a tracheostomy tube, or cannula, is inserted to maintain the airway.

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Decisions regarding the type and size of tracheostomy tube to be used are made by the otolaryngologist, based on the child's size and medical needs. Tracheostomy tubes have either a double or a single cannula. Single-cannula tubes, which are smaller in diameter, are typically used with infants and small children. With double-cannula tubes, the inner cannula acts as a liner and can be removed for brief periods for cleaning. Some tracheostomy tubes have a cuff. A cuffed tracheostomy tube has an inflatable balloon at the distal end. When inflated, the tracheostomy cuff provides a seal that allows for greater air supply to the lungs with ventilator patients. Although an inflated cuff does not preclude aspiration, it minimizes the risk of secretions or other material entering the airway. In some instances, a fenestrated tracheostomy tube is used. Fenestrated tracheostomy tubes have an opening in them to permit airflow into the upper airway and across the larynx when the stoma is closed off. Fenestrated tracheostomy tubes are rarely used with young children due to concern that granulation tissue may develop in or around the fenestration (American Thoracic Society, 2000).

The extent of time that an individual has a tracheostomy varies. In some instances, a tracheostomy is required on a short-term basis. For others, this may be a long-term measure and, in some cases, permanent. Decannulation, or removal of the tracheostomy tube and closure of the stoma, may be achieved with some children and is typically done in a hospital setting under the direction of an otolaryngologist. Decannulation is dependent on the underlying diagnosis/condition and status following growth and/or surgical correction of the underlying problem.

Some individuals with a tracheostomy also require use of a ventilator to mechanically inflate and deflate the lungs and regulate the appropriate exchange rate of gases in the blood. With advances in technology, the size of ventilators has been reduced dramatically, and portable ventilators (similar in size to a laptop computer) are now used by many persons who require ventilatory support. Such advances in technology allow individuals who are medically stable to be mobile. Consequently, mechanically ventilated children who were previously confined to a facility with nursing care or their home setting can be integrated into educational and other community settings.

COMMUNICATION WITH A TRACHEOSTOMY

An individual with a tracheostomy breathes in a modified way, whereby air is inhaled and exhaled through the tracheostomy. There may be some air leakage up to the vocal cords on exhalation; however, expiratory air will follow the route with the least resistance and most will be exhaled out the tracheostomy tube. When air leaks into the upper airway, there will be a decrease in subglottal air pressure; however, this will not be adequate to achieve the driving force necessary for normal voice production.

The degree of obstruction in the airway, status of the vocal cords, and pulmonary status will affect one's ability to vocalize with a tracheostomy. The size and type of the tracheostomy tube are two factors that impact the openness of the airway. Generally, in order to achieve voice, a tracheostomy tube, or cannula, should not exceed two thirds of the diameter of the trachea (American Thoracic Society, 2000) or it must be fenestrated. A tracheostomy tube that fits snuggly in the airway, or inflation of a tracheostomy cuff, will prevent air movement around the cannula and up over the larynx.

Oral Communication With a Tracheostomy

There are times when exhaled air leaks around the tracheostomy tube sufficiently to result in the production of some degree of voice. Typically, voiced productions with an open tracheostomy tube are weak in intensity and of short duration. Children with a tracheostomy sometimes compensate with abnormal behaviors (Jackson & Albamonte, 1994) in order to achieve voice, or increase the loudness or duration of phonation. The compensatory behaviors used by children may constitute hyperfunction, and in some instances, voice is produced with the false vocal cords, known as ventricular phonation.

When there is enough air leakage around the tracheostomy tube, voice production may be achieved, or enhanced, by occluding the open end of the tracheostomy tube. The stoma can be blocked off with a gloved finger for brief periods while the child exhales. Children sometimes learn to cover the stoma themselves by using a finger or tucking their chin. Use of a chin tuck for occlusion of the tracheostomy tube may not be optimal, however, because the resulting neck flexion is believed to contribute to suprastomal collapse (American Thoracic Society, 2000).

A tracheostomy speaking valve offers another option for voice production with a tracheostomy tube. A speaking valve is a one-way, removable valve that is attached to the open end of the tracheostomy tube. Speaking valves that are used with children at Children's Hospital Boston include the Passy-Muir Speaking Valve (Passy-Muir, Inc., Irvine, CA), the Shiley Phonate Speaking Valve (Nellcor Puritan Bennett, Inc., Pleasanton, CA) and the Montgomery Tracheostomy Speaking Valve (Boston Medical Products, Westborough, MA; see Appendix for more information). Although the Montgomery speaking valves and the Shiley Phonate valves are open-position valves, Passy-Muir valves use a closed-position design. Open versus closed refers to the resting position of the valve. As implied, open-position valves are maintained in an open position, and the valve closes during expiration. Passy-Muir's biased closed design remains closed at rest. The Passy-Muir valves open with inspiration and close before the end of the inspiratory cycle and the beginning of the expiratory cycle. Regardless of design, all one-way speaking valves allow air to flow freely from the tracheostomy into the lungs. The valves are closed on exhalation, directing the expired air into the upper airway and across the larynx and out the mouth or nose. Children of all ages, including infants, may be candidates for use of a speaking valve. There are some contraindications for use of a speaking valve, and these include:

- presence of severe tracheal or laryngeal obstruction
- a laryngectomy
- use of an inflated cuffed tracheostomy tube
- presence of excessive secretions that cannot be managed adequately
- gross aspiration
- bilateral adductor vocal cord paralysis
- serious illness
- an unconscious state

Given that there are medical situations when a speaking valve should not be used, medical clearance from the child's otolaryngologist is necessary to obtain a speaking valve. Even with physician approval, an initial trial of the valve should be conducted in the presence of a respiratory therapist or other medical personnel responsible for the child's respiratory care. He or she should monitor the child's respiratory status during use of the speaking valve and determine the acceptability of respiratory status with the valve.

In instances when phonation cannot be achieved, an artificial larynx, or electrolarynx, offers an option for oral communication. This is a small, hand-held device and, depending on the type of artificial larynx, it will either be placed on the neck or inserted in the mouth. When activated manually, the device produces a vibratory source and sets air along the vocal tract in motion to provide a sound source for speech production.

Mouthing (Kazandjian & Dikeman, 1998), as used in "lip synch," can also be used effectively in some instances when children are aphonic. In at least one instance, a preschool child with a tracheostomy, who was followed by the author, used this method of communication effectively. The child was not a candidate for use of a speaking valve due to a severely compromised airway. The family opted not to employ an augmentative means for communication, and articulation therapy was done with the child to foster optimal speech patterns. This child used mouthing effectively for a number of years pending laryngeal reconstruction surgery and eventual decannulation, after which voice and more normal speech patterns were achieved.

Oral Communication With Ventilatory Support

Children on ventilators need a cannula with a snug fit, or a tracheostomy tube with a cuff, in order to achieve adequate ventilation. These conditions limit the likelihood of voice production. With some individuals, partial or full deflation of the cuff may be allowed for periods of time. The deflated cuff, in conjunction with adjustment of the ventilator settings, may permit voicing on air furnished by the ventilator during the inspiratory cycle. This is referred to as "leak speech" (Stanton & Murry, 1998), as voice results from air that leaks around the tracheostomy tube and deflated cuff. Direct involvement of the professional person(s) responsible for the child's respiratory care, such as a respiratory therapist or nurse, is essential when attempting "leak speech" in order to ensure that alterations in ventilator settings are appropriate. The quality of voice achieved under these circumstances may be reduced in volume and of limited duration. It may also be difficult, and effortful, for the child to coordinate phonation with the ventilator cycles (Kazandjian & Dikeman, 1998).

Passy-Muir and Montgomery tracheostomy speaking valves come in models designed for use with a ventilator, and their use can aid oral communication for the child in need of ventilatory support. Deflation of a tracheostomy tube cuff is required for use of a speaking valve, and medical clearance is required for use of this device. Careful monitoring is essential, particularly during the initial period of use, and this requires teamwork with appropriate medical personnel.

Some individuals on ventilators who are unable to tolerate cuff deflation can use a device known as a talking tracheostomy tube. The Portex Trach-Talk Tracheostomy Tube (Smiths Medical, London, England) and the Bivona Mid-Range Aire-Cuf Talking Tracheostomy Tube (Smiths Medical) have inflatable cuffs (see Appendix for address). The Bivona Fome-Cuf (Smiths Medical), as suggested by the name, has a foam-filled cuff. Each of these adapted tracheostomy tubes has an external air port connected to an additional air source. Air enters the tracheostomy tube above the cuff and is directed upward through a fenestration in the tube. Again, it is critical that the child's doctor approves use of a talking tracheostomy tube, and that appropriate medical personnel are involved with implementation.

Augmentative Communication With a Tracheostomy

Not all individuals with a tracheostomy are able to produce voice and/or articulate speech at a level that is adequate for oral communication purposes. Many children with tracheostomies use various nonverbal modes of communication, including electronic devices, communication boards, and sign, as alternative or augmentative communication means.

ROLE OF THE SLP

Although lack of normal phonation is perhaps the most apparent effect of a tracheostomy, it is important to note that communication difficulties related to phonological disorders and/or delays in receptive and expressive language development are common in children with tracheostomies (Kaslon & Stein, 1985; Kertoy, Guest, Quart, & Lieh-Lai, 1999; Simon, Fowler, & Handler, 1983). SLPs have a central role in working with children with tracheostomies to achieve their potential for communication. This necessitates that the SLP conduct evaluation of, and intervention around, all aspects of communication skills. As part of intervention, the clinician is responsible for counseling and guiding family members, educators, and other key persons in the child's life with respect to achieving maximum potential in the area of communication. Assessment and treatment of swallowing

problems is also within the SLP's scope of practice. These aspects of care, however, are not addressed in this article.

A Team Approach

In order to achieve the goals for evaluation and intervention with the child with a tracheostomy, it is essential that the SLP work with other professionals as a team. Members of the team may include physicians, medical personnel involved in the child's respiratory care, educators, and psychologists. When there is not an established team, the SLP will need to obtain parental permission and take the initiative to contact appropriate professionals. Communication with team members is necessary to gather pertinent information regarding the child's medical, psychological, educational, and social status. Choices to be made around communication may require interrelated decisions based on input from multiple professionals, parents, and even the child. Implementation of carryover of learned skills also involves a team effort that will likely involve family members, educators, and other key persons across the school and home settings.

Evaluation Process

The SLP's evaluation includes the acquisition of pertinent background information. In relation to his or her work with the child with a tracheostomy, the clinician should understand the presenting medical diagnosis/diagnoses, specific information regarding the child's health status, medical procedures that have been conducted, and plans for future treatment. It is important to have knowledge of the type of tracheostomy tube the child has, as well as information from the otolaryngologist regarding any alterations in laryngeal structure and/or function. It is noted that the status of a child with a tracheostomy may not remain static. Changes may occur over time due to continued development, the disease process, or surgical intervention. Therefore, means for acquiring updated medical information should be established, and repeat assessments should be conducted as indicated.

A comprehensive assessment of overall communication skills should be conducted to determine current levels with respect to cognitive skills, receptive language, expressive communication (including nonverbal means), oral–motor function, articulation, and voice. With regard to the assessment of voice with the child with a tracheostomy, components of a routine voice evaluation should be conducted when possible. Information provided in the article in this publication on noninstrumental measures of speech and voice can serve as a model for the voice evaluation protocol to be followed.

When routine voice evaluation procedures are not applicable because of severely limited/deviant voice and/or developmental status, the initial speech and voice evaluation may consist of clinical observations. Specific behaviors to target for observation include phonation, resonance, respiration, sound production, and communicative interactions. Communication behaviors may be elicited during play situations or other age-appropriate activities. With regard to voice, the clinician should attend to any vocalizations produced and should note the conditions under which voice is produced. For example, is voice produced with the tracheostomy tube occluded or open, with effort (e.g., such as with excitement or anger), on exhalation or inhalation? The clinician should also describe the pitch, quality, and loudness of voiced productions; observe respiration; and note the coordination between speech and respiration. In some instances, the clinician may judge that voicing results from the vibration of tissues other than the true vocal cords, and it is important to identify the probable sound source(s), such as false vocal cord phonation, esophageal sound, pharyngeal sound, or buccal sound (i.e., sound produced by constricting air in the oral cavity between the teeth and the cheeks). Children with tracheostomies sometimes exhibit multiple, and diverse, voice productions (Harvey, 1996). If this is the case, some of their productions may be judged to constitute "better" voice. These better productions can sometimes serve as a guide for the clinician in terms of what to target for voice therapy.

Choosing Communication Options

Decisions regarding communication options for the child with a tracheostomy can be challenging. The SLP uses information from the evaluation to aid in determining the communication option, or combination of options, that is most appropriate for the child. It is important to be sure that the child meets the cognitive, physical, and medical requirements for any communication system or device that is considered (Silverman McGowan, Bleile, Fus, & Barnas, 1993). Additionally, consideration should be given to changes that are likely to occur with regard to development and medical status over time.

Voice Therapy

Intervention that is directed toward establishing, or improving, the voice of a child with a tracheostomy covers a range. When the child is a candidate for verbal speech, use of the least restrictive method of voice production is desirable (Conway, 1994) and, in many cases, this will be a tracheostomy speaking valve. For children using a speaking valve, a first goal may be to have the child wear the speaking valve for periods of time so that he or she can become accustomed to how it feels. Time spans can be increased until the child is able to wear the speaking valve long enough to support verbal speech. Achievement of this end goal is sometimes challenging, as the resulting changes in breathing with the valve in place can be scary for the child. It is essential to monitor the child's respiratory status when wearing the valve, and to increase wearing time gradually. Initially, it may be helpful to provide a distraction while the child is wearing the valve. A chart detailing progressive time increments to wear the valve is a helpful aid for the family/caregivers with regard to accomplishing this goal.

Voice production is frequently an early goal for a child with a tracheostomy. Establishing voice may be relatively quick when the stoma is occluded manually or with use of a speaking valve, or it may take a long time. Once a child is vocalizing on a regular basis, increased rate and the variety of the sounds produced should be shaped. Even with young children, normal articulation should be promoted. Children who have had a tracheostomy for a long time may exhibit deviant sound production patterns or phonological processes (Kertoy et al., 1999). In such instances, specific work on speech sound production is necessary.

Behaviors that are targeted for voice therapy may include consistency of voicing, as with sustained vowels, and increased phonation time. With regard to increased phonation time, work with sustained vowel productions and producing multiple syllables on a single breath unit is appropriate. As necessary, attention should also be given to the coordination of respiration and voice. Atypical aspects with coordination that may warrant modification include speaking on inhalation, exhaling before speaking, poor phrasing, and speaking too long on one breath. A child's pitch, or fundamental frequency, may be too high or too low for his or her age. This may indicate an underlying problem with the laryngeal structures or function. In some instances, the causal factor is vocal hyperfunction, and pitch may be improved if air pressure is optimized and voice is produced with less effort. Similarly, when increased loudness is a problem, work on decreased effort, or production of "easy" voice, may help to facilitate improvement.

The vocal quality of some children with a tracheostomy may be deviant. Atypical vocal quality can result from one or more factors, including alterations in the laryngeal structures and/or function, the use of compensatory behaviors, and respiratory difficulties. The SLP needs to understand the conditions and/or behaviors that contribute to the voice differences and determine if there is a potential for vocal improvement with therapy. When there are limiting factors, such as a vocal cord paralysis, scar tissue, or compromised respiration, the overall goal for treatment is to help the child achieve his or her best voice possible. The SLP may face a dilemma when a child uses compensatory behaviors that are characterized by hyperfunction. In such instances, the clinician must decide whether to accept the child's voice as optimal, given the medical circumstances, or to attempt to improve the child's voice through therapy. When a decision is made to proceed and at least attempt treatment, then traditional voice therapy techniques, as outlined in numerous textbooks (Andrews, 1999; Boone & McFarlane, 2000; Colton & Casper, 1996; Stemple, 1993; Wilson, 1987), can be used as a starting point for facilitating vocal improvement. In general, therapy approaches described in these and other resources can be used effectively with children. Adaptations in the presentation of the information to the cognitive and interest level of the individual child will be necessary, but the underlying principles are the same.

Carryover is an expected outcome with any voice therapy program. It is, therefore, important for the SLP to build generalization training into the treatment plan. This can be accomplished through elicitation of the targeted vocal behaviors during natural communication interactions conducted across settings with a variety of people. Collaboration with either the child's parent(s) or classroom teacher is helpful, and perhaps necessary, for successful carryover.

Two case studies detailing noninstrumental voice evaluations and intervention with children with a tracheostomy follow. The cases provide some insight with regard to the variability in this population. The first case study highlights voice therapy techniques that were used with a child, PK, with a tracheostomy who spoke with an open tracheostomy tube and used compensatory behaviors to achieve voice production. In the second case, JV was aphonic for a number of years and effectively communicated using Signing Exact English when she began to exhibit some voiced productions with a tracheostomy speaking valve at 6 years of age. For further case studies detailing intervention with children with a tracheostomy, and following decannulation, the reader is directed to a previous article by the author (Harvey, 1996).

CASE STUDY: PK

Background Information

PK was seen for an initial evaluation when she was 5;8 (years;months) at the request of her otolaryngologist. Background information was obtained from medical records provided by the otolaryngologist and included the following. PK was born prematurely at 24 weeks gestation. She required intubation and ventilatory support for a period of approximately 7 weeks as a neonate, which resulted in subglottic stenosis. A tracheostomy was completed at 2 years of age, after endoscopic enlargement of the subglottis failed. It was anticipated that laryngotracheal reconstructive surgery would be done in the future.

PK had been in a special needs preschool program and then attended a regular kindergarten. At the time of her evaluation, PK had finished kindergarten and was going into first grade. She had a personal aide with her in the school setting. School personnel reported mild delays in PK's language skills. She received speech-language therapy at school twice a week for 1 hr. PK had a tracheostomy speaking valve, but she wore the valve only when receiving speech-language therapy at school.

Laryngeal Examination

The otolaryngologist conducted a direct laryngoscopy. This procedure is done under anesthesia and allows for direct observation of the laryngeal structures. Findings were remarkable for edema of both the true and false vocal cords. A 4.0-mm tracheostomy tube was in place. Use of a tracheostomy speaking valve was previously approved, and the otolaryngologist indicated support for ongoing use of this device.

Speech and Voice Evaluation

PK presented as a pleasant and interactive little girl. Although she brought her tracheostomy speaking valve with her, PK was not wearing the valve when she came to the evaluation. PK readily engaged in conversation, speaking on inhalation as well as exhalation. Breath units were short, and PK was aphonic most of the time. Speech intelligibility was judged moderately severely impaired.

Additional perceptual judgments were made with the tracheostomy tube occluded. This was accomplished with a finger occlusion as well as with the speaking valve in place. Given PK's tendency to speak on inhalation as well as exhalation, trial teaching to modify the abnormal behavior of talking on inhalation was conducted. PK was first guided to speak with the trach occluded with her finger. Specific directions following three sequential steps were given. One, "breathe in," two, "put your finger over your trach" or "close," and three, "talk." After a brief period of practicing this 1,2,3 sequence, PK successfully demonstrated phonation on exhalation for vowel productions.

When placement of the tracheostomy speaking valve was attempted, PK held her breath. This behavior attenuated after the clinician directed PK to breathe in through her trach and out through her mouth or nose. PK proceeded to wear the valve without difficulty for 15 min. Perceptual judgments of her voice and speech were made during various speaking tasks, including spontaneous speech, counting, and vowel productions. PK continued to speak on inhalation and exhalation during spontaneous speech, but phonated only on exhalation for structured tasks of counting and production of vowels. She demonstrated consistent voicing with sustained vowels. Average phonation for the vowel /i/ across three trials was 6.14 s, which was at the bottom of the normal range for girls her age (Wilson, 1987). PK's voice was judged to be consistently moderately severely hoarse. Vocal pitch was judged high for her age and sex. Vocal intensity was reduced. Resonance was judged to be normal. Respiration was characterized by shallow inhalation. Speech intelligibility was intermittently reduced and was judged improved in comparison with speaking with an open tracheostomy tube.

Articulation was assessed based on elicited word productions using the Goldman-Fristoe 2 Test of Articulation (Goldman & Fristoe, 2000). PK demonstrated sound substitutions that were judged developmental in nature and within normal limits for her chronological age. Specifically, she exhibited interdental tongue placement with /s/ and /z/.

A brief assessment of oral structures and oral motor function was unremarkable. Oral structures were normal and symmetrical. Range of motion for the lips and tongue was good for isolated movements. The palate was normal with good velar mobility with phonation. Diadochokinesis was normal.

Considerations for Intervention

There was some air leakage around PK's tracheostomy tube on exhalation, and she inconsistently produced voice that was weak with respect to intensity and of short duration. PK appeared to use some compensatory behaviors to aid voice production. Most obvious was speaking on inhalation. Also, given documentation of edema of the true and false vocal cords, it was believed that hyperfunction of the laryngeal mechanism was used in a compensatory manner to support phonation on exhalation.

Improved voice production was demonstrated when the tracheostomy tube was occluded. PK tolerated a tracheostomy speaking valve well, and it was believed that she would benefit from wearing her valve on a consistent basis at home and school. Use of a one-way speaking valve would optimize respiratory support for voice by directing the exhaled air into the upper airway, over the vocal cords, and out the mouth/nose, rather than losing most exhaled air out the tracheostomy tube.

It was recommended that speech therapy goals with PK be expanded to include goals for voice. Consistent use of the tracheostomy speaking valve was identified as a primary goal. Other treatment goals targeted elimination/reduction of undesirable compensatory behaviors.

Management Program

Voice therapy was conducted in PK's school setting. Treatment goals that were identified based on the evaluation findings, and suggested approaches to management, are stated below.

- Goal 1

  Target behavior: PK will consistently wear her tracheostomy speaking valve at home and school.

  Treatment suggestion: A program was detailed to gradually increase use of the tracheostomy speaking valve on a systematic basis. PK initially wore the valve for 10 min each day. Increments of 30–45 min were planned on a weekly basis until PK wore the valve approximately 8 hr daily.

- Goal 2

  Target behavior: PK will consistently exhibit phonation on exhalation.

  Treatment suggestion: Initial teaching of this behavior was conducted during the evaluation and followed a 1,2,3 sequence. One, "breathe in," two, "put your finger over your trach" or "close," and three, "talk." PK responded well to this approach, consistently demonstrating phonation on exhalation for vowel productions. Implementation of a traditional behavioral treatment approach was appropriate for this target behavior. The training program outlined for the SLP working with PK began with vowel productions and progressed through a hierarchy of speech tasks to spontaneous speech across a variety of situations.

- Goal 3

  Target behavior: PK will consistently exhibit easy phonation when speaking.

  Treatment suggestion: Facilitating techniques to achieve the target behavior of easy phonation (Boone

& McFarlane, 2000; Colton & Casper, 1996), including chant talk, chewing, humming, and yawn/sigh, were recommended.

Outcome

Direct laryngoscopy was conducted 1 year after the initial evaluation and revealed no hypertrophy of the true or false vocal cords, as previously documented. A report from the otolaryngologist at that time indicated that PK used her tracheostomy speaking valve on a consistent basis without difficulty. PK was described as having good verbal communication skills, but it was noted that her voice was "somewhat weak and hoarse."

A follow-up examination for voice was conducted 2½ years following the initial evaluation. At that time, PK was 8 years of age. She had undergone laryngotracheal reconstructive surgery and was decannulated. It would seem that the end goal is achieved once the tracheostomy is eliminated. This is not necessarily so, and in PK's case, there were ongoing concerns regarding the quality of her voice. The otolaryngologist conducted fiberoptic laryngoscopy while PK was awake, which allowed for the assessment of laryngeal structures and function. Findings revealed an immobile left vocal cord in a midline position and "sluggish" movement of the right vocal fold. A moderate degree of supraglottic compression was also noted. Perceptually, PK's vocal quality was judged to be severely hoarse and breathy. Vocal pitch was judged to be low, and vocal loudness soft. Muscular tension was observed in the neck. Respiration was characterized by shallow inhalation, intermittent audible inhalation, and speaking in short phrases. Resonance was adequate. Speech intelligibility was reduced secondary to the voice difficulties described above.

The otolaryngologist indicated that phonosurgery was not an option because PK's airway was "marginal." A trial period of voice therapy was recommended to work on improved coordination of respiration with phonation and reduction of vocal hyperfunction. In light of the diagnosed vocal fold paralysis/paresis, the goal for therapy was to achieve the best voice possible.

CASE STUDY: JV

Background Information

JV was referred for a voice evaluation at 7 years of age, at the request of her mother. She came to the initial evaluation with her mother, her nurse, and her occupational therapist. Pertinent background information was obtained based on an interview with these persons and a review of medical reports that were obtained from the otolaryngologist. JV was born prematurely at 35 weeks gestation and presented with a congenital muscle disorder of unknown cause. Pertinent medical history included (a) tracheomalacia, (b) completion of a tracheostomy at 2 months of age secondary to upper airway obstruction, (c) recurrent otitis media with repeated surgical placement of pressure-equalizing tubes, (d) presence of a gastrostomy tube (initially placed at 2 months of age) and NPO (i.e., nothing by mouth) status, (e) chronic lung disease, and (f) clubfoot repair. JV was on aspiration precautions secondary to chronic lung disease. It was reported that she had constant, excessive oral secretions, which she managed by pooling them orally and then spitting them out. General health status fluctuated, with incidence of viral infections reported, on average, every 3 to 4 weeks. Medical personnel, or a person trained in respiratory management, remained with JV at all times.

JV was largely nonspeaking and she communicated using Signing Exact English. Although she had normal hearing, JV attended a school for children who were deaf and hard of hearing, where she was in an ungraded primary level class. A prior speech-language evaluation, conducted by an SLP who was proficient in sign, indicated above-average receptive language abilities for spoken English and normal expressive language abilities using sign.

Medical clearance for use of a speaking valve was obtained when JV was in preschool. The mother reported that it was initially difficult to get JV to wear the valve. Reportedly, it was almost a year until JV wore the speaking valve "comfortably," and she started achieving some vocal productions after that. At the time of this evaluation, JV wore her tracheostomy speaking valve during "select activities." Duration for use of the valve was 20–30 min, and length of time the valve was tolerated was affected by a lack of adequate humidity, a problem that is sometimes experienced with speaking valves. The SLP in JV's school setting worked with her using the Lindamood Phoneme Sequencing Program, also known as LiPS (Lindamood & Lindamood, 1998), to teach articulation placement for speech production.

Laryngeal Examination

Report of a recent direct laryngoscopy indicated moderate-to-severe constriction of the upper airway in the presence of tracheomalacia/suprastomal collapse, symptoms that are consistent with gastroesophageal reflux, smooth and straight true vocal cords, and a patent subglottic airway. A 4.5-mm tracheostomy tube was in place. Use of a tracheostomy speaking valve was previously approved, and the otolaryngologist noted his support for ongoing use of this device.

Speech and Voice Evaluation

JV presented as a pleasant and interactive little girl who communicated using a combination of sign language and verbal words and phrases. She wore her speaking valve throughout the evaluation. JV demonstrated an open mouth posture, with forward tongue placement at rest. Copious oral secretions were present continually. Little or no movement of the articulators was observed with spontaneous word productions. Verbal attempts were generally understood with the aid of situational cues.

Perceptual judgments regarding voice were made with the speaking valve in place. JV's voice was judged to be consistently weak, but with clear quality. Vocal pitch was

judged appropriate for her age and sex. Voice loudness was consistently reduced. Respiration was described as weak, and phonation times were significantly reduced (i.e., maximum sustained phonation demonstrated with vowel productions was 2 s). In regard to resonance, reduced intraoral breath pressure was perceived with production of pressure consonants. Further screening of resonance was conducted using the nasal flutter technique (Boone & McFarlane, 2000) to test for hypernasality and placement of a cold mirror under the nose (McWilliams, Morris, & Shelton, 1990) to detect visible nasal emission. Results from both of these assessments were negative; there was no perceived difference in sustained production of /i/ during a nasal flutter and no fogging on a mirror.

Articulation was assessed based on elicited word productions using the Goldman-Fristoe 2 Test of Articulation (Goldman & Fristoe, 2000). JV's phonemic repertoire was limited. JV consistently demonstrated correct production of vowels and the consonants /p/, /w/ and /h/ in words. She also produced the following consonants correctly in some, but not all, contexts: /n/, /b/, /f/, /t/, /l/, /v/, and /θ/. JV failed to produce other consonants. It was noted that JV sometimes placed her tongue or lips correctly for a phoneme, but the manner of the resulting sound was different from the target. For example, when shown a picture of a thumb, she correctly placed her tongue between her teeth, as necessary for /θ/, but the production perceived by the examiner was "hum." In this example, JV exhibited correct tongue placement for the sound, that is, /θ/, but she failed to direct air over the tongue and out between closely approximated tongue and teeth, as necessary to achieve the turbulent airflow required for production of a fricative sound. Correct placement of the articulators with incorrect manner was also demonstrated with substitution of /p/ for /m/. JV inconsistently demonstrated voicing errors, such as with the production of voiceless /t/ for the voiced cognate /d/.

Next, the oral structures and oral motor function were assessed. Examination of the oral mechanism revealed the presence of normal and symmetric oral structures. Range of motion of the lips and tongue was good for isolated movements. Labial and lingual strength were reduced, as was rate of movement of these articulators. Palatal vaulting was unusually high. JV had copious, thick oral secretions pooled in the back of her mouth. Although she cleared secretions upon demand, they returned immediately, prohibiting visualization of the back of the mouth and the velum. Parental report indicated that JV occasionally experienced nasal reflux of her secretions.

Considerations for Intervention

In an attempt to understand JV's difficulties with oral speech, it was helpful to consider the entire speech mechanism, including respiration, laryngeal structures and function, velopharyngeal structures and function, oral structures, and oral motor function. Based on reports from the otolaryngologist and a perceptual evaluation, it appeared that JV had healthy vocal cords that were functioning adequately, and voice quality was clear. Respiration was compromised, however, and it was questioned if there was a reduction in the driving pressure necessary to produce and sustain voice at normal levels to support speech production, even with the speaking valve in place. This correlated with the perceived weak voice and limited duration for sustained phonation. Oral structures were intact, and range of motion of the lips and tongue was good for isolated movements. However, strength of the lips and tongue was reduced, as were rate and coordination for sequenced movements with these articulators. Limitations with production of specific speech sounds and sequencing sounds as necessary for production of words and connected speech were considered likely given these reductions in oral–motor function. Velopharyngeal competence was questioned due to perceived reduction in intraoral breath pressure with production of pressure consonants and report of nasal reflux. However, there did not appear to be gross velopharyngeal inadequacy, given the absence of hypernasality and nasal emission with speech production.

It was recommended that JV use a tracheostomy speaking valve, as tolerated, and that she continue to receive speech and voice therapy to work toward improved oral communication. As is sometimes the case, factors were identified that would possibly limit verbal communication outcome. In the case of JV, reduced oral–motor function was one limitation that was documented. There were also undetermined factors. Specifically, in the case of JV, there was no objective information regarding velopharyngeal status or respiration. It was recommended that these parameters be reevaluated informally at a later date with subsequent referral to a specialty program where instrumental measurements could be obtained, if indicated. Given the identified limitations and unanswered questions, the goal for therapy was to achieve the best speech possible.

Management Program

JV was seen for continued voice and speech therapy in her school setting. Based on the assessment findings detailed above, it was recommended that an occupational therapist work with JV to determine the best seating to aid in achieving support for optimal respiration. Additional treatment goals for voice and speech that were recommended are presented below.

- Goal 1

  Target behavior: JV will demonstrate correct placement and manner for articulation of consonant sounds.

  Treatment suggestion: Begin training with sound(s) in isolation and systematically move through a hierarchy of tasks (e.g., syllables, words, phrases, sentences, and connected speech). Conduct generalization training across settings as necessary.

- Goal 2

  Target behavior: JV will demonstrate increased maximum phonation as measured by duration of sustained vowels and number of syllables produced on one breath.

Treatment suggestion: Sustained vowel production and the production of multiple syllables on one breath unit are two tasks that can be used to work on increased phonation time. Provision of feedback, such as measuring duration for sustained vowel production with a stopwatch or charting number of syllables produced on a breath unit, can be used to motivate a child to "beat" his or her best time. When working on sustained vowel productions, voicing should be maintained throughout the production.

- Goal 3

  Target behavior: JV will demonstrate appropriate phrasing, and use of replenishing breaths, during connected speech.

  Treatment suggestion: Printed materials can be helpful when working on phrasing. Make a slash mark (/) on the materials to indicate appropriate points to take a breath. These points should be based on punctuation, with additional points marked that allow for the most natural phrasing. When work on phrasing in spontaneous speech is indicated, visual and auditory feedback via videotape may be useful.

Results of Therapy

Six months after the evaluation, a follow-up interview was conducted with the mother of JV by telephone. The mother reported that JV received weekly therapy in her school setting, with treatment focusing on the goals stated above. She reported that JV had made "very good" progress. At the time of the telephone contact, it was reported that JV spoke in complete sentences with fair to good intelligibility. According to the mother, she understood "most" of what JV verbalized, and she estimated that unfamiliar persons understood her speech approximately 50% of the time. The mother commented that she had difficulty learning new sign vocabulary to maintain pace with JV, and she understood her verbal language better than her communication using manual signs at that point. She also noted that JV had experienced new opportunities with the onset of functional verbal language skills. For example, she was able to talk on the telephone.

SUMMARY

The SLP plays a vital role in assessing and treating children with tracheostomies and in counseling their families. The presenting problems of this diverse population may seem overwhelming, and it will be helpful to draw on resources that are available. To begin with, other team members, and in particular, the professionals responsible for the child's respiratory care, may be good informational sources. Also, manufacturers of tracheostomy tubes, speaking valves, and talking tracheostomy tubes can provide instructional materials on their products. There is a steady increase in the number of books that address communication for persons with a tracheostomy (Bissell, 2000; Bleile, 1993; Conway, 1994; Dikeman & Kazandjian, 1995; Kertoy, 2002; Mason, 1993; Myers, Johnson, & Murry, 1998) and, finally, continuing education workshops/courses offer another way to further one's knowledge and comfort with dealing with children who are dependent on tracheostomies and ventilators. In the end, when the clinician forges ahead, obtains diagnostic data that lead to understanding of the clinical problem, sets realistic goals and then implements intervention strategies effectively, the rewards for successful management of voice and communication needs of the child with a tracheostomy can be enormous.

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APPENDIX. ADDRESSES FOR MEDICAL SUPPLY COMPANIES THAT PROVIDE EQUIPMENT FOR PATIENTS WITH TRACHEOSTOMIES

Boston Medical Products, Inc.
117 Flander Road
Westborough, MA 01581

Nellcor Puritan Bennett, Inc.
4280 Hacienda Drive
Pleasanton, CA 94588

Passy-Muir, Inc.
PMB273
Campus Drive
Irvine, CA 92612

Smiths Medical
765 Finchley Road
London, NW11 8DS