The Gift of Speech . . . Priceless

More than 30 years ago, Blom, a speech-language pathologist, revolutionized speech intervention for patients with laryngectomies when he and co-inventor Singer developed the tracheoesophageal prosthesis.[1] This device allows air to be routed from the lungs, through the tracheoesophageal wall, to the pharyngoesophageal segment where the air flow vibrates tissue and produces "voice" in someone without a larynx. Now, once again, Blom has created a device that will offer a new speech option for individuals with tracheostomas. In this issue of RESPIRATORY CARE, Kunduk and colleagues[2] report the successful application of the new Blom Tracheostomy Tube and Speech Cannula, which allow speaking while the cuff is fully inflated. This means that patients who cannot tolerate a deflated cuff will have the option to speak. The "talking tracheostomy tube" has long been available, but it has met with mixed success.[3,4]

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Patients who are medically unstable or who have recently begun to use mechanical ventilation sometimes can not tolerate cuff deflation, but without cuff deflation they cannot speak. This was the case for the participants in the Kunduk et al study,[2] most of whom had been ventilated for less than 2 months. With the Blom Tracheostomy Tube and Speech Cannula, nearly all the patients could speak almost immediately and with minimal coaching. Clearly, this new device promises to improve the quality of life of many patients who would otherwise remain speechless.

The Blom Tracheostomy Tube and Speech Cannula represent an important step forward for patients who must maintain an inflated cuff, but it is also important to acknowledge that many patients are not candidates for this device, because they can deflate the cuff and produce "leak speech" (ie, air flows around the deflated cuff to vibrate the vocal folds and produce voice). These patients have learned how to control the larynx in ways that allow them to maintain adequate ventilation as well as to speak. The cuff can be safely deflated in most chronically ventilated patients[5,6] and in many patients who have been ventilated only a short time.[7] Unfortunately, all too often, when the cuff is deflated, a one-way inspiratory valve is placed in the line, creating a situation that can be dangerous and uncomfortable for the patient.[8] There are safer and more easily tolerated solutions to improving "leak speech" that involve making simple adjustments to the ventilator. These lesser-known speech-enhancing ventilator adjustments were identified in the collaborative research efforts of 2 respiratory physiologists (Banzett and Shea), a pulmonologist (Brown), and 3 speech scientists and speech-language pathologists (Hixon, Lohmeier, and myself). In a clinical setting these adjustments are best determined through collaborative efforts of a respiratory therapist and a speech-language pathologist, with the oversight of a pulmonologist.

When making ventilator adjustments, we have found it useful to focus our efforts on "optimizing" the tracheal pressure (P_T) waveform for speech production, while carefully monitoring blood gas levels to ensure adequate ventilation. Through our focus on P_T, we have been able to determine the primary causes of common problems encountered in ventilator-supported speech, as well as how to improve such speech. This can be easily explained by contrasting P_T during normal speech and P_T during invasive volume-controlled ventilation. As shown schematically in Figure 1, normal speech is produced with a relatively low P_T (usually 5–10 cm H_2O for speech of conversational loudness), which changes little over the course of the expiration and lasts, on average, 5 seconds, though this can vary substantially, depending on linguistic and other influences. This P_T waveform is in sharp contrast to a volume-controlled ventilator-delivered P_T, which rises swiftly to a high peak during inspiration, falls rapidly

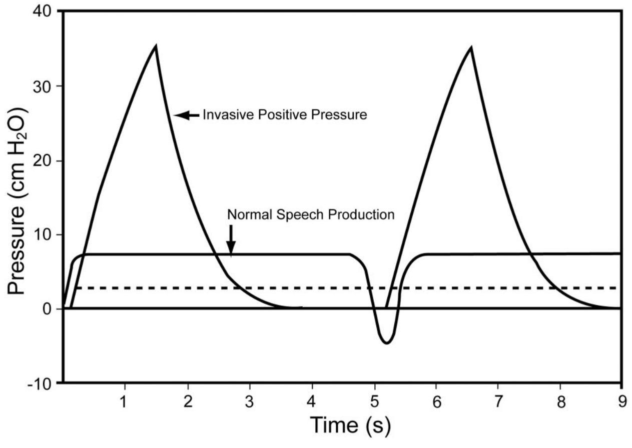

Fig. 1. Tracheal pressure during volume-controlled ventilation and during normal speech production. The dashed line indicates the minimum tracheal pressure needed to vibrate the vocal folds. (Adapted from Reference 9, with permission.)

to 0 cm H_2O during expiration, and remains there until the next inspiration begins. Note, too, that this ventilator-delivered P_T remains below the minimum pressure necessary to vibrate the vocal folds (shown as a dashed line at approximately 2 cm H_2O) for several seconds. This is in contrast to the normal P_T waveform, which remains above this voicing threshold for the entire 5 seconds, though that period can be substantially extended; for example, consider how long you can continue speaking a long sentence or hold out a sung note before you have to stop to inspire.

Certain features of the ventilator-delivered P_T waveform profoundly affect speech. Whereas the P_T waveform of a normal speaker is relatively stable (except for brief increases associated with linguistic stress and declinations at the end of declarative sentences), the ventilator-delivered P_T waveform is rapidly changing, highly peaked, and insufficient to produce voice during much of the cycle. It is these features that underlie the core speech problems encountered in ventilator-supported patients:

- Abnormally long pauses
- Abnormally short breath groups (phrases)
- Abnormally variable loudness
- Abnormal voice quality[10]

The long pauses and short phrases are primarily due to P_T dropping below the voicing threshold. The loudness problems (eg, too variable, fading loudness) and voice-quality problems (eg, strained voice, breathy bursts) are related primarily to the fast rate of pressure change, because the larynx is unable to make rapid enough adjustments to maintain normal loudness and voice quality. Because of this, ventilator adjustments to improve speech are aimed at increasing the portion of the cycle during which P_T exceeds the voicing threshold, and at smoothing out the waveform to make the voicing task easier on the larynx.

Two simple ventilator adjustments have proven especially successful for improving ventilator-supported speech: increasing inspiratory time and adding PEEP.[10-12] The increased inspiratory time prolongs the time that P_T remains above the voicing threshold during inspiration, and it causes the P_T rise during inspiration to be more gradual. The addition of PEEP, even as little as 5 cm H_2O, prolongs the time that P_T remains above the voicing threshold during expiration and also causes the P_T fall to be more gradual. With these adjustments (particularly in combination[12]), speech becomes more fluent (more speech and less pause time) and loudness and voice quality improve. Another strategy for improving speech, demonstrated by Prigent and colleagues,[13] involves the use of pressure-support ventilation combined with PEEP. This provides periods of relatively constant P_T and potentially limitless time during which P_T is above the voicing threshold.

Having to rely on mechanical ventilation is difficult enough without the added burden of not being able to express one's thoughts and emotions in words. Fortunately, patients who can tolerate a deflated cuff can speak, and they can often speak quite well with the right combination of ventilator settings. Now, with the advent of the Blom Tracheostomy Tube and Speech Cannula, many patients who must keep the cuff inflated will also be able to use their voices to communicate with family, friends, and healthcare professionals.

Jeannette Dee Hoit PhD
Speech, Language, and Hearing Sciences
University of Arizona
Tucson, Arizona

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Correspondence: Jeannette Dee Hoit PhD, Speech, Language, and Hearing Sciences, University of Arizona, PO Box 210071, Tucson AZ 85721. E-mail: hoit@e-mail.arizona.edu.

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