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## An Improvised Tracheotomy Speaking Valve

### ABSTRACT

**Objective:** To design and test an improvised tracheotomy speaking valve fabricated from recycled parts of an anesthesia airway breathing circuit.

### Methods:

**Design:** Surgical Instrumentation

**Setting:** Tertiary Private Hospital

**Subjects:** Speaking valves fabricated from discarded anesthesia breathing circuit parts were pilot-tested on three patients: one with vocal fold paralysis, another with a supraglottic mass and one post hemi-laryngectomy.

**Results:** The improvised tracheotomy speaking valve was inexpensive and relatively easy to assemble. All three patients tolerated speech well through the speaking valve and were pleased to reestablish their means of verbal communication. Maximum Phonation Time (MPT) averaged 8 seconds for all three subjects.

**Conclusion:** In our local setting, improving the quality of life of tracheotomized patients should be accessible to all, hence the value of an improvised speaking valve. It provides a more affordable means of restoring speech and because it is made from recycled materials, it is eco-friendly. Our improvised speaking valve is also a cheaper but viable alternative to more expensive commercially available ones. Clinical trials with standardized feedback questionnaires, multi-observer perceptual evaluation with a system such as the GRBAS and/or vocal acoustic measures in a speech laboratory should be made to assess long term use, efficiency and safety measures.

**Keywords:** *tracheotomy, tracheostomy, speaking valve, speaking device*

**Tracheotomy** is a common essential surgical procedure that establishes an alternative airway. The disadvantage of this often-lifesaving procedure is altered ability to verbally communicate effectively, which may lead to depression. Speech is an integral part of quality of life, and its loss results in psychological and emotional strain. Various devices have been developed over the years to improve speech in cognitive, tracheotomized patients. From aesthetic to functional accessories, the speaking tracheotomy tube has evolved to what we know now as the speaking valve. A tracheotomy speaking valve works by allowing inspired air to pass through it and the tracheotomy tube whilst directing exhaled air towards the glottis to provide pulmonary airflow for phonation. However, the high cost of these devices limits their availability to only a select few in a developing country like the Philippines. There is thus a need for an affordable yet durable alternative, without compromising pulmonary function and aesthetic value.

We designed and pilot-tested an improvised tracheotomy speaking valve fabricated from recycled parts of an anesthesia airway breathing circuit, as a cheaper substitute to commercially-available speaking valves.

**METHODS**

The primary materials used (1, 2) were taken from discarded anesthesia breathing circuits:

1. Endotracheal Tube external adaptor (Portex Tracheal Tube 7.5mm Soft Seal Cuff Oral, Smiths Medical International Ltd., Brisbane, Australia)
2. Airway Breathing Circuit elbow connector (Anesthesia Breathing Circuit A10007183, Inspired Medical, Vincent Medical Manufacturing Co., Ltd., Kowloon, Hong Kong)
3. Transparency OHP Acetate Film Clear, A4 210mm x 297mm 100 micron (Star 360 Philippines Inc, Quezon City, Philippines)
4. Fine-toothed hacksaw blade (Eclipse All Hard Power Hacksaw Blades, Model: ECL.AE 353K Blade size 400 x 32 x 1.60 mm; 16" x 1 ¼" x 0.06" teeth per inch: 10 (Neill Tools, Spear & Jackson, Sheffield, England)
5. Multipurpose Cutter No. 760 (KW-Trio Company LTD, Taiwan)
6. Silicone Carbide Abrasive Sand Paper 320C (Crocodile Brand, Korea)

The anesthesia airway breathing circuit (ABC) elbow connector has a universal inner diameter size of 15mm which is commonly used with most endotracheal tubes (ETT) and tracheostomy tubes. Endotracheal tube external adaptors and tracheostomy tubes on the other hand, have standard outer diameters of 14mm which fit snugly in place with ABC elbow connectors.

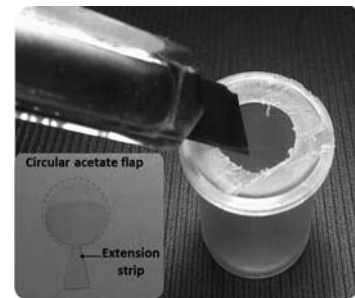
With a fine-toothed saw, the ABC elbow was cut just before the bend so that a plastic cylinder, open at both ends, was produced. (Figures 1-2) To hold a flap that could seal one end of this cylinder during breathing, a 2mm thickness was then trimmed from the distal end of the ETT external adaptor to make a ring. (Figure 3) With a cutter, a circular flap with a small protruding tongue was then fashioned from a sheet of acetate. The flap was positioned with the tongue ready to be wedged between the ring and the cylinder. The ring was then inserted tightly with the acetate flap at the distal portion of the cylinder to hold the flap tongue in place and to serve as a stopper during exhalation. (Figures 4-5)

During inhalation the flap moves towards the patient allowing free flow of air and conversely, during exhalation, the acetate flap shuts off securely against the inner ETT ring creating unidirectional airflow. During exhalation, the air is directed towards the glottis to provide pressure for phonation. (Figures 6-7)

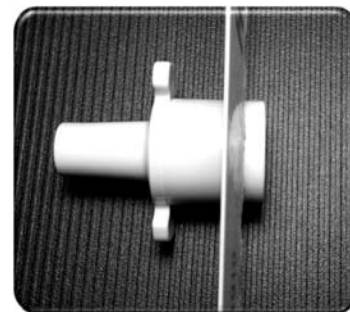
With informed consent, the device was then pilot-tested on three patients from the social service outpatient department of the St. Luke's Medical Center. (Figure 8) One patient had bilateral vocal fold paralysis, another had a supraglottic mass and the third was a post hemi-



**Figure 1.** The Airway Breathing Circuit (ABC) elbow was cut before the angle so that a cylinder is produced.



**Figure 2.** The rough edges of the cylinder were evened out using a multipurpose cutter and sand paper. Inset shows circular acetate flap with extension strip



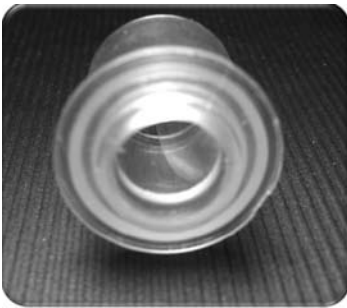
**Figure 3.** A 2mm-thick ring was tailored from the distal end of the Endotracheal Tube external adaptor



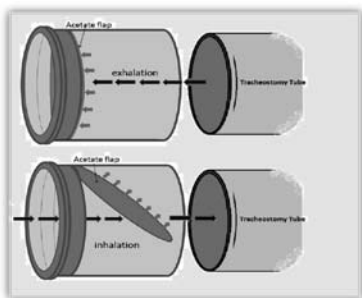
**Figure 4.** This ring was poised to fit snugly inside the ABC cylinder at the distal end and serve as a "stopper" to hold the flap in position



**Figure 5.** A circular acetate flap was positioned with the small tongue extension wedged between the cylinder and the ring



**Figure 6.** Finished product; the acetate flap moves freely with airflow, being wedged only by the small tongue



**Figure 7.** Mechanism of flap movement with airflow during inhalation and exhalation

laryngectomy patient, all of whom required long-term tracheotomy.

Using a fenestrated inner cannula and tracheotomy tube with inflated cuff, the subjects were seated upright and under normal breathing circumstances were asked to speak. We observed the quality of their voices and obtained feedback on the ease of use of the improvised speaking valve. We also obtained a three-trial average Maximum Phonation Time (MPT), the maximum length of time (in seconds) in which a person can sustain a vowel sound on one deep breath at a comfortable pitch and loudness, which is acceptable if greater than 7 seconds, in patients where glottic efficiency is poor.<sup>6</sup>



**Figure 8.** The device was pilot-tested on three patients from the social service out-patient department of our hospital

## RESULTS

All three patients tolerated speech using the improvised tracheotomy speaking valve without difficulty of breathing. Although with a harsh and breathy quality, their voices were clearly understood. Our subjects verbalized that the device was easy to use. They also liked the fact that they did not have to manually occlude the tube anymore while speaking. One patient who previously utilized intermittent corking of the tracheotomy tube during speech claimed to have decreased breathing effort after using the device, because inspiration with corking required more effort to overcome upper airway resistance. Using our device made it easier and more comfortable for the patients to breathe freely without the need for manual occlusion of their tracheotomy tubes. It was easily adapted and did not require any special training or breathing exercises. Maximum Phonation Time (MPT) averaged 8 seconds in all three patients.

Even if we had used a new endotracheal tube external adaptor & ABC elbow connector, the production cost of the innovative speaking

**Table 1.** Cost of Production

Material	Price
Endotracheal Tube (External Adaptor)	P400 *
Airway Breathing Circuit (Elbow Connector)	P350 *
Transparency OHP Acetate Film	P 45
Fine-toothed hacksaw blade	P 25
Multipurpose Cutter	P 35
Abrasive Paper (Sandpaper)	P 15
TOTAL	P870

\*price based on brand new item

valve would have been a mere Php 870 (Table 1) - a great difference from commercially available speaking valves which range from Php5,000 to 10,000 each depending on the brand and number of accessories.

## DISCUSSION

Tracheotomies are performed for a variety of indications and maintained for different durations. When prolonged tracheotomy is necessary, it becomes disabling and adversely affects the patient's capability to effectively communicate verbally. This impacts on quality of life and may lead to psychosocial complications. In our study, the patients became accustomed without difficulty to the use of our "low-cost" improvised device. Furthermore, the patients expressed ease of use and comfort during phonation.

Voice production requires good pulmonary support. In spontaneously-breathing patients with tracheotomy tubes this is made possible by adding a valve that will allow air to pass through the larynx during phonation. The speaking valve directs the exhaled air through the upper airway allowing the patient to speak.

Although many patients may benefit from a speaking valve, there are also contraindications to its use. According to Hess<sup>3</sup> speaking valves should only be used in fully conscious patients who are able to follow commands and attempt to communicate. Airway clearance should be assessed completely as secretions may obstruct airflow and compromise the airway. Upon application of the speaking valve, the patient's ability to breathe should be carefully assessed as many patients require long periods before acclimatization. In our subjects, the use of the improvised device was easily adopted. Neither further adjustments nor exercises were necessary to familiarize with its use. Although flap malfunction from adherence to the stopper due to tracheal secretions was theoretically possible, the patients were cautioned to immediately remove the device as a precautionary measure in such an eventuality.

During the assessment no adverse events were observed.

Commercially-available speaking valves are much more expensive, precluding their availability to financially-disadvantaged patients. Our improvised speaking valve provides an alternative to restoring speech without causing undue financial burden.

We were able to improvise a tracheotomy speaking valve devised from recycled materials which was functional and eco-friendly. The patients had their hands free to do other things while speaking. The device was easily adopted even without special preparations. Maximum phonation time averaged 8 seconds indicating efficiency of its use. Formal clinical trials are recommended to assess long term use, efficiency and safety issues especially regarding materials fatigue and maintenance procedures for daily care of the device. A standardized feedback questionnaire, and multi-observer perceptual evaluation with a system such as the GRBAS and/or vocal acoustic measures in a speech laboratory should be utilized in these trials.

## REFERENCES

1. Elpern EH, Scott MG, Petro L, Ries MH. Pulmonary aspiration in mechanically ventilated patients with tracheostomies. *Chest* 1994 Feb; 105(2):563-566.
2. Suiter DM, McCullough GH, Powell PW. Effects of cuff deflation and one-way tracheostomy speaking valve placement on swallow physiology. *Dysphagia* 2003 Fall; 18(4):284-292.
3. Hess DR. Facilitating speech in the patient with a tracheostomy. *Respir Care* 2005 Apr; 50(4): 519-25.
4. Stachler RJ, Hamlet SL, Choi J, Fleming S. Scintigraphic quantification of aspiration reduction with the Passy-Muir valve. *Laryngoscope* 1996 Feb; 106 (2 Pt 1):231-4.
5. Elpern EH, Borkgren Okonek M, Bacon M, Gerstung C, Skrzynski M. Effect of the Passy-Muir tracheostomy speaking valve on pulmonary aspiration in adults. *Heart Lung* 2000 Jul-Aug; 29(4):287-293
6. Graham Williamson, MPT as a Measure of Vocal Function. *Speech Therapy and Information Resources*, 2008 [cited 2008 November 24] 22:11 Available from: <http://www.speech-therapy-information-and-resources.com/maximum-phonation-time.html>