Tracheostomy: Evolution of an Airway

by Steven E. Sittig, RRT, and James E. Pringnitz, RRT

It was a frigid afternoon that day in Virginia, December 1799, as three physicians gathered around a dying man. The man kept shifting his position as he gasped for air. The physicians gave the man sage tea with vinegar to gargle, but it nearly caused the patient to choke to death. It was obvious the patient's airway was severely compromised, but poultices did little to help. It had been only a year since the medical literature of the time described a surgical procedure in which the trachea could be accessed in cases of airway obstruction. In 1799, even elective tracheotomy, let alone emergent tracheotomy, were rarely performed.

The patient's condition continued to deteriorate as he struggled for breath. One of the physicians was aware of the tracheotomy procedure but was reluctant to attempt it on such a famous person because the procedure was considered futile and irresponsible. Soon the patient became calm and died. History buffs may recognize this story as the death of George Washington. While arguments still persist about the cause of Washington's death, the most popular theory is that he died from an upper airway obstruction caused by bacterial epiglottitis.[1]

The surgical procedure of tracheotomy is actually a very ancient one. The procedure was portrayed on Egyptian tablets dating back to 3600 BC. The earliest known references to tracheostomy are made in the "Rigveda," a sacred Hindu book published around 2000 BC.[2,3]

Before 1800 only 50 life-saving tracheotomies had been described in the literature. In the 19th century, the tracheotomies performed for upper airway obstruction and those done for disorders of the lower airway were in the ratio of 90:10. Nowadays, the ratio is 20:80.[4]

Evolution of the tracheostomy

Tracheostomy tube materials have certainly evolved since 160 AD, when Galen wrote, "If you take a dead animal and blow air through its larynx (through a reed), you will fill its bronchi and watch its lungs attain the greatest dimension."[5]

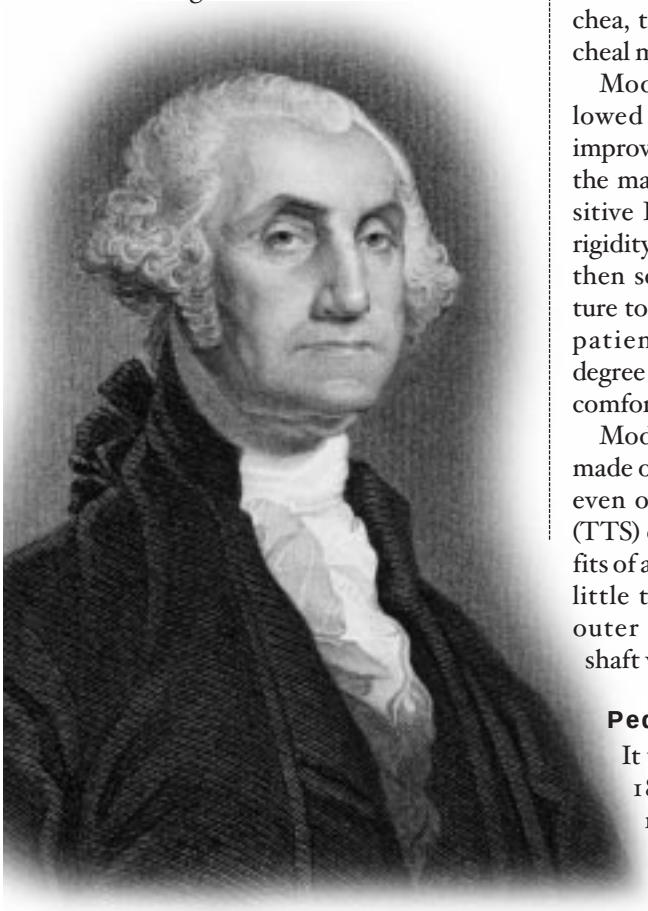
Early stainless steel or sterling silver tracheostomy tubes were very similar to that of today's oral airway in regard to angle and shape of the lumen. One can only imagine how uncomfortable these early tracheostomy tubes must have been. (A photo of antique sterling silver tracheostomy tubes can be seen at **www.twinenterprises.com/trach/history.htm**.)

With developmental improvements of natural and synthetic

materials such as silicone and polyvinyl chloride, improvements have been made over the years, resulting in improved designs more conducive to the anatomic airway, eventually leading to the modern-day tracheostomy tube.

Cuff evolution

In 1869, Trendelenburg first proposed the use of a cuffed tracheostomy tube.[6] It was not until the development of positive pressure ventilation (PPV) that such an adaptation of the tracheostomy tube was required. Before the 1970s, cuffs for both tracheostomy and endotracheal tubes were of the low-volume, high-pressure design, fulfilling the need to provide the application of PPV. These were designed for short-term use in the operating room. In the late 1960s, complications of tracheal mucosal damage caused by the application of high-pressure cuffs were discovered. Alternative designs were tried and tested, leading to the advent of the modern high-volume, low-pressure cuff.[5] When inflated, these cuffs provide a larger surface area for contact with the trachea, therefore minimizing tracheal mucosa destruction.



Modern technology has allowed manufacturers to craft improved products currently on the market. Today's thermosensitive PVC provides sufficient rigidity for initial insertion and then softens at body temperature to accommodate individual patient anatomy with a 105 degree angle in situ for improved comfort.

Modern-day cuffs are being made of velvet-soft material and even offer a tight-to-the-shaft (TTS) cuff, which has the benefits of a cuffed tube while adding little to the dimension of the outer diameter of the tube's shaft when deflated.

Pediatric tracheostomy

It was common in the early 1800s for children to receive tracheotomies in their treatment of diphtheria. Little changed in the indication for tracheostomy until 1932, when Wilson first suggested the proposed prophylactic and therapeutic use of a tracheostomy with poliomyelitis. Up until this time, tracheotomies were performed exclusively for patients with upper airway obstruction.[4,7] Early tracheostomy tubes were made of sterling silver or stainless steel, and these early airways had inherent problems associated with their use. They did not conform well to the airway, which led to complications such as formation of granulomas in the airway from repeated irritation, potential tracheal wall erosion, and tracheostomy tube occlusion against the tracheal wall.[8] While granuloma formation is tolerated in the adult population, any process that decreases an already narrow airway can have serious consequences in pediatrics.

With the advent of improved neonatal care, more premature infants were surviving only to develop acquired subglottic stenosis from prolonged tracheal intubation and mechanical ventilation. In 1972, only 30 percent of children who required tracheotomy were under the age of one year. This percentage increased to 45 percent by 1983, and

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in 1996 this figure climbed to 70 percent with over half of these children being under three months of age. These statistical changes placed an increased need for surgeons to become more skilled as they performed tracheotomies on smaller and smaller patients. This new patient population required specialized tracheostomy tubes in special sizes and lengths that were at that time never before been needed.[9]

Specialized tracheostomy tubes made from synthetic materials soon replaced most applications of the metal tracheostomy tube. The newer generation tracheostomy tubes are now better designed for children of all ages. The curvature of the modern cannula is now designed to be co-linear and concentric with the trachea to better conform to the airway, leading to less abrasion by the tracheostomy tube.

There are now many options available in the pediatric population. Specialized lengths and a wider range of sizes with and without cuffs are some of the many options available.

Not all that long ago, children who had tracheostomy tubes were kept in the hospital, as there was no formal education program to allow them to transition to home. During my research for this article, a lady who had a tracheotomy as a young child in the mid 1950s told me a story. She was allowed to go home only occasionally because a nurse lived next door, and her mother developed a crude alarm to monitor her daughter as she lay in the crib. The alarm system consisted of a small bell tied to the child's toe, and the mother slept on a mattress on the floor next to the crib.

Today there are many advances in technology and education that make it possible for the child with a tracheostomy tube to safely and effectively transition to the home setting.

The improvement in design/materials of tracheostomy tubes and the medical management and education of parents/caregivers has significantly decreased pediatric mortality.[10] A better understanding of the pathophysiology that can occur to the pediatric airway when even routine tracheostomy care is completed, has led to important new tracheostomy care guidelines. It is imperative that caregivers of pediatric tracheostomy patients are educated to manage the two most serious complications of mucous plugging and inadvertent decannulation.[7] Fortunately, advances in corrective surgery for pediatric airway disorders has continued to improve, allowing more children to be decannulated without complications and allowing them to lead more normal lives.[10]

It is important that we as respiratory care professionals be involved in all aspects of tracheostomy issues from routine care, patient/family education, and home transitional care plans. Airway management is a forte of the respiratory care practitioner; our expertise can be a valuable asset to the health care team, family, and especially the patient. The one constant thing about those of us who work in the field of medicine and patient care is that there is always an evolution in technology and knowledge. As we help care for patients with tracheostomy, we become part of the history that has been illustrated here.

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