TRACHEOTOMY – EVOLVING TECHNIQUE AND CURRENT INDICATIONS

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Abstract

Tracheotomy has been around for thousands of years, having been described in hieroglyphs and texts from ancient Egypt, dating as much as 3000 B.C. However, it was not until the 19th century that this procedure was utilized on a large scale. Its evolution was directly linked to two great epidemics, the diphtheria epidemic of nineteen century Europe, and the poliomyelitis epidemic of North America in the 20th century. Its use as both a life-saving measure and aid in assisted pulmonary ventilation and care have been established by trial and error during these troubled times. The classic, open tracheotomy is not without risks and complications, with important hemorrhage from anterior jugular veins, thyroid vessels and the Lalouette pyramidal thyroid lobe being cited. Possible injury to the subclavian vein or brachiocephalic venous trunk, although extraordinary, is associated with life-threatening hemorrhage. Because of these possible complications, as well as the need for a ENT surgeon and an operating theatre and instrumentation, modern alternatives have been developed and thus the percutaneous dilatation tracheotomy has been introduced in emergency room and ICU settings. Modern indications for performing a tracheotomy, whatever technique is used, are grouped in 4 main categories: bypassing superior airway obstruction, surgical access, prolonged intubation and mechanical ventilation and pulmonary toilet. Tracheotomy is an essential procedure in the surgical armamentarium of head and neck surgeons, utilized less today as an emergency life-saving intervention and more as a supportive measure in ICU patients.

Keywords: tracheotomy, percutaneous tracheotomy, ICU care

Introduction

Tracheotomy was one of the first surgical procedures known to man, with references of it found in ancient egyptian and hindu texts, dating back to 5000 years ago [1]. Even Alexander the Great was said to have had saved a man’s life by cutting an opening in his windpipe with his sword [2].

However, the first modern recorded technique is attributed to Antonio Mussa Bresavola (Figure 1), an italian surgeon from Ferrara, who described the procedure he performed on a patient with a „laryngeal abscess” (probably of the epiglottis) in his medical treaty of 1546: „Examen omnium simplicium medicamentorum, quorum in officinis usus est.”

After Bresavola’s work was published a long period of neglect came upon this
procedure, doctors of the time considered it dangerous, mutilating and unnecessary, failing to recognize its necessity.

Figure 1 - Antonio Mussa Bresavola, sketch by Farina – picture courtesy of The U.S. National Library of Medicine (Public Domain; ID: 101410826)

A famous, but otherwise tragic, episode was the one that led to the death of George Washington, former first president of the United States of America. In his later years, after retiring to the countryside, he developed what we now believe to be, after the description of his physicians, acute epiglottitis with superior airway obstruction. Of the three doctors summoned to treat him, only one advocated for performing a tracheotomy (Dr. Elisha Dick), but was voted against by his senior, more experienced colleagues. George Washington died one day later from his illness, as well as bloodletting – the treatment of the day prescribed by his team of doctors [3].

Tracheotomy, in its modern form, with its modern indications, owes its existence to two great pandemics – the diphtheria outbreak of the mid nineteen century in Europe and the poliomyelitis epidemic in the United States of America, in the twentieth century. In Europe, diphtheria was causing a great number of deaths due to „diphtheroid croup” – airway obstruction – and surgeons soon realized that tracheotomy was a life-saving procedure, as described by Dr. Armand Trousseau, who operated 200 patients, with great results [1]. The next century, during the polio epidemic, tracheotomy was used to facilitate ventilation – combined with positive pressure ventilation, as well as an aid in the pulmonary toilet. Its value was demonstrated as it reduced mortality in patients with bulbar poliomyelitis with as much as 70% [4].

Surgical technique

The procedure may be performed either under general anesthesia or, as is the case in airway obstruction or emergency settings under local anesthesia. In extreme emergencies, tracheotomy is performed with only one incision through all anatomic planes reaching the trachea in one swipe.

The standard technique, utilizes a vertical incision in the midline of the neck, from the inferior border of the thyroid cartilage to the sternal notch (Figure 2).

Figure 2 - Personal sketch by Dr. Coman Cristina (co-author):
A. Important cervical landmarks underlying the skin and platysma muscle
B. Exposure of the thyroid istmus after incision and separation of the prelaryngeal strap muscles
C. T shape incision of the trachea after ligation of the thyroid isthmus
D. Final aspect, after hemostasis and tracheal cannula placement.

In selected cases, because of aesthetic or access considerations, a horizontal, arcuate incision may be utilized. This is mostly used when later elevating a cervical flap, as is the case in laryngectomy, or in the case of thyroidectomy.

The prelaryngeal strap muscles are divided along the cervical „linea alba”, with minimal blood loss if respecting this anatomic
plane. The thyroid isthmus is then dissected anteriorly and posteriorly – thus delimiting it from the anterior wall of the trachea, clipped and separated. When the anterior wall of the trachea is evident, the tracheotomy is performed, either by a vertical midline incision of the first and second tracheal rings („high“ tracheotomy), second and third tracheal rings (standard procedure) or third and fourth rings („low“ tracheotomy) or by executing a U-shaped flap (Björk technique) which is then sutured to the cervical skin. It is important to define that tracheotomy is the procedure that opens the trachea and it is temporary – remaining open for as long as a tracheal cannula is in place to prevent the collapse of the tracheal wall.

During a tracheostomy, the walls of the trachea are sutured to the skin of the neck, thus preventing collapse and spontaneous closure of the incision. So, a tracheotomy is by definition temporary, while a tracheostomy may be temporary (requiring surgical closure if unnecessary) or permanent (as in total laryngectomy) [5].

Complications

Classification of complications is usually done in three categories: intraoperative, early (<7 days) and late (more than 7 days).

Intraoperative complications usually are: bleeding – from the anterior jugular veins or thyroid gland vascular arches; pneumothorax or pneumomediastinum – uncommon, by accidental instrumentation of the pleural dome; airway fire – rare, mostly due to high concentration of oxygen ventilation and use of cautery when cutting open the tracheal wall. Also, a rare complication may be cardiac arrest, when cutting open the trachea. This is due to a vagal reflex, and usually responds favorably to resuscitation and epinephrine administration. In the rare case of extreme emergency tracheotomy, a deep cut with the scalpel may protrude through the posterior tracheal wall, with perforation of the esophagus and a subsequent eso-tracheal fistula formation. In cases of lateral deviation of the trachea, injury to the recurrent laryngeal nerves is more likely.

Early postoperative complications may be: wound infection, hemorrhage, subcutaneous emphysema, tracheal tube obstruction and accidental decannulation – all easily preventable by proper dressing and antibiotic treatment of the wound and management of the tube. When using cuffed tracheotomy cannulas, the inflated cuff acts as external compression on the esophagus – making swallowing difficult.

Late complications are: peristomal granulations, tracheal stenosis, tracheo-innominate fistula (a lethal complication, due to fistula formation between the tracheal wall and the innominate artery – the arterial brachiocephalic trunk), tracheoesophageal fistula and tracheocutaneous fistula [6,5].

Modern alternatives

Performing a tracheotomy is not without risks and possible complications, some of which can be life-threatening [7]. These risks, which are associated with open surgery, the need for a ENT surgeon and an operating theatre, as well as the ICU setting which imposes sometimes fast „on-the-fly“ decisions, have concurred to give birth to alternatives when performing tracheotomy – the percutaneous dilatation tracheotomy.

First developed by Toy and Weinstein in 1969 [8], it was later publicized with the apparition of the Ciaglia technique [9], and appeared to be more time-efficient and cheap than open surgery. However, cases were reported of bleeding and aspiration, attributed to trauma and intersection of the anterior venous vessels in the cervical area. Efficient as it is, this technique requires „blind“ insertion of the catheter through the anterior structures of the neck, and has obvious limitations [10].

Long-term evaluation and comparison between open surgery and percutaneous tracheotomy has shown similar results – with complications regarding bleeding being more numerous in the percutaneous group and wound infections more frequent in cases when open tracheotomy was performed [11,12].
Current indications

Indications for performing a tracheotomy can be grouped in four major categories [6]: airway obstruction – the first „historic” indication – used to bypass an obstruction, such as in severe facial or cervical trauma, acute inflammation (supraglottitis, epiglottitis, angioedema), bilateral vocal fold paralysis, tumors, foreign bodies or even obstructive sleep apnea.

The second group of indications is surgical access, such as in cases of reconstructing complex facial and maxillary fractures or surgical excision and consequent reconstruction of locally advanced oral, base of tongue or laryngeal cancer.

The third, and newest group of indications for tracheotomy, is prolonged mechanical ventilation. In patients with neurologic and neuromuscular conditions, respiratory diseases or depressed mental status (which leads to the inability to protect the airway and pulmonary aspiration), tracheotomy is a valuable tool to prevent laryngeal stenosis, to aid in ventilation by reducing the load and pressures, and to ease pulmonary toilet.

The last indication for tracheotomy is pulmonary toilet – sometimes necessary in patients with severe chronic pulmonary diseases, mucoviscidosis, or degenerative neuro-muscular conditions.

Timing and benefits of tracheotomy

Apart from emergency situations of airway obstruction (epiglottitis, foreign bodies, bilateral vocal cord paralysis, tumors), tracheotomy is elective, thus care should be taken in choosing the adequate moment for it.

Advantages of tracheotomy versus oro-tracheal intubation are: avoids the risk of laryngeal stenosis (due to the lesions from the intubation tube resting on the posterior commissure of the vocal cords) – which is very difficult to treat and risks damaging the swallowing and speech of the patient; decreases the need for sedation; quickens the return to oral feeding and communication.

It is debated and currently under scrutiny the assumption that patients who are ventilated through a tracheostomy performed early on admission in the ICU have a better overall outcome and a shorter ICU stay than those under oro-tracheal intubation.

As far as the timing of this procedure, in 1989 a first guideline was proposed by the American College of Chest Physicians that stated that if less than 10 days of mechanical ventilation were expected then tracheotomy was not needed, but if more than 21 days of mechanical ventilation was to be expected, then a tracheotomy should be performed [6].

The more recent TracMan extensive study performed in the U.K., concluded that early tracheotomy has no benefit on patient ICU stay or mortality, and because of the 6.3% complication rate and the highly variable estimations of clinician of the mechanical ventilation time should be avoided and a decision on whether to perform a tracheotomy should be delayed to around day 10 of intubation and ventilation [13].

Conclusions

Tracheotomy is a surgical procedure with a vast history, which has seen its indications expand in conjunction with the developments of medical science. First regarded and used as an emergency life-saving measure in cases of upper airway obstruction it is now performed mostly on an elective basis in the Intensive Care Unit, with a clear shift towards alternative minimally invasive percutaneous dilatative techniques.

Not without complications, tracheotomy has clear advantages in the ICU, reducing the risk of laryngeal stenosis, as well as need for sedation and securing a more rapid return to oral feeding and communication. Even if it does not influence mortality of the critical ill patients, tracheotomy is recommended for prolonged intubation with mechanical ventilation. The future will decide which direction this storied procedure will take, but it is certain that the need for it will always be present and it will be an indispensable weapon in the ENT surgeon’s armamentarium.
References