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Emergency operative airway techniques

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The otolaryngologist—head and neck surgeon must be adept at providing assistance and intervening surgically in airway management when adequate ventilation becomes challenging. A step-wise and logical approach to airway emergencies can prevent poor outcomes. It is therefore important to have both a strong understanding of airway anatomy as well as an armamentarium of strategies or techniques in securing the airway if ones initial approach is problematic. The present article discusses several surgical approaches to the patient with a difficult airway.

Historical perspective

The surgical airway as a critical lifesaving measure has been well documented throughout history. Egyptian tablets depict tracheotomy procedures dating back to 3600 BC. The Rig Veda, an ancient Hindu medical text, makes reference to throat incisions for airway management in 2000 BC and Alexander the Great reportedly used the tip of his sword to incise the trachea of a soldier who had aspirated a bone. Although, Asclepiades of Bithynia is credited with performing the first tracheostomy around 100 BC, Aretaeus and Galen, both Greek physicians, described the procedure in the second century AD.[1,2] Paulus Aegineta, a seventh century Byzantine Greek physician, described a procedure initially developed by Antyllus of Rome in which a transverse incision was used to open the trachea between the third and fourth cartilaginous rings, drawing the cartilages apart with hooked instruments and later reapproximating the wound edges when the patient's airway obstruction had resolved.[1,2] Following the decline of the Roman empire, during the ensuing dark ages, there was little mention of airway procedures. However, during the Renaissance, efforts to manage the surgical airway regained prominence and descriptions of various procedures can be found throughout the literature of this time. The first documented case of a successful modern tracheotomy, in a patient with tonsillar hypertrophy resulting in obstruction, was by Italian physician Antonio Brasavola in 1546. Despite continued advances in surgical airway management throughout the ages, its implementation continued to be inconsistent by physicians. In possibly the most poignant historical account, the first president of the United States, George Washington, died in December 1799 owing to his medical staff's disinclination to surgically manage his airway obstruction caused by infections. The first successful tracheotomy was later performed in the United States in 1852.[2] The patient unfortunately later died of airway stenosis, a common complication of the procedure for some time to follow. Mortality rates of 50% were documented for tracheotomy in the late 1800s.[3] It was not until 1909 that a landmark paper by Chevalier Jackson illustrated a safe surgical technique with significantly lower mortality rates of 3%. Jackson[4] also criticized what was referred to as “high tracheotomy,” now commonly known as cricothyroidotomy, owing to the incidence of stenosis following the procedure. However, in retrospect it has been speculated that the primary indication at the time, inflammatory upper airway lesions,

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likely contributed to the high rate of subglottic stenosis. It was not until Brantigan and Grow[5] later published a series of 655 patients who had undergone cricothyroidotomy, describing a procedure that was significantly less technically demanding and safer than tracheotomy, that it became more widely implemented. They reported a stenosis rate of 0.01% with no other major complications.[5] Innovations made from antiquity until the twentieth century have therefore formed the foundation of modern surgical airway management. The development of progressively effective airway instruments coupled with a more comprehensive understanding of the physiology of the upper airway has greatly influenced modern practice.

Indications for emergency surgical airway management

Patients with upper airway obstruction who have failed management with less invasive methods of ventilation and intubation are candidates for emergency surgical airway interventions. Failure to successfully intubate a patient may be attributable to difficult airway anatomy, significant airway edema, oropharyngeal hemorrhage, obstruction due to mass lesions, and substantial maxillofacial or neck trauma. Surgical airway management should be considered after 1 or 2 attempts at intubation by an experienced provider have failed, the patient cannot be ventilated with face mask or a supraglottic airway, or there is an immediate need for establishment of a definite secure airway. In spite of the advent of numerous emergency devices for failed airways, repeated unsuccessful attempts at intubation result in significant errors in management of difficult airways.[6] The American Society of Anesthesiologists Difficult Airway Algorithm recommends establishment of an invasive airway access as the ultimate endpoint for the unsuccessful arm of the pathway.[7] Failure to successfully identify a patient or scenario in which ventilation cannot be successfully executed in a noninvasive manner will result in a delay in securing control of the airway placing the patient at unjustifiable risk for hypoxic brain injury or death. Surgical interventions for establishment of an airway include open surgical cricothyroidotomy, needle or percutaneous cricothyroidotomy, transtracheal jet ventilation (TTJV), and tracheotomy.

Surgical cricothyroidotomy

Cricothyroidotomy, or cricothyrotomy, is the surgical establishment of an opening into the airway through the cricothyroid membrane with subsequent placement of a tube for ventilation.[8] In emergent scenarios in which one is limited by both time and experience, cricothyroidotomy may be superior to tracheotomy owing to less time required for the procedure, the relative simplicity with which it can be performed in less experienced hands, and lower associated complication rates. The cricothyroid membrane extends from the thyroid cartilage to the cricoid ring consisting primarily of fibroelastic soft tissue. In adult males, the cricothyroid membrane measures 2-3 cm in width and 1 cm in height. It is located in the midline approximately one finger breadth below the laryngeal prominence. The membrane is roughly 1 cm below the vocal folds and injury to these structures therefore remains a risk with this procedure. This membrane is amenable to incision at any age owing to the fact that it does not calcify and has no muscles, nerves, or large vessels overlying it. It should be noted that the anterior jugular veins border the membrane laterally and may result in substantial bleeding if injured. The cricothyroid arteries branch from the superior thyroid arteries bilaterally and typically cross the superior aspect of the cricothyroid membrane, anastomosing in the midline.[9] These vessels may be injured in this procedure, but the resulting hemorrhage is generally self-limited and controlled without difficulty using gauze packing. The location of the membrane can be estimated to be 3-4 finger breadths above the suprasternal notch with neutral positioning of the neck. This is approximately 1 finger breadth below the laryngeal prominence. In patients with larger body habitus, soft tissue edema, or neck trauma, palpable anatomical landmarks may be distorted rendering this procedure more difficult. Relative contraindications for cricothyroidotomy include expanding neck hematomas, neck trauma causing complete inability to identify landmarks, pre-existent laryngeal disease with involvement of the subglottis (eg, tumor, infection, and trauma), or patients younger than 10 years old. In these circumstances, a planned urgent awake tracheotomy is favored. However, it should be noted that an emergency, or "slash," tracheotomy has a high risk of complications, often cited as up to 5 times that of an elective tracheotomy.[10]

The initial step in cricothyroidotomy includes palpation of the sternal notch, laryngeal prominence of thyroid cartilage, and cricoid cartilage. The surgeon's nondominant hand is used to stabilize the airway. The superior cornu is held between the thumb and long finger while the index finger is used to palpate for the cricothyroid membrane (Figure 1). This technique immobilizes the larynx, maintaining anatomically correct positioning of the airway. This has been reported as being the most important factor influencing successful outcomes.[11] A vertical midline incision is then made, avoiding injury to anterior jugular veins, jugular, and carotid vessels, through the skin overlying the cricoid cartilage (Figure 2). The cricothyroid membrane is subsequently palpated through the incision. Once identified, a horizontal incision is made at the inferior aspect, to avoid the cricothyroid artery and vein (Figure 3). This opening is then bluntly expanded with either a Kelly clamp or hemostat (Figure 4). A tracheal hook may be used to retract the inferior edge of the cartilage to assist in exposing the airway. A small tracheotomy tube or a 5-0 endotracheal tube can then be secured in position (Figure 5). After the patient's airway has been established and he or she has been stabilized, the cricothyroidotomy should be altered to a formal tracheotomy, particularly if long-term implementation is anticipated. Several simplified techniques