Tracheal Injuries Complicating Prolonged Intubation and Tracheostomy

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KEYWORDS

• Postintubation airway complications • Tracheal stenosis • Prolonged intubation

KEY POINTS

- Airway complications following prolonged ventilator assistance remains a significant but largely preventable problem.
- Postintubation tracheal stenosis most commonly results from overinflation of the cuff causing pressure necrosis of the adjacent tracheal wall.
- Symptoms, including increasing shortness of breath and wheezing, usually present between 4 and 8 weeks after extubation and are frequently misdiagnosed as asthma.
- Malpositioning of an endotracheal tube cuff in the subglottic region may result in subsequent stenosis at that level, following as little as 2 days of exposure.
- A high tracheostomy site, at the level of the cricoid cartilage or the first tracheal ring, may result in partial or complete subglottic stricture and the inability to safely decannulate the tracheostomy tube.

INTRODUCTION

Injuries to the upper airway related to the use of endotracheal and tracheostomy tubes for ventilatory assistance reflect a common theme: innovative advances in the medical field often generate a new set of complications, which then generate further advances designed to reduce or eliminate such consequences. During the authors' preparation of this article, written in tribute to Dr F.G. Pearson, there were many long pauses for reflection on the remarkable advances in cardiothoracic surgery, anesthetic management, and postoperative care that have occurred since the author was a surgical intern in 1964.

HISTORY OF POSITIVE-PRESSURE VENTILATION

The oldest recorded surgical procedure on the airway is in the Edwin Smith Papyrus, an ancient Egyptian medical text thought to date around 1600 BCE. It illustrates what is thought to be a tracheotomy to provide an emergency airway. The use of tracheotomy, with or without insertion of a tracheostomy tube, was used almost exclusively for treatment of upper airway obstruction until the latter half of the nineteenth century. Several articles have chronicled the history and evolution of tracheostomy use.[1–3]

The development of thoracic surgery, the ability to safely operate within the chest, posed a unique problem. Specifically, opening the chest and exposing the lung to atmospheric pressure eliminated the normal negative differential pressure between the pleural space and the upper airway, allowing the lung to collapse from its unopposed elastic recoil. Endotracheal intubation was used by Vesalius in 1543 for artificial respiration. In 1895, Tuffier modified an endotracheal tube by adding an inflatable cuff around it to allow positive

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pressure to be applied to the lung. Nonetheless, for some reason, this technique was not used in the early days of thoracic surgery. Desiring to operate on patients with esophageal malignancies, von Mikulicz charged his disciple Sauerbruch with the task of solving the problem. Sauerbruch's solution was a negative pressure operating room chamber, in which the operating theater was a sealed room in which the pressure could be reduced by 10 to 20 cm below atmospheric pressure. The patient's head went through a hole in the wall with the neck surrounded by a sealing cuff so that the mouth and nose were exposed to atmospheric pressure on one side of the wall while the chest (and the operating staff) was exposed to a negative differential pressure on the operating room side. Thus, when the chest was open, the lung could remain inflated because subatmospheric pressure was maintained in the chamber and anesthesia was administered by the anesthetist outside the chamber. By the summer of 1904, von Mikulicz had performed 16 pulmonary or esophageal cases on patients using this technique.

Meltzer and Auer, in New York in 1909, recognized the advantage of using positive intraoperative pressure with an endotracheal tube but the reputation of Sauerbruch and von Mikulicz, and their continued advocacy of the negative pressure chamber, suppressed the acceptance of positive-pressure ventilation with an endotracheal tube for almost a decade.

Until the 1950s, positive-pressure ventilation was reserved almost exclusively for intraoperative anesthetic management using a facial mask, uncuffed endotracheal tubes with pharyngeal packing to prevent air-leakage, or cuffed endotracheal tubes. The extension of positive-pressure ventilation to the treatment of respiratory failure resulted from the poliomyelitis epidemic in Copenhagen in 1952 as a substitute for the use of the iron lung. Its routine use for postoperative respiratory support occurred a decade later, primarily in association with the development of cardiac surgery. Until that time, there were no postoperative intensive care units and the concept of electively providing postoperative respiratory support was not generally adopted. This is sadly illustrated by the authors' reminiscence, as an intern in 1964, of a woman in her late 20s with myasthenia gravis who had undergone median sternotomy for excision of a thymoma. Postoperatively, the patient was in respiratory distress for several days with labored breathing and secretion retention. It was uncertain whether or not the problem was a myasthenic crisis mandating higher doses of steroids and anticholinesterase medications, or a cholinergic crisis due to excessive administration of anticholinesterase agents. At the time, the notion of intubating and ventilating the patient was apparently not considered and the patient succumbed.

ETIOLOGIC FACTORS OF POSTINTUBATION UPPER AIRWAY INJURY

With the advent and proliferation of subspecialty intensive care units, which included the provision of mechanical respiratory support, the use of tracheostomy markedly increased and, not surprisingly, complications of this procedure were not uncommon. By and large, these were early postoperative complications, including wound hemorrhage, or displacement or secretion obstruction of the tube. Increasing experience eliminated most of these early complications but, as patients began to survive longer periods of respiratory assistance, a new group of late complications from the use of cuffed endotracheal tubes or tracheostomy tubes developed. There were reports documenting an increased incidence of postintubation tracheal stenosis as high as 20%. Strictures were reported both in the region of the tracheostomy stoma and at the level of the inflatable cuff.

In 1968, Pearson and colleagues reported on 24 individuals with postintubation tracheal strictures, over two-thirds of which were thought to arise at the level of the stoma.[4] Over a similar period, Grillo[5] reported surgical management in 31 postintubation strictures, 27 of which were thought to be at the cuff site and 4 at the stomal site.

TRACHEAL STENOSIS AT THE CUFF SITE

In 1965, the author, under the direction of Dr Grillo, performed autopsy examination of the larynx and trachea on 30 patients who died in the hospital while receiving respiratory assistance through cuffed endotracheal or tracheostomy tubes.[6] The duration of intubation before death ranged from 1 day to 8 weeks. The gross and microscopic evaluation revealed a consistent pattern of damage to the tracheal wall correlating with the site of the balloon cuff. In general, the longer the duration of mechanical ventilation the greater the injury to the trachea. Early changes included mucosal hemorrhage and ulceration, which progressed to deeper ulcerations exposing portions of the cartilaginous rings. With longer exposure, these ulcerations increased in extent, resulting in fragmentation and dissolution of adjacent cartilaginous rings. This left a segment of trachea without support and full-thickness damage to the tracheal

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