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Under Pressure: Tracheostomy Cuff Over Inflation Leading to Tissue Necrosis and Cuff Rupture

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Learning Objectives

- Identify indications and complications associated with tracheostomy.
- Describe the risk factors of tracheostomy complications, specifically tracheal fistula.
- Describe how tracheostomy teams, staff education and cuff monitoring protocols help to avoid tracheostomy complications.
- Understand how proper tracheostomy tube choice and sizing, as well knowledge of different tracheostomy brands can decrease the risk of leaks around cuffs.

The Case

A 56-year-old man was admitted with Coronavirus Disease 2019 (COVID-19) pneumonia and acute respiratory failure, requiring mechanical ventilation. Given his severe lung damage and the anticipated need for very slow weaning from the ventilator, the critical care team decided to proceed with early tracheostomy. This procedure was performed percutaneously at the bedside, with some difficulty dilating the tracheal ring, requiring repeated dilations. The tracheostomy tube was secured, inspected via bronchoscopy, and properly sutured.

Over the following days, the respiratory therapist noted an air leak around the tracheostomy cuff; additional inflation of the cuff was required to obtain an adequate seal. The tracheostomy site was evaluated by the clinical team and instructions were given to further inflate the cuff and monitor cuff pressures. However, cuff pressure values were neither documented in the medical record nor communicated to the physician team. After multiple air leak episodes treated by adding more air into the cuff, the decision was made to change the tracheostomy tube. Before this could happen, the patient developed increasing hypoxemia and respiratory distress, ultimately leading to hypotension and requiring 100% inhaled oxygen via the ventilator. On inspection, the tracheal cuff had burst, leading to a severe leak in addition to a tracheal tear with surrounding tissue necrosis. An oral endotracheal tube was placed with the balloon distal to the tracheal injury and adequate ventilation was achieved. The patient subsequently underwent surgical repair of the tracheal injury. The repair was uneventful, and the patient’s postoperative course was notable for continued slow weaning from the ventilator and discharge to an appropriate rehabilitation facility.

The Commentary

By Elizabeth Gould, NP-C, CORLN, Kathleen M Carlsen, PA, Brooks T Kuhn, MD, MAS, and Jonathan Trask, RN

Background

This case addresses the management of a recurrent leak around the cuff of a tracheostomy tube. The clinical team's response was to insert air repeatedly into the cuff, but increased balloon pressure led to tissue necrosis, leading to even more air leakage. This cycle led to the patient's acute decompensation, and eventually to surgical repair of the iatrogenic tracheal injury. This case highlights the importance of monitoring endotracheal and tracheostomy tube balloon pressures carefully and intervening in a timely manner to avoid tissue breakdown from ischemia.

Indications, Complications, and Risk Factors of Tracheostomy

The modern percutaneous tracheostomy technique was first described in the 1950s by Shelden and colleagues,[1] although tracheostomies have been performed for thousands of years.[2] Ciaglia and colleagues improved the percutaneous procedure by applying the Seldinger technique, which involves needle access of the trachea followed by placement of a guidewire and dilation.[3] The procedure now includes bronchoscopy to directly visualize the tracheal puncture.[3] The advantage of the percutaneous compared to the open approach is that it can be performed at the bedside without the resources and potential delay of scheduling time in an operating room. An open approach should be considered in patients with morbid obesity, short necks, tracheal deviation, or impaired neck extension. The indications for tracheostomy include upper airway obstruction (e.g., obstructive sleep apnea; stridor and air hunger due to vocal cord paralysis or neck trauma, tumors, foreign bodies, or inflammation after surgery or radiation), prolonged or expected prolonged intubation for respiratory failure, inability to manage respiratory secretions, inability to orally intubate, ventilatory support for neuromuscular disease, and as an adjunct to head/neck surgery or trauma.[4] The benefits of tracheostomy, compared with endotracheal tubes, include improved patient comfort and ability to eat by mouth, more rapid liberation from mechanical ventilation, fewer days in intensive care, decreased need for sedation, and decreased risk of ventilator-associated pneumonia.[5]

Complications from tracheostomy can occur intraoperatively (creation of a false tract, bleeding, posterior tracheal wall perforation, thyroid injury, hypoxemia), perioperatively (pneumothorax, subcutaneous emphysema), and postoperatively (tube dislodgement, airway stenosis, tracheal fistulas). Tracheal fistulas represent abnormal connections between structures and are categorized by the involved structures: tracheoesophageal, tracheoinnominate artery, or tracheocutaneous fistulas.[6,7] With the use of the Seldinger technique, complications from esophageal or carotid injuries are unlikely.[4] Deaths directly caused by tracheostomy are rare but have been described. A large study of tracheostomy-related deaths over a 10-year period in the US found a higher prevalence among children and younger adults (18-64 years of age), and among African American children and adults. Tracheostomy-related deaths were more frequent on weekends than on weekdays, supporting the belief that these deaths are largely preventable through careful procedural and post-placement care.[6]

Patient-related risk factors that affect wound healing after tracheostomy placement include diabetes, tracheomalacia, smoking tobacco products, chronic obstructive pulmonary disease, sleep apnea, peripheral vascular disease, history of stroke, abnormal chest anatomy, and exposure to larger endotracheal tubes before tracheostomy.[8] Modifiable care-related risk factors for tracheal fistulas include overinflation of the cuff, malpositioning of the tracheostomy, corticosteroid use, tracheal infection, and tracheostomy below the third tracheal ring.[7,8]

Approach to Improving Safety

Tracheostomy tube leaks are problematic for patient management because they may cause inadequate ventilation, necessitate early tracheostomy tube changes, and contribute to ventilator related pneumonias.[9,10] Leaks around cuffs can be caused by improper sizing or positioning of tracheostomy tubes, high ventilator settings, as well as prolonged ventilator dependence and progressive dilation of the trachea at the tracheostomy tube cuff site.[9,10] The description of this case does not include information about what type of tracheostomy tube was placed, what ventilator settings were applied, or the patient's body habitus, but this information would be useful in identifying patient-specific contributing factors.

Patients dependent on mechanical ventilation require a tracheostomy tube that has an appropriate internal diameter to achieve adequate air exchange and a resting cuff diameter that will achieve a seal between the cuff and the tracheal walls, without overinflation of the cuff.[8] Overinflation of the cuff can cause excessive pressure on the capillary structure of the trachea and lead to necrosis and fistulas, as in this case scenario.[7,8] Also, the smallest tracheostomy tube that will meet clinical requirements should be chosen to prevent stenosis, which could potentially necessitate permanent tracheostomy.[7,8]

Choosing a size and brand of tracheostomy tube is often approached based on physician experience and preference, guided by how tracheostomy supplies are managed and made available in an institution. A regular length, size 8 cuffed tracheostomy tube is a standard choice for initial placement on adult patients requiring mechanical ventilation; however, the patient's body habitus, anticipated ventilator settings, and tracheostomy brand variations should be considered. Different brands have different external diameters and lengths, which affect anatomic fitting into the trachea. Some brands use Jackson sizing and others use International Sizing Organization (ISO) standards. Jackson sizing does not reference any measurement on the tracheostomy tube, whereas ISO sizing typically refers to the internal diameter of the outer cannula, which is useful when considering air flow resistance. A larger adult patient requiring mechanical ventilation should usually have a size 8 or 9 tracheostomy tube, while a smaller adult can have either a size 7 or 8. Ventilator settings requiring high flow rates and driving pressures require larger tracheostomy tubes. Furthermore, longer tracheostomy tubes, with proximal extensions, should be considered for patients with body mass index (BMI) greater than 30.

Even if an air leak is noted after initial placement of a tracheostomy tube, immediate replacement with a larger tube may be unsafe due to the immature stoma. Unfortunately, it may be necessary to leave the cuff overinflated until it is safe to perform the first tracheostomy tube change, but the team should acknowledge the situation and plan the change as early as possible. Some institutions have adopted the practice of placing tracheostomy tubes with a distal extension, which leaves the tube lower in the airway, but with the tip terminating at least 2 cm above the carina. These tracheostomy tubes have relatively large resting cuff diameters, thus minimizing the frequency and severity of air leaks.

Generally, the resting cuff diameter of the cuff causing the leak should be compared to the resting cuff diameter of the tracheostomy tube cuff being considered as a replacement. Imaging of the trachea can be reviewed for any clinically significant abnormalities. In cases of localized tracheomalacia or air leaks that have developed over time, upsizing should be avoided to prevent further dilation of the airway. Dilated tracheas at the level of the tracheostomy tube cuff should prompt clinical evaluation, particularly in long-term ventilator-dependent patients. Longer tracheostomy tubes may be placed in the distal intact trachea to bypass areas of dilation, as appropriate.

The patient in this clinical scenario was noted to have COVID-19 pneumonia. Many patients with COVID-19 complications from tracheostomy in the setting of long-term mechanical ventilation have been noted to have high BMI and ventilator settings.[11] For both these reasons, tracheostomy tubes with larger internal lumens should be considered. Patients with COVID-19 lung injury should also be evaluated for extended tracheostomy tubes, but unfortunately these tubes are not available for percutaneous placement.

Systems Change Needed

To prevent patient harm from cuff overinflation for both endotracheal and tracheostomy tubes, hospitals must adopt protocols outlining routine practices for monitoring cuff pressures and communicating abnormal findings to providers. Staff education and training are needed to understand and troubleshoot any issues with cuff pressures or air leaks.[12] A dedicated tracheostomy team can be a resource for education and can help maintain standards of care for tracheostomy tube management.[13,14]

Many studies have been conducted to determine a safe range for cuff pressure. Consensus opinion suggests endotracheal and tracheostomy tube cuff pressures have a goal range of 20-30 cm H_20.[9,15] Cuff pressures over 30 cm H_20 can cause impaired capillary blood flow, and even absent capillary blood flow at cuff pressures over 50 cm H_20.[15] Stenosis, fistulas, and other tracheal injuries can occur due to local tissue damage caused by tissue ischemia at high cuff pressures.[15] Underinflation of cuffs is also detrimental, leading to leaks around the cuff and ventilator acquired pneumonia due to aspiration.[15] Cuff monitoring protocols can help maintain optimal cuff pressures resulting in better patient outcomes and fewer complications.[9]

Cuff pressure monitoring by manual manometer should be done every 8 to 12 hours and documented in the medical record.[16] Abnormal findings should be communicated with the care team. Cuff pressures should also be checked anytime there are other clinical signs of an air leak, including audible turbulent air flow from the patient’s upper airway, ability to phonate while the cuff is inflated, or a cuff leak reading on the ventilator (i.e., difference between measured inhalation and exhalation volumes).[16] Cuff pressures taken at any single timepoint can be subject to variation from patient positioning, work of breathing, and ventilator settings.[10,17,18] Continuous cuff pressure monitoring devices are now being used more frequently; these devices can trend and visually display continuous data, identify and respond to positional changes, and ultimately require less frequent manipulation of the pilot balloon, which may contribute to fluctuations in cuff pressures.[19]

Hospital staff often have knowledge deficits about proper manometric technique.[12] Cuff pressure monitoring policies, techniques, and clinical rationale should be a standard part of onboarding and skill maintenance for respiratory therapists.[12] Signs of a ruptured cuff, such as a continual air leak despite reinflation of the cuff, should be included in teaching.[12,16] It is appropriate for ICU staff to check cuff pressures at the bedside when needed, but proper technique should be taught and reinforced.[12,16]

Many institutions have a tracheostomy consult service, but creating a multidisciplinary tracheostomy team can support implementation of broader hospital standards.[13,14] Tracheostomy teams can be structured in different ways and often include pulmonary and otolaryngology physicians, advanced practice providers (APPs), respiratory therapists (RTs), and speech language pathologists (SLPs).[13,14] Authors of an expert opinion focused on collaborative tracheostomy care identified five key elements common to successful tracheostomy teams,[13] including multidisciplinary synchronous ward rounds, standardization of care protocols, appropriate staff training and allocation, patient and family involvement, and use of data to drive improvement.[13]

The use of tracheostomy care bundles and multidisciplinary tracheostomy teams are supported by the American Academy of Respiratory Care,[14] although the body of evidence supporting tracheostomy teams is low to moderate quality.[14] However, there is recognition of a need for collaborative work to improve care for tracheostomy patients.[13,14] Optimizing tracheostomy care and practices can be challenging in a large health care system with diverse patient populations undergoing tracheotomy and a variety of clinical services involved. A group of tracheostomy experts should be enlisted to agree on standards of care, to serve as a resource for these standards, and to provide expert consultation when needed.

Take-Home Points

- Proper tracheostomy tube choice and sizing can prevent leaks around cuffs and should also be considered when addressing these leaks. Brand dependent sizing and cuff design should be considered.
- Policy and staff education should include airway cuff pressure monitoring technique and protocols. Cuff pressures should be maintained in a range of 20-30 mm H_20. Any overinflation of a cuff should be temporary and a plan should be in place to address the cuff issue when safe to do so. Failure to do so can lead to tracheal and surrounding structure damage with severe clinical consequences.
- Multidisciplinary tracheostomy teams are useful to optimize tracheostomy care and can be a resource for education and adherence to policy.

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