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CASE REPORT AIRWAY MANAGEMENT

Barotrauma following liquid nitrogen spray cryotherapy for airway recanalization

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ABSTRACT

Spray cryotherapy (SCT) using the truFreeze® system (Steris, Mentor, Ohio, USA) is a minimally invasive technique that is becoming increasingly common for airway stenosis management. Although generally considered safe, rare but serious, high-morbidity complications such as barotrauma can occur. We report the case of a 49-year-old female with a history of tracheal and subglottic stenosis who developed a pneumothorax during airway recanalization with truFreeze® cryotherapy. This complication occurred despite the use of standard safety protocols and safeguards, including passive venting. Shortly after the initiation of the cryotherapy, significant abdominal distention was detected, prompting immediate cessation of the procedure. Subsequently, the patient developed transient hypoxemia, and imaging confirmed a left-sided pneumothorax with mediastinal shift. A chest tube was inserted with near-complete resolution of the pneumothorax and associated symptoms. The patient was then discharged in stable condition. This case demonstrates the necessity of intraoperative vigilance and preparation for high-risk complications when using the truFreeze® system. As its usage becomes more widespread, clinicians must have preplanned interventions for barotrauma in order to increase early recognition, timely management, and improved patient outcomes.

Abbreviations: ED: Emergency department, LMA: laryngeal mask airway, PSI: pounds per square inch, SCT: Spray cryotherapy

Keywords: Spray Cryotherapy, Airway Stenosis, Barotrauma, Pneumothorax, Tracheal Recanalization

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1. INTRODUCTION

Cryotherapy has been effectively used for the ablation of various airway and gastrointestinal (GI) lesions for many years. Previous techniques relied on direct contact between a cryoprobe and the target tissue, using the Joule-Thomson effect to reach the desired freezing temperatures.[1] More recently, spray cryotherapy (SCT) has emerged as an alternative approach, utilizing a catheter to deliver liquid nitrogen directly onto the tissue without requiring contact.[1]

The truFreeze® system, an FDA approved SCT system developed by CSA Medical, delivers liquid nitrogen to target tissues at -196 ℃ and a low pressure of 2-4 PSI through a 7F catheter inserted through an endoscope or bronchoscope.[2] The liquid nitrogen is stored in a unit within the console, and its release is controlled by a foot pedal at an initial pressure of 19-20 PSI. As the liquid nitrogen travels through the system, a series of valves reduces the pressure before the spray is released at the catheter tip. The system allows for direct visualization as the target area undergoes rapid cycles of freezing and thawing, while the excess gas from the expansion of

nitrogen is vented through active or passive mechanisms.[3]

The truFreeze® therapy allows for non-contact thermal injury by freezing the intracellular components of the target area, while the structural extracellular matrix elements like fibrin and collagen are less affected. SCT also promotes vascular stasis of the underlying vasculature. Unlike heat ablation, these characteristics result in regenerative healing with minimal scarring.

Though the truFreeze® system has been validated through multiple studies and is generally considered safe with multiple safety checks in place to minimize complications, there are numerous cases in which complications have occurred. Hypotension, pneumothorax, and other forms of barotrauma have been reported. Physicians and other healthcare providers should have heightened awareness of these possible complications even when using the proper technique.

We present the case of a middle-aged female who experienced barotrauma and tracheal injury after undergoing airway recanalization with the truFreeze® cryotherapy, despite the use of standard safety protocols, including passive venting.

2. CASE REPORT

A 49-year-old female with a history of hypertension, hyperlipidemia, and obstructive sleep apnea presented to the ED in late December 2018 with dyspnea. The patient had an extensive history of episodes of respiratory distress and failure due to a combination of obesity hypoventilation syndrome and tracheal stenosis. She was intubated for nine days in late June of 2017 and subsequently had a tracheostomy tube placed for 16 months. During that period, the patient underwent multiple airway recanalization procedures for recurring tracheal and subglottic stenosis.

Her most recent procedure was 22 days before ED presentation and involved monopolar radiofrequency ablation spray cryotherapy. This improved her airway from 4-5 mm to a resultant 9 mm at the time. However, upon ED admission, bronchoscopy revealed subglottic stenosis with a residual airway diameter of <5 mm and evidence of regrowth of the previously seen tracheal stenosis 1-2 cm below the subglottic tunnel. The bronchoscope was unable to pass the area of stenosis.

Airway Recanalization was again attempted after these bronchoscopy findings. Given the patient's body habitus and history of obesity hypoventilation, the patient was intubated. The following induction with propofol and the airway was secured with size 4 laryngeal mask airway (Aurastraight#4). Once the positioning of the LMA was confirmed through direct visualization through the fiberscope, the patient was paralyzed with Rocuronium(50mg). The anesthesia was maintained with continuous infusion of propofol, and the patient was placed in volume-controlled mode of ventilation (TV 500ml, RR 12). The patient was ventilated with FIO2 set at 50%. The attending physician initially performed ablation of soft tissue obstruction and granulation tissue at the subglottic tunnel using a CoreCath monopolar radiofrequency catheter at 15-25 watts. Following ablation, the bronchoscope was advanced to the trachea where 8mm tracheal stenosis was observed. An 18mm esophageal balloon was used to dilate the airway followed by the initiation of truFreeze® spray cryotherapy.

Prior to performing spray cryotherapy, passive venting pathways were confirmed to be patent. One assistant applied abdominal pressure to detect distention, while another held chest pressure for tactile sensation of crepitus suggestive of pneumomediastinum. During the first spray cycle after crystal formation, the provider monitoring the abdomen through tactile palpation felt an abrupt pop. Soon after, it became difficult to ventilate the patient, with increasing airway pressures and a drop in patients' oxygen saturation. Approximately 2 seconds of spray cryotherapy on the timer had elapsed and potentially 5 to 6 seconds of total duration of spray. With the finding of abdominal distention, further spray cryotherapy was immediately stopped and the change in the patient's abdominal distention was further evaluated. During evaluation, the patient developed transient hypoxemia that was improved with assisted ventilation.

Possible pneumothorax prompted the need for immediate clinical assessment. Auscultation revealed clear breath sounds on the right but diminished breath sounds on the left. A bedside ultrasound was performed by multiple attendings and fellows showing evidence of lung sliding seen on the right and no evidence of lung sliding seen on the left, consistent with left-sided pneumothorax. A portable chest x-ray was performed and confirmed the left-sided pneumothorax and additionally showed a rightward mediastinal shift. There was free air noticed under the right hemidiaphragm as well.

A 14-French chest tube was placed by the Pulmonologist and the Pulmonary fellow physician in the left fourth intercostal space at the midaxillary line. The chest tube was connected to a Pleur-Evac with air drainage through the system until all residual air had been removed. A follow-up chest x-ray showed near complete resolution of the left-sided pneumothorax with a possible small apical pneumothorax remaining. The chest tube was removed 2 days post placement with near complete resolution of pneumothorax. Patient was then discharged with improvement in symptoms for some time.

3. DISCUSSION

Spray cryotherapy with truFreeze® is becoming a staple in treating central airway stenosis from both malignant and nonmalignant causes. This system serves as a minimally invasive alternative to previous procedures by inducing non-contact cell death with the preservation of the extracellular matrix and a regenerative type of growth. Its safety and efficacy have been documented in multiple studies.[1,4,5]

Despite having all safety techniques and mechanisms in place, serious complications such as barotrauma can occur. In this case, barotrauma developed in the patient even with passive venting and close procedural monitoring. The -196 ℃ liquid nitrogen experienced a rapid gas expansion when exposed to body temperature in the patient's central airway. This sudden increase in gas volume should have been evacuated via passive venting but in this case the venting was inadequate. The sudden increase in gas volume likely caused a rapid increase in pressure in the central airway, resulting in the pneumothorax. The early detection of abdominal distention by the procedural assistant allowed for the immediate cessation of cryotherapy, preventing further deterioration. This demonstrates the crucial need for maintaining hypervigilance during spray cryotherapy procedures, even when all safety procedures are followed.

Cryotherapy via the truFreeze® system applicator has been proven safe and efficacious for treating multiple conditions, including tracheal stenosis, Barrett's esophagus, and gastrointestinal lesions.[6,7,8] Although complications may rarely occur, the complications that do occur are high morbidity events. This necessitates proactive prevention strategies and readiness to intervene. Providers must avoid complacency and maintain strict adherence to procedural safeguards, including venting pathway verification, tactile monitoring, and preparedness for barotrauma.

4. CONCLUSION

This case illustrates that serious complications such as barotrauma can occur during the truFreeze® spray cryotherapy, despite using proper technique and safety measures. It highlights the need for continued vigilance, early recognition of warning signs, and adherence to comprehensive safety protocols to reduce the risk of complications and optimize patient outcomes.

5. Conflict of interest

All authors declare that there was no conflict of interest.

6. Funding

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7. Authors' contribution

NM: Concept, Manuscript Writing and Editing
GR: Manuscript Editing
JC: Literature Search

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