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Case Presentations of the Harvard Affiliated Emergency Medicine Residencies

RESPIRATORY DISTRESS IN A PATIENT WITH A TRACHEOSTOMY

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Dr. Jennifer Przybylo: Today's case is that of a 64-year-old woman with a tracheostomy on a ventilator who was transferred by ambulance from a local rehabilitation center to the Emergency Department (ED) for evaluation of respiratory distress. Earlier that evening, she had complained of feeling short of breath, her work of breathing was notably increased, and she then became increasingly somnolent. She had not had any recent fevers or chills. She had not had a cough, nor had she complained of chest pain, nausea, palpitations, or lightheadedness.

Dr. Susan Wilcox: Did the patient have any past medical history, surgical history, medications, or allergies that might contribute to her presentation?

Dr. Przybylo: The patient had a longstanding history of chronic obstructive pulmonary disease (COPD) with frequent hospitalizations in the year prior to presentation. She had just been discharged to rehabilitation 3 days prior to presentation after an extended hospitalization for a fall that had resulted in multiple right-sided rib fractures, with her course complicated by a large right-sided pleural effusion, subsequently drained 1 L by thoracentesis, and hypercapnic respiratory failure necessitating intubation. She eventually required a tracheostomy when she was unable to wean from the ventilator. Unfortunately, severe kyphosis resulting in a tortuous trachea (Figure 1) as well as tracheomalacia resulted in a position-dependent tracheostomy tube that required multiple re-intubations and tracheostomy tube changes. The patient was ultimately discharged to rehabilitation on a ventilator with her fourth tracheostomy tube, a wire-reinforced 8.0 TRACOE long (110 cm).

The patient had a number of other medical conditions that could have contributed to her presentation, including cor pulmonale, coronary artery disease, and history of a remote provoked deep venous thrombosis. She had multiple prior hospitalizations for pneumonia. The patient's relevant medications included budesonide nebulizers, albuterol/ipratropium nebulizers, prednisone for rheumatoid arthritis, clopidogrel for coronary artery disease; due to an allergy to aspirin, diltiazem and digoxin for paroxysmal atrial fibrillation; subcutaneous heparin, oxycodone and tramadol for chronic pain, as well as several other sedating medications, including quetiapine and mirtazapine. She had a remote history of an anaphylactic reaction to hydromorphone. Per chart review, she had a remote smoking history, and no history of drug or alcohol use.

Dr. Christopher Taicher: Can you describe the physical examination?

Dr. Przybylo: On arrival, the patient had a temperature of 36.2°C (97.2°F), a heart rate of 102 beats/min in sinus tachycardia, and a blood pressure of 136/62 mm Hg. She arrived on a travel ventilator set to pressure control ventilation with a pressure of 20 cm H_2O, positive end-expiratory pressure (PEEP) of 5 cm H_2O, and a

respiratory rate of 10 breaths/min, but she was overbreathing at a rate of 26 breaths/min. She had an oxygen saturation of 100% on 100% FiO_2. The travel ventilator did not display a numerical minute ventilation, but the alarm displayed the warning, "low minute ventilation."

The patient was awake and alert, in marked respiratory distress, mouthing "I can't breathe," in a panic. She appeared older than stated age. Her head was atraumatic, the sclerae were anicteric, and the pupils were equal, round, and reactive to light. The oropharynx was clear and the mucosa was moist. The patient's wire-reinforced tracheostomy tube was in place and connected to the ventilator; there was no surrounding erythema, swelling, or bleeding at the stoma site. Accessory muscles of the neck were engaged. The lungs had diminished breath sounds bilaterally, right greater than left. Cardiac examination revealed a regular tachycardia without murmurs, rubs, or gallops. The abdomen was soft, nontender, and nondistended, with an unremarkable gastrostomy tube in place. The lower extremities had 2+ pitting edema and venous stasis changes bilaterally. The skin was warm and capillary refill was <2 s. She had a left basilic single lumen power peripherally inserted central catheter in place.

Dr. Kimo Takayesu: What was in your differential diagnosis at this point?

Dr. Przybylo: Given this patient's recent clinical history, tracheostomy tube malpositioning was high on our differential. The combination of a tortuous trachea and tracheomalacia meant that even small perturbations of the tracheostomy tube could result in marked decompensation. The patient's severe COPD meant that breath stacking and a COPD exacerbation were also strong contenders. A pneumothorax, large pleural effusion, or mucous plugging could have resulted in the asymmetric breath sounds appreciated on examination. A ventilator-associated pneumonia could have resulted in the patient's increased oxygen requirement. A ventilator malfunction, though relatively rare, was also considered.

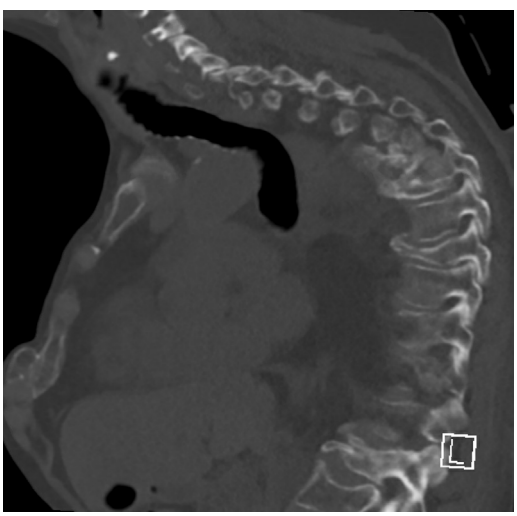

Figure 1. Sagittal view of computed tomography scan demonstrating severe kyphoscoliosis and tortuous trachea.

Cardiovascular etiologies were also considered, including supraventricular tachycardia or other tachydysrhythmia, heart block or other bradydysrhythmia, acute coronary syndrome, or cardiac tamponade. We also considered flash pulmonary edema from left-sided heart failure, although this was less likely given that the patient had a history of cor pulmonale only. Additionally, with her history of a remote deep venous thrombosis, we considered a pulmonary embolism, but this was less likely given that the patient had been on prophylactic anticoagulation for months.

Dr. Chris Kabrhel: Can you describe your initial management of this patient?

Dr. Przybylo: Our first intervention was to disconnect the patient from her travel ventilator and connect her to a bag to provide manual ventilation. However, there was a good deal of resistance. To exonerate a mechanical obstruction from mucous or blood, suctioning was then attempted. Unfortunately, all attempts to pass the suction catheter were met with firm resistance at approximately one-third of the way in. Suctioning did not relieve the obstruction. This early data point supported the leading hypothesis that the patient's tracheostomy tube was malpositioned, as the resistance could have been caused by the tracheostomy tube abutting the tracheal wall. As the bronchoscope was prepared, the patient was switched over from her travel ventilator to one of the ED's ventilators. The same settings were applied, with the resultant tidal volumes <300 mL. Intravenous fentanyl of 25 μg was administered just prior to bronchoscopy.

When the bronchoscope was advanced, healthy-appearing pink tissue was visualized at the end of the tracheostomy tube, with only a 1–2-mm opening off to the side, at approximately 9 o'clock, which was not fully obstructed by the pink tissue. It seemed most likely that the visualized mucosa was the posterior tracheal wall, and that the patient was moving her entire tidal volume through the tiny peripheral sliver that was not obstructed.

Because the tracheostomy tube was a special wire-reinforced tube, it could potentially be coaxed into a different position using the bronchoscope as a guide. The bronchoscope was thus advanced approximately 1.5 cm past the end of the tracheostomy tube and maneuvered to just above the carina. The tracheostomy tube was then pushed down further, following the curve of the bronchoscope, which was then removed. The patient's work of breathing improved markedly.

Dr. Wilcox: If she had not had a wire-reinforced tube, what else could you have done?

Dr. Przybylo: Placement of a longer tracheostomy tube, or a differently shaped tracheostomy tube, could

have been attempted. Failing that, an endotracheal tube could have been advanced through the tracheostomy site to bypass the problematic area. Given the length of a standard adult endotracheal tube, care would need to be taken to ensure it was not advanced past the carina. Finally, if the patient can be intubated from above, this is another possibility to address malpositioning of a tracheostomy tube. However, clinicians should note that some patients cannot be intubated from above due to laryngotracheal separation—a surgical cordoning off of the airway from the oropharynx that is typically performed in patients with intractable aspiration or certain cancers. Understanding the patient's anatomy is crucial in their care.

Dr. Takayesu: What were your next steps in management?

Dr. Przybylo: At this point, laboratory specimens were sent, including: complete blood count with differential, basic metabolic panel, venous blood gas, lactate, troponin-T, and N-terminal pro B-type natriuretic peptide (NT-proBNP). An influenza A and B polymerase chain reaction swab was also sent for analysis. The patient's white blood cell count was 25.3 K/uL with a neutrophilic predominance, hemoglobin was 8.8 g/dL, stable from prior, venous blood gas 7.25/86/74/37 on 100% FIO_2, and NT-proBNP 949 pg/mL (just above the age-adjusted cut-off of 900). Her basic metabolic panel, lactate, and troponin were unremarkable. An anterior-posterior chest x-ray study showed mild interstitial pulmonary edema, bibasilar patchy opacities, right greater than left, and a moderate right-sided pleural effusion, with a similar appearance to her radiograph from 2 days prior. The tracheostomy tube was noted to terminate in the mid-thoracic trachea. A urinalysis, urine culture, and blood cultures were sent. Vancomycin 1250 mg i.v. and piperacillin-tazobactam 4.5 g i.v. were started and an arterial line was placed.

Dr. Taicher: What was the patient's clinical course in the ED?

Dr. Przybylo: Shortly after the tracheostomy tube repositioning, the patient's ventilator settings were adjusted to pressure control 13 cm H_2O, down from 20 cm H_2O, a PEEP 10 cm H_2O, increased from 5 cm H_2O, a respiratory rate of 10 breaths/min, and FiO_2 of 30%, down from 100% on presentation. With these settings, she had tidal volumes in the 460 mL range, increased from <300 mL on presentation, and her minute ventilation was 7.6 L/min, with the patient overbreathing the ventilator at a rate of 26 breaths/min. At approximately 2.5 h after the initial tracheostomy tube repositioning, the patient's arterial blood gas revealed significant improvement in her respiratory status: 7.41/56/74 on 30% FIO_2. Due to persistent ventilator requirements, we admitted the patient to the Medical Intensive Care Unit.

Dr. Kabrhel: What did her inpatient work-up reveal?

Dr. Przybylo: Bronchoscopy by the Interventional Pulmonology service was notable for tracheomalacia and a well-positioned tracheostomy with the posterior membrane obstructing the tracheostomy tip during Valsalva maneuvers. Unfortunately, the patient continued to have intermittent episodes of respiratory distress requiring higher ventilator settings during her hospitalization, so Thoracic Surgery was consulted. Thoracic Surgery took the patient to the operating room, where her tracheostomy tube was exchanged for a Bivona 8 TTS (88 mm from flange to tip; Smiths Medical International, Ltd., Ashford, UK). Over the next 2 weeks, the patient was treated for a COPD exacerbation with steroids and was able to be weaned from mechanical ventilation. She tolerated the speaking valve and tracheostomy tube capping, and was downsized further to a Shiley 5 single cannula tracheostomy tube to ensure overall safety without a tracheostomy tube. Her tracheostomy tube was kept in place for intermittent suctioning. She was ultimately discharged to a rehabilitation facility.

Dr. Takayesu: What can you tell us about the initial management of respiratory distress in a patient with a tracheostomy?

Dr. Przybylo: A great mnemonic device for quickly thinking through the potential causes of respiratory distress in patients on a ventilator is the "DOPES" mnemonic (1,2). "D" stands for "dislodgment" or "displacement" of the endotracheal or tracheostomy tube, or "deflation" of the cuff (if it is a cuffed tube). "O" stands for "obstruction" of the tube with mucous ("mucous plugging") or blood (3). "P" is a reminder that "patient" disease processes such as pneumothorax, pulmonary embolism, pulmonary edema, and bronchospasm result in respiratory distress in the patient on a ventilator, just as they can in the patient who is not on a ventilator. "E" stands for equipment failure, and can refer to a problem with the ventilator itself, with the ventilator's connection to its power source, or with the ventilator's connection to the patient; it's important to check all elements of the ventilator circuit. If all else fails, check to ensure the power source itself is not malfunctioning. Finally, "S" stands for "stacking," as in "breath stacking." Breath stacking occurs when the expiratory time is not long enough to allow the patient to exhale the full breath they just took. As a result, a little extra volume remains in the lungs at the conclusion of each breath. Over time, this leads to hyper-expansion of the lungs and can cause decreased venous return to the heart, resulting in hypotension, or barotrauma to the lungs (1,2).

Having thought through the potential causes of respiratory distress in a patient with a tracheostomy on a ventilator, the next step is to begin troubleshooting the problem using the "DOTTS" mnemonic (2). First, "disconnect" the patient from the ventilator and listen for

hissing sounds; release of air from hyperinflated lungs results in this particular noise. If hissing is present, this is a good indication that breath stacking was at least a contributing factor to the respiratory compromise. Press down on the patient's chest for 10 s to assist in the release of air. The focus should next turn toward "oxygenation." Provide positive pressure ventilation (with a PEEP valve, if necessary) via bag-valve mask. While ventilating, assess the patient's lung compliance. If it is difficult to ventilate the patient, obstruction and conditions that decrease lung compliance, such as pulmonary edema or pneumothorax, should move higher on the differential. If it is easy to ventilate the patient, consider air leaks such as those caused by a dislodged tube or deflated cuff. "Tube" position should be assessed by comparing the depth of the tube and its positioning to prior notations by consulting with the patient, caretakers, or records, and tube function should be ensured by passing a suction catheter to help clear out any obstructions. If the tube is cuffed, you can try deflating the cuff to see if this allows the patient to breathe around the tube, and this is especially helpful if the tube is obstructed. If the patient is still unable to breathe around the tube, then the tracheostomy tube should be removed (3). Finally, "tweak" the ventilator settings as the situation dictates. This may mean lowering the respiratory rate or tidal volume in the case of breath stacking.

Dr. Taicher: What can you tell us about the tracheostomy emergencies you're most likely to encounter in clinical practice?

Dr. Przybylo: The types of tracheostomy emergencies and complications you are likely to encounter vary according to how old the tracheostomy is. As such, it's always a good idea to ask the patient how old the tracheostomy is. During or immediately after insertion of the tracheostomy, the most common complications are posterior wall laceration or a paratracheal insertion, also known as a "false tract." In the early postprocedural phase, up to 7 days after insertion, the stoma is not yet mature and you are likely to encounter bleeding (primarily minor), stoma infection, accidental decannulation, subcutaneous emphysema, loss of airway, aspiration, and pneumothorax. After 7 days, the stoma has matured, and the problems encountered in this late postprocedural phase include: tracheal stenosis (most common), delayed stoma closure, tracheomalacia, vocal cord paralysis, tracheoarterial fistula, and tracheoesophageal fistula (4–7).

Tracheal stenosis is a narrowing of the trachea (typically above or at the stoma and below the vocal cords) that results from the formation of granulation tissue in response to infection or inflammation, and is typically associated with prolonged endotracheal intubation, prolonged tracheostomy, or a combination of the two. It tends to present from 1 to 6 months after decannulation and often requires surgery or tracheal dilatation to correct (5–8).

The pathophysiology of tracheomalacia is similar to tracheal stenosis, but in tracheomalacia, the tracheal cartilage is weakened or destroyed such that the patient's airway may collapse during exhalation. As in the patient discussed in this case, a temporary solution is a longer tracheostomy tube. Definitive management may involve stenting of the airway or surgical correction or resection of the problematic segment (5–7).

In the ED, brisk bleeding from a tracheostomy is a tracheoarterial fistula until proven otherwise. These abnormal connections between the trachea and an artery (most commonly the innominate artery, followed by left innominate vein, aortic arch, and right common carotid artery) are thought to result from anterior tracheal wall erosion from an over-inflated cuff or tracheostomy tube tip. The first 3 weeks after tracheostomy placement are the highest risk time for tracheoarterial fistula, as 70% will occur within this window; however, there is no outer limit, as tracheoarterial fistulas may occur years after tracheostomy placement (6,9). Approximately 50% of patients who have a tracheoarterial fistula will have a sentinel bleed. If presented with a patient with brisk bleeding from their tracheostomy site, try inflating the cuff as much as possible to try to tamponade the artery. If this fails, remove the tracheostomy tube and apply direct pressure to the anterior wall with your gloved finger. Unfortunately, despite the best efforts of emergency providers, tracheoarterial fistula carries an 80% mortality rate (5,6).

Dr. Kabrhel: What are the major teaching points of the case?

Dr. Przybylo: Just because a patient has a "secure" airway does not mean they are immune to respiratory compromise. There are a number of mechanical problems that can occur with the tracheostomy itself, as well as problems with the ventilator or its settings. A good first step is to disconnect the patient from the ventilator and bag them manually while using the "DOPES" mnemonic to think through the potential causes of respiratory distress. Troubleshoot the problem with the help of the "DOTTS" mnemonic. If there are ventilator alarms going off, use their prompts to help zero in on the problem. Finally, it is important to keep in mind why a tracheostomy was placed and when it was placed, as this information may help pare down your differential.

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