

Airway Obstruction during Anterior Cervical Spine Surgery

February 28, 2024

Bohringer C, Vo L. Airway Obstruction during Anterior Cervical Spine Surgery. PSNet [internet]. 2024. <https://psnet.ahrq.gov/web-mm/airway-obstruction-during-anterior-cervical-spine-surgery>

The Case

A 47-year-old obese man (body weight 135kg) with hypertension fell down the stairs while intoxicated with alcohol and suffered a cervical spine (C5/C6) fracture. Although he could not feel his body below his neck, he retained some movement of both upper limbs. He was scheduled for urgent anterior cervical decompression and fusion and was transferred to the operating room (OR) where general anesthesia was induced. He was very carefully intubated with a wire-reinforced size 8 endotracheal tube using a McGrath laryngoscope.

Anesthesia was maintained with sevoflurane and remifentanyl target-controlled infusion. His peak airway pressures were initially 23-25 cm H₂O but suddenly increased to 48-52 about 30 minutes into the operation. The patient's vital signs remained stable although his expired tidal volume decreased from a normal value of 560 ml (7 ml/Kg ideal body weight) to about 330 ml. He was manually ventilated through the endotracheal tube, which proved very difficult. An urgent chest X-ray did not reveal any pneumothorax. The endotracheal tube tip was noted to be above the clavicles although the depth mark at the level of the incisor teeth was at the typically expected 23 cm. The Black Belt cervical retractor was released by the surgeon resulting in complete resolution of the airway obstruction. The endotracheal tube cuff was deflated, it was advanced by another 2 cm, and the cuff was reinflated, resulting in almost complete resolution of the obstruction.

The Commentary

By Christian Bohringer, MBBS, and Linda Vo, MD

Background

Airway obstruction in a patient who is already intubated is an uncommon but very dangerous clinical scenario. This situation needs to be remedied emergently to prevent hypoxemia and/or hypercapnic

acidosis, which may lead to cardiac arrest.¹ The differential diagnosis includes a blocked or kinked endotracheal tube (ETT), among other conditions.² The patient may also bite down on the ETT or resist lung inflation. Breathing circuit or ventilator malfunction, severe bronchospasm, and tension pneumothorax are other potential causes of for this clinical scenario.

The patient in this case report had several risk factors and pertinent findings. First, he had a body weight of 135 kg. Obesity is often associated with difficult ventilation because high airway pressures are required to displace excess adipose tissue in the chest wall and the abdomen when inflating the lung.³ High airway pressure is then transmitted to the heart, which impairs venous return and cardiac output. Prolonged high airway pressure not only produces barotrauma, which can manifest as mediastinal emphysema, subcutaneous emphysema, or pneumothorax, but also contributes to low cardiac output and circulatory shock.

This patient had a fracture of his cervical spine with total loss of sensation below the neck but some preserved motor function in both upper limbs. To prevent exacerbating the neurologic deficit, it is of utmost importance for the anesthesia clinician to avoid movement of the cervical spine during intubation and positioning on the operating table.⁴ As highlighted in a previous [WebM&M commentary](#), using a video-laryngoscope is the intubation technique of choice in this scenario because these devices have been designed to allow intubation with the neck in neutral position. The “sniffing position” that aligns the oral, pharyngeal, and laryngeal axes is not required with these devices, and the endotracheal tube can often be placed without having to remove the hard collar from the neck.⁵ This patient was intubated with a McGrath laryngoscope, which is a video-laryngoscope that also reduces movement of the neck during intubation.

Thirty minutes into the operation the airway pressures suddenly increased from 25 to 50 cm of H₂O and the tidal volume decreased to 330 ml (2.4 ml/Kg). The cause for this sudden change was initially unclear, but this patient had been intubated with a spirally reinforced ETT, which made kinking of the ETT unlikely. A CXR ruled out pneumothorax but unexpectedly revealed shallow intubation with the tip of the ETT located high in the larynx, above the clavicles, even though it was taped at a standard distance of 23 cm at the mouth. The rapid availability of an intraoperative CXR was very important in this case because it helped to make the correct diagnosis quickly. In retrospect, impaired ventilation was likely caused by compression of the trachea by the self-retaining surgical retractor. Advancing the ETT tube further into the trachea helped splint the trachea open and prevented the surgical retractor from obstructing it. Repositioning the surgical retractor was probably even more helpful than advancing the ETT. Self-retaining soft tissue retractor systems of this type may cause traction or compression injury to adjacent structures, such as recurrent laryngeal nerve injury, esophageal perforation, airway compression, and even cerebral ischemia.^{6,7}

In this case, rapid-cycle communication between the anesthesia clinician and the surgeon identified faulty positioning of the surgical retractor as the most likely cause of the problem. Without such communication, it would have taken much longer to rectify the situation. Failure to ventilate a patient is a very stressful event but this team appeared to communicate well. The patient did not suffer any harm from his transient increase in airway pressure because the team made the correct diagnosis and corrected the airway obstruction in a timely manner.

Management of Airway Obstruction in an Intubated Patient

When airway obstruction is suspected in an intubated patient, a trial of ventilation with a manual bag-valve resuscitator (e.g., an Ambu or Artificial Manual Breathing Unit) bag should be performed to rule out malfunction of the breathing system or the ventilator.⁸ If ventilation remains inadequate after switching to the Ambu bag, the origin of the problem can be narrowed down to either the ETT or the respiratory tract distal to the ETT. It is generally appropriate to replace the ETT to rule out endotracheal tube malfunction. With nasal ETTs, a turbinate bone may have become dislodged and may be blocking the tube.⁹

If difficult ventilation persists despite changing the ETT, the patient may have severe bronchospasm or tension pneumothorax. Bronchospasm should be treated with intravenous dexmedetomidine, epinephrine and lidocaine. Inhaled therapy with albuterol and sevoflurane is not effective when bronchospasm is severe because gas exchange is insufficient to deliver inhaled therapy to the smooth muscle in the bronchial tree. Severe bronchospasm in intubated patients should therefore be treated with intravenous medications.¹⁰

Tension pneumothorax is treated emergently with needle thoracostomy. Pneumothorax can occur in trauma patients who may have undiagnosed rib fractures. A small preexisting pneumothorax that was not visible on the preoperative chest radiograph may expand rapidly after initiating positive pressure ventilation in the operating room. Positive pressure in the lungs can quickly transform a small asymptomatic pneumothorax into a tension pneumothorax that may precipitate severe hemodynamic compromise and cardiac arrest. A chest drain should be inserted whenever a spontaneously breathing patient with known pneumothorax is intubated and subjected to positive pressure ventilation.¹¹

Patients who are undergoing spine surgery are often monitored with motor evoked potentials to assess the integrity of the spinal motor pathways during the operation.¹² Neuromuscular blocking drugs should be avoided when monitoring motor potentials, although avoiding these drugs can lead to problems with ventilation. When muscle relaxants cannot be used, as in the present case, the patient must receive adequate anesthesia. Inadequate sedation may cause the patient to bite down on the ETT or resist the ventilator with their respiratory muscles. On rare occasions, the trachea is compressed by surgical packs inserted to control bleeding or by surgical instruments such as a retractor or a mediastinoscope.

When the airway is completely obstructed, there is limited time to make a diagnosis and correct the problem. Therapeutic intervention often must be initiated based on clinical probabilities, before a definitive diagnosis has been made. Clinicians therefore need to maintain an open mind about the accuracy of their initial diagnosis. They must be prepared to change their treatment plan immediately if their initial intervention does not improve ventilation rapidly.¹³

When airway obstruction is mild, there is more time to perform diagnostic investigations. An ultrasound, chest radiograph, or flexible bronchoscopy may help to diagnose the cause of the problem. When bronchospasm is suspected and aspiration of gastric contents seems unlikely, bronchoscopy should be avoided because physical irritation of the bronchi may exacerbate bronchospasm. Suction tubing can be inserted into the ETT to ensure that it is not obstructed, and to rule out an unrecognized aspiration event. Occasionally, the ETT is kinked in the pharynx, which can be diagnosed either via bronchoscopy or by placing a gloved index finger in the patient's mouth to feel the ETT. Kinking of the ETT typically occurs with the patient in the prone position and during brainstem surgery, when the patient's chin touches their chest or shoulder. Spirally reinforced ETTs that have a metal wire embedded in the wall to prevent kinking are

often used for this type of operation.

Approaches to Improving Patient Safety

Anesthesia clinicians must monitor the patient carefully

Vigilant monitoring of airway pressure identified this problem early so that it could be corrected rapidly. Excessive background [noise](#) in the operating room should be avoided so that anesthesia clinicians can hear auditory signals from the electrocardiogram, the pulse oximeter, and airway alarms.¹⁴ Anesthesia clinicians also need to observe the surgical field vigilantly so that they can evaluate if a new problem could have been precipitated by a recent surgical intervention.

Good communication among all operating room staff is essential

[Good communication](#) among the surgeon, the anesthesia team, the scrub and circulating nurses as well as the neurophysiologist who is monitoring the integrity of the patient's spinal cord pathways is an indispensable requirement for providing safe patient care.¹⁵

The anesthesiologist should notify the surgeon immediately of any significant problem with ventilation or cardiac output. The surgeon should provide information about any surgical intervention that may have precipitated the problem. If surgeons think that they may have inadvertently lacerated the pleura, they should inform the anesthesia clinician early so the patient can be monitored for signs of an expanding pneumothorax.

During a crisis, all team members should communicate calmly with one another. A team leader should be designated, and this can be the surgeon or the anesthesiologist depending on the nature of the problem. Team members should review all events together to try to understand what may have precipitated the emergency. Blaming other members of the team for any difficulties is not helpful and exacerbates stress. Mental stress from the "blame game" makes it more difficult to solve the problem in a timely manner. Communication among all team members therefore needs to remain focused and constructive until adequate ventilation has been reestablished.

An Ambu bag should be used promptly to maintain oxygenation

Patients who cannot be ventilated adequately with the anesthesia machine should be disconnected from the breathing circuit and the ventilator. A manual bag-valve resuscitator like an Ambu bag should be used instead for ventilation.¹⁶ When the patient requires an increased inspired fraction of oxygen (FIO₂), a positive end expiratory pressure (PEEP) valve should be attached to the Ambu bag.

If ventilation is successful with the bag-valve resuscitator, then the problem originated in the breathing circuit or the ventilator. Once adequate ventilation is reestablished with the bag-valve resuscitator, there will be time to look for the equipment malfunction without worrying that the patient will become hypoxemic. Anesthesia can be maintained with intravenous propofol. Correcting the error in the breathing system and/or the ventilator may take time. A bag-valve resuscitator for backup ventilation should therefore always be readily available next to the ventilator. Trying to troubleshoot the equipment problem without using a bag-valve resuscitator may lead to hypoxemia, and then to hypoxic cardiac arrest.

Anesthesia clinicians need to review algorithms for troubleshooting problems with ventilation frequently

A problem with ventilation can rapidly deteriorate into a life-threatening emergency. Anesthesia clinicians therefore need to regularly review and practice their algorithms for solving ventilation problems so that they can fix issues quickly.¹⁷ Troubleshooting algorithms need to be so familiar that anesthesia staff can solve the crisis even when they are under great stress. Intraoperative crisis management should be practiced regularly with all members of the surgical team during simulations to improve their performance during actual patient care emergencies. During stressful situations, this preparation will help staff avoid non-productive fight/flight reactions and remain calm while they solve the problem. Simulation has been shown to improve knowledge, skill, and behavior of health care professionals.^{18,19}

Checklists and cognitive aids can be helpful during stressful life-threatening incidents

[Checklists](#) and other cognitive aids can help clinicians identify and troubleshoot errors.²⁰ They can also prevent missing important information or processes when staff are under great stress during extremely difficult clinical situations. Checklists can be made readily available on smart phone apps or tablets.²¹ They can also be displayed on large monitors so that staff who are scrubbed into the case can participate in this visual aid for a shared mental model. Some crises occur infrequently, and checklists are particularly helpful when dealing with uncommon problems.

Insertion depth of the ETT must be adjusted for every patient individually

Tall patients or patients with long necks may require increased depth of ETT insertion. Clinical judgment is necessary to determine how far the ETT should be inserted in every patient individually.

Coexisting health problems need to be identified and treated

Obese patients like the patient in this Commentary may have undiagnosed type 2 diabetes and perioperative blood glucose values should be monitored carefully. When patients were intoxicated with alcohol at the time of the injury as in this case they should be closely monitored for the development of alcohol withdrawal syndrome. They should also be given intravenous thiamine to prevent the development of psychosis during their hospitalization.

Take-Home Points

- Anesthesia clinicians need to monitor patients vigilantly so that they can respond quickly to life-threatening events.
- Good communication between team members is vital when diagnosing and managing an operative emergency, in order to save the patient's life.
- The differential diagnosis and management of high airway pressure should be reviewed regularly so that the cause of an unexpected increase in a patient's airway pressure can be diagnosed and managed immediately.
- If ventilation with the anesthesia machine becomes difficult, manual ventilation with an Ambu bag should be initiated promptly
- Checklists and cognitive aids can help during stressful events.
- Team participation in simulations of intraoperative emergencies can improve crisis management skills and outcomes.

Christian Bohringer MBBS

Consulting Editor, AHRQ, Patient Safety Network (PSNet)

Professor of Anesthesiology

Department of Anesthesiology and Pain Medicine

UC Davis Health

chbohringer@ucdavis.edu

Linda Vo, MD

Resident Physician

Department of Anesthesia and Pain Medicine

UC Davis Health

livo@ucdavis.edu

References

1. Artime CA, Roy S, Hagberg CA. The difficult airway. *Otolaryngol Clin North Am.* 2019;52(6):1115-1125. [[Available at](#)]
2. Nash P, Segal G, Collins M. Intraoperative management of a severely kinked endotracheal tube and difficult airway. *Anesthesiology.* 2022;137(4):471-472. [[Free full text](#)]
3. De Jong A, Wrigge H, Hedenstierna G, et al. How to ventilate obese patients in the ICU. *Intensive Care Med.* 2020;46(12):2423-2435. [[Free full text](#)]
4. Kovacs G, Sowers N. Airway management in trauma. *Emerg Med Clin North Am.* 2018;36(1):61-84. [[Free full text](#)]
5. Bohringer C, Duca J, Liu H. A synopsis of contemporary anesthesia airway management. *Transl Perioper Pain Med.* 2019;6(1):5-16. [[Free full text](#)]
6. Seex KA. An anterior cervical retractor utilizing a novel principle. *J Neurosurg Spine.* 2010;12(5):547-551. [[Available at](#)]
7. Palumbo MA, Aidlen JP, Daniels AH, et al. Airway compromise due to laryngopharyngeal edema after anterior cervical spine surgery. *J Clin Anesth.* 2013;25(1):66-72. [[Free full text](#)]
8. Lee CP, Yip YY. Understanding your bag-valve-mask resuscitator. *BJA Educ.* 2023;23(6):208-211. [[Available at](#)]
9. Dost P, Armbruster W. Nasal turbinate dislocation caused by nasotracheal intubation. *Acta Anaesthesiol Scand.* 1997;41(6):795-796. [[Available at](#)]
10. Bohringer C, Copeland D, Liu H. A contemporary approach to the treatment of perioperative bronchospasm. *Transl Perioper & Pain Med.* 2020;7(2):190-99. [[Free full text](#)]
11. Hsu CW, Sun SF. Iatrogenic pneumothorax related to mechanical ventilation. *World J Crit Care Med.* 2014;3(1):8-14. [[Free full text](#)]
12. Acharya S, Palukuri N, Gupta P, et al. Transcranial motor evoked potentials during spinal deformity corrections-safety, efficacy, limitations, and the role of a checklist. *Front Surg.* 2017;4:8. [[Free full text](#)]
13. Wong P, Wong J, Mok MU. Anaesthetic management of acute airway obstruction. *Singapore Med J.* 2016;57(3):110-117. [[Free full text](#)]

14. Nasri BN, Mitchell JD, Jackson C, et al. Distractions in the operating room: a survey of the healthcare team. *Surg Endosc.* 2023;37(3):2316-2325. [[Free full text](#)]
15. Yeganeh S, Torabizadeh C, Bahmani T, et al. Examining the views of operating room nurses and physicians on the relationship between professional values and professional communication. *BMC Nurs.* 2022;21(1):17. [[Free full text](#)]
16. Khoury A, Hugonnot S, Cossus J, et al. From mouth-to-mouth to bag-valve-mask ventilation: evolution and characteristics of actual devices--a review of the literature. *Biomed Res Int.* 2014;2014:762053. [[Free full text](#)]
17. Runciman WB, Merry AF. Crises in clinical care: an approach to management. *Qual Saf Health Care* . 2005;14(3):156-163. [[Free full text](#)]
18. Shailaja S, Hilda SS, Pinto PA, et al. Evaluation of resident satisfaction and change in knowledge following use of high-fidelity simulation teaching for anaesthesia residents. *Indian J Anaesth.* 2019;63(11):908-914. [[Free full text](#)]
19. Lei C, Palm K. Crisis Resource Management Training in Medical Simulation. In: *StatPearls*. Treasure Island (FL): StatPearls Publishing; July 24, 2023. [[Free full text](#)]
20. Hepner DL, Arriaga AF, Cooper JB, et al. Operating room crisis checklists and emergency manuals. *Anesthesiology.* 2017;127(2):384-392. [[Free full text](#)]
21. Schild S, Sedlmayr B, Schumacher AK, et al. A digital cognitive aid for anesthesia to support intraoperative crisis management: results of the user-centered design process. *JMIR Mhealth Uhealth.* 2019;7(4):e13226. [[Free full text](#)]

This project was funded under contract number 75Q80119C00004 from the Agency for Healthcare Research and Quality (AHRQ), U.S. Department of Health and Human Services. The authors are solely responsible for this report's contents, findings, and conclusions, which do not necessarily represent the views of AHRQ. Readers should not interpret any statement in this report as an official position of AHRQ or of the U.S. Department of Health and Human Services. None of the authors has any affiliation or financial involvement that conflicts with the material presented in this report. [View AHRQ Disclaimers](#)