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Intraoperative endotracheal tube kinking: clinical findings and early diagnosis

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Keypoints

1. Kinking of an endotracheal tube (ETT) can simulate other ventilatory issues including ventilator malfunction, mucus plugging, bronchospasm, ETT obstruction, bronchial intubation, pneumothorax or pulmonary parenchymal disease including pneumonia, pulmonary edema, or aspiration pneumonitis.
2. Prompt recognition is important as difficulties with ventilation can lead to cardio-respiratory complications including cardiac arrest.
3. Kinking of an ETT can lead to immediate or gradual changes in respiratory parameters including an increase in the peak inflating pressure and a decrease in delivered tidal volume.
4. The potential for such events may be increased by patient positioning in the prone position with the neck flexed as is necessary during posterior fossa surgery. Progressive obstruction to air flow may be noted as the ETT warms to body temperature and becomes more pliable.
5. When increases in peak inflating pressure or decreases in expired tidal volume are noted, a pre-determined algorithm may be helpful in identifying the cause of problem.

Abstract

Endotracheal intubation is a procedure performed by multiple medical specialists in various clinical scenarios. Difficulties with direct laryngoscopy and placement of an endotracheal tube (ETT) have received significant attention in the literature with the production of guidelines for dealing with scenarios during which bag-valve-mask ventilation or endotracheal intubation are problematic or impossible. However, there has been less attention paid to problems arising following placement of the ETT. Kinking of an ETT can simulate other ventilatory issues including ventilator malfunction, mucus plugging, bronchospasm, ETT obstruction, bronchial intubation, pulmonary edema, pneumothorax, aspiration, or pneumonia. We present two pediatric patients who developed altered respiratory compliance intraoperatively that was eventually determined to be the result of a kinked ETT. Previous reports of such problems are reviewed, an algorithm for determining the etiology of altered intraoperative compliance presented, and techniques to prevent the problem are discussed.

Keywords

Endotracheal tube, airway management, mechanical ventilation.

Introduction

Airway management during intraoperative anesthetic care may include use of a mask, supraglottic airway or an endotracheal tube (ETT).[1] During airway management, difficulties with placement of an ETT have received significant attention in the literature with the production of guidelines for dealing with scenarios during which bag-valve-mask ventilation or endotracheal intubation are problematic or impossible.[2,3] However, there has been less attention paid to problems arising following placement of the ETT during intraoperative anesthetic care. During intraoperative care, peak inflating pressures (PIP) and exhaled tidal volumes are monitored to assess respiratory resistance and compliance.[4] Changes in PIP or exhaled tidal volume may indicate various pathologic processes including malfunction of the anesthesia machine/ventilator, upper airway obstruction, mucus plugging, bronchospasm, obstruction of the ETT, bronchial intubation, pulmonary edema, pneumothorax, aspiration, or pneumonia. We present two pediatric patients who developed altered respiratory compliance intraoperatively that was eventually determined to be the result of a kinked ETT. Previous reports of such problems are reviewed, an algorithm for determining the etiology of altered intraoperative compliance presented, and techniques to prevent the problem are discussed.

Case reports

Review of these cases and presentation in this format followed the guidelines of the Institutional Review Board of Nationwide Children's Hospital.

Patient 1: A 10-year-old male, who had been involved in a motor vehicle accident (MVA) four weeks prior, was scheduled for a nephrostomy tube placement in the interventional radiology suite to treat right ureterovesical junction (UVJ) obstruction due to a stone. The patient's past medical history included developmental delay, attention deficit hyperactivity disorder, and a seizure disorder. Initial injuries following the MVA included a traumatic brain injury, left temporal hemorrhage, C2 trauma with prevertebral edema, and a grade III liver laceration. The hospital course had been complicated by traumatic rhabdomyolysis, spastic quadriplegia, contractures, dysautonomia, seizures, and nephrolithiasis. Four days prior to nephrostomy tube placement, the patient had a seizure with emesis. He was transferred from the inpatient rehabilitation unit to the Pediatric Intensive Care Unit (PICU) due to the onset of fever and ongoing symptoms of agitation, tachycardia, and tachypnea. The pre-operative visit and examination revealed that the patient had a patent airway and was maintaining oxygen saturations in the normal range on room air. A chest radiograph was unremarkable. The patient remained in a cervical collar secondary to spinal trauma. Episodes of dystonia, diaphoresis, tachycardia, hypertension, and hyperthermia were attributed to autonomic dysfunction from the traumatic brain injury. Symptoms were being treated with diazepam, clonidine, bromocriptine, and propranolol. Other medications included ranitidine, lorazepam, lacosamide, and hydromorphone. The patient was transported to the operating room and routine American Society of Anesthesiologists' monitors were placed. Following pre-oxygenation, anesthesia was induced with propofol and fentanyl. The cervical collar was left in place during endotracheal intubation and throughout the procedure. Following manual-in-line cervical stabilization, oral endotracheal intubation was performed with a 5.5 Microcuff® ETT over a fiberoptic bronchoscope. The patient was positioned prone for the procedure. Ten minutes after securing the airway, ventilation became problematic with increased PIP and decreased expired tidal volumes. Breath sound were decreased and auscultation revealed audible wheezes. Fresh gas flows were increased and the FiO2 changed to 1.0 while manual bag ventilation was started. A quick survey of the breathing circuit including the extra-oral ETT revealed no disconnections or kinks. Due to respiratory symptoms of cough and tachypnea prior to the induction of anesthesia, a mucus plug was considered and an attempt was made to pass a suction catheter through the ETT. The suction catheter would not pass beyond 5

centimeters beyond the intra-oral portion of the ETT (figure 1). Digital palpation of the course of the ETT in the mouth was performed and a kinked ETT was noted. The kink was relieved by untwisting the tube, which was performed with the patient in the prone position, while the head continued to be supported on the prone pillow that was placed during initial positioning. C-spine precautions were maintained throughout. Tidal volumes and airway pressures quickly normalized following unkinking the ETT and the procedure was completed with no further complications.

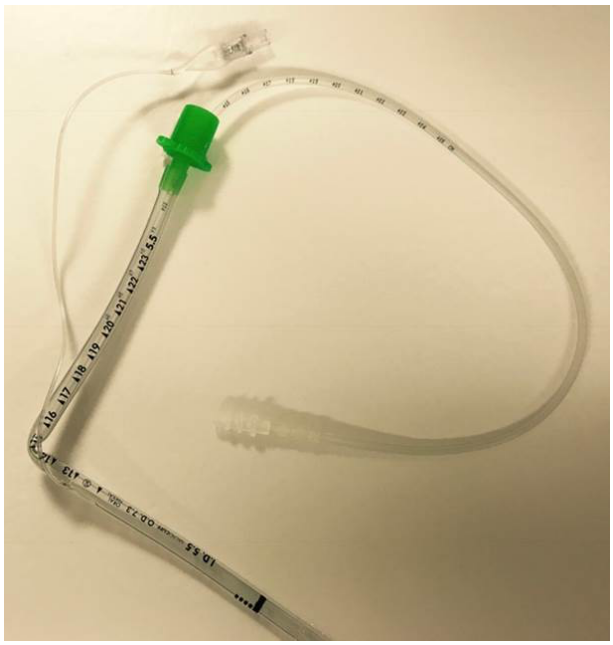

Figure 1. Kink in the endotracheal tube blocking the passage of a suction catheter

Patient 2: A 16-year-old adolescent female presented as an emergency for control of a postoperative tonsillar hemorrhage on post-operative day 8 following tonsillectomy at another institution. The patient had no significant past medical history. Laboratory evaluation from the emergency department revealed a mild normocytic anemia attributed to acute hemorrhage with a hemoglobin and hematocrit of 11.1 gm/dL and 32.8%. Coagulation studies were within the normal range. The patient was transported to the operating room where routine American Society of Anesthesiologists' monitors were placed. After pre-oxygenation, rapid sequence induction was performed with propofol and succinylcholine. Oral endotracheal intubation with direct laryngoscopy was then performed with a 6.0 Microcuff® ETT. Auscultation of the chest to confirm ETT position revealed bilateral and equal air entry without wheezing. A Crowe-Davis mouth gag was inserted atraumatically into the oral cavity and suspended from the Mayo stand. Approximately five minutes after commencement of the surgical procedure, the PIP doubled with a significant decrease in the exhaled tidal volume. Verbal confirmation was obtained from the pediatric otolaryngologist that no ETT kink or obstruction was noticed around the mouth gag. The surgeon was requested to stop the procedure and the FiO2 was increased to 1.0. Auscultation of the chest revealed bilateral decreased air entry. While other causes for the change in the patient's condition were being considered, albuterol was administered via the ETT since bronchospasm was considered high on the differential diagnosis. Since the difficulty in ventilation persisted despite the administration of albuterol, a suction catheter was passed into the lumen of the ETT to suction a mucus plug or blood clot. Resistance to passage of the suction catheter was noted with an inability to pass the catheter beyond the depth of the oral cavity. The Crowe-Davis mouth gag was removed and direct laryngoscopy performed. An intra-oral kink in the ETT was noted distal to where the mouth gag was previously placed (figure 2). The kinked ETT was removed while cricoid pressure was maintained during ETT replacement (figure 3). The procedure was restarted and completed uneventfully. The patient's trachea was extubated without difficulty at the end of the procedure and she was discharged home the following day.

Figure 2. Intra-oral kinking of the endotracheal tube in the backof the oropharynx (yellow arrow) during intraoperative direct laryngoscopy when peal airway pressure increased.

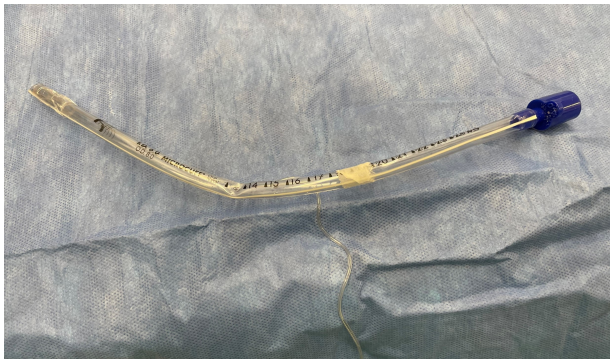

Figure 3. Kinked endotracheal tube after removal froma the airway

Discussion

Various intraoperative processes can result in difficulties with oxygenation and ventilation during intraoperative anesthetic care. Although kinking of an ETT during anesthesia and surgery is generally uncommon, early recognition and prompt treatment are necessary to avoid morbidity and mortality.[5] Analysis from the Australian Incident Monitoring System for problems related to the ETT revealed that the majority of kinks occurred outside the mouth and therefore were generally easy to identify; however, no single monitoring parameter emerged as a reliable detector of obstruction.

A kinked ETT may mimic other pathologic processes including bronchospasm, mainstem intubation or ventilator malfunction. Regardless of the site of obstruction, prompt recognition is important as difficulties with ventilation can lead to cardio-respiratory complications with disastrous consequences including cardiac arrest. As noted in our patients, obstruction to the ETT may result in audible wheezing simulating bronchospasm.[6] Given these concerns, a specific algorithm as outlined in table 1 may be helpful in identifying the problem when increases in PIP or decreases in the exhaled tidal volume are noted. Once ventilator/anesthesia machine malfunction is ruled out, patient conditions that may alter respiratory resistance or compliance should be identified. In the absence of these, passage of a suction catheter is indicated. ETT obstruction or kinking will result in difficulty or inability to pass the suction catheter past the distal end of the ETT. As noted in both of our patients, the inability to pass a suction catheter through the ETT led to the identification of ETT kinking.

In summary, intraoperative kinking of an ETT can simulate other ventilatory issues including ventilator malfunction, mucus plugging, bronchospasm, ETT obstruction, bronchial intubation, pneumothorax or pulmonary parenchymal disease including pneumonia, pulmonary edema, or aspiration pneumonitis. Problems can be noted immediately following endotracheal intubation or at any time during intraoperative care. Progressive obstruction to air flow may be noted as the ETT warms to body temperature and becomes more pliable. The potential for such events may be increased by patient positioning in the prone position with the neck flexed as is necessary during posterior fossa surgery. Prevention of such events includes careful evaluation of the course of the ETT following patient positioning. This may include passage of a fiberoptic bronchoscope to evaluate ETT patency especially when neck flexion is required for posterior fossa surgery. Other potential interventions include nasal intubation to limit ETT angling during passage through the oropharynx and use of a wire reinforced ETT. However, while reinforced ETTs may limit the potential for kinking, once kinked, they may be limited options to re-establish patency. During intraoperative kinking of the ETT, initial clinical findings may include an increase in PIP or a decrease in expired tidal volume. A pre-determined algorithm for clinical care as outlined in table 1 may be helpful in rapidly identifying the etiology of the event and

allowing for immediate intervention prior to clinical decompensation.

1.	Manual ventilation with 100% oxygen
2.	Auscultation to ensure bilateral breath sounds
3.	Cessation of surgical or airway stimulation
4.	Ventilator and anesthesia machine check to rule out mechanical issue or ventilator disconnect
5.	Passage of a suction catheter to identify secretions or ETT blockade
6.	Visualization or manual palpation of the ETT to rule out kinking
7.	Identification of potential anaphylactoid reactions
8.	Identification of primary parenchymal lung disease (aspiration pneumonitis, adult respiratory distress syndrome, pneumonia)
9.	Treatment of bronchospasm as needed
10.	Consider ETT exchange
11.	Chest radiograph if clinically indicated

Table 1. Approach to altered respiratory compliance

References

1. Holm-Knudsen RJ, Rasmussen LS. Paediatric airway management: basic aspects. Acta Anaesthesiol Scand. 2009;53(1):1-9.
2. Hsu G, von Ungern-Sternberg BS, Engelhardt T. Pediatric airway management. Curr Opin Anaesthesiol. 2021;34(3):276-83.
3. Engelhardt T, Fiadjoe JE, Weiss M, Baker P, Bew S, Echeverry Marín P, von Ungern-Sternberg BS. A framework for the management of the pediatric airway. Paediatr Anaesth. 2019;29(10):985-92.
4. Hans GA, Sottiaux TM, Lamy ML, Joris JL. Ventilatory management during routine general anaesthesia. Eur J Anaesthesiol. 2009;26(1):1-8.
5. Szekely SM, Webb RK, Williamson JA, Russell WJ. The Australian Incident Monitoring Study. Problems related to the endotracheal tube: an analysis of 2000 incident reports. Anaesth Intensive Care 1993;21(5):611-6.
6. Woods BD, Sladen RN. Perioperative considerations for the patient with asthma and bronchospasm. Br J Anaesth. 2009;103(Suppl 1):i57-65.
7. Looseley A. Management of bronchospasm during general anaesthesia. Update in Anaesthesia. 2011:17-21.