Case Study

Tom is scheduled for a basal cell carcinoma removal from his left cheek under monitored anesthesia care. The surgeon said she was in a rush, and that the OR team would have to move quickly. The circulator prepped the patient with an alcohol-based prep solution and quickly draped the patient. Next, the anesthesia provider administered propofol and fentanyl to sedate the patient in preparation for local anesthetic injection by the surgeon. The patient required a jaw thrust and oxygen 4 L/min via nasal cannula to maintain an oxyhemoglobin saturation of 93%. The surgeon hurried the team through the pre-surgical time out and began the operation. After using the electrocautery unit, the surgeon reported that there was a fire in the surgical field.

What was the cause of this complication? What is the treatment? Can you identify all of the risk factors that contributed to this catastrophe? In this objective, we're going to explore a selection of complications related to airway management including, laryngospasm, airway fire, and pulmonary aspiration.

Laryngospasm

Laryngospasm is the sustained and involuntary contraction of the laryngeal musculature that results in the inability to ventilate (cricothyroid muscles tense the vocal cords and lateral cricoarytenoid and thyroarytenoid muscles adduct the vocal cords). This response often outlasts the stimulus and may result in complete airway obstruction, negative pressure pulmonary edema, cardiac arrest, and death.

Recognition of who is at risk is the first step in preventing laryngospasm.

- Patient-related risk factors include active or recent upper respiratory tract infection (within 2 weeks), exposure to secondhand smoke, reactive airway disease, GERD, and age less than 1 year.
- Anesthesia-related risk factors include light anesthesia (particularly with concurrent airway manipulation), blood or saliva in the upper airway, hyperventilation, and hypocapnia.
- Surgical-related risk factors include airway surgery, such as tonsillectomy, adenoidectomy, nasal/sinus procedures, laryngoscopy, and bronchoscopy.

We may be able to prevent laryngospasm with the following interventions:

- Avoid noxious stimulation during “light” anesthesia.
- Ensure adequate depth of anesthesia before instrumenting the airway.
- Suppress laryngeal nerve function with topical lidocaine.
- Administer IV lidocaine (1.5 – 2 mg/kg) 3-5 minutes prior to extubation.
- Extubate the trachea or remove a supraglottic airway device when the patient is deep or fully awake – but not in-between.
- There is no data to support the use of atropine in the prevention of laryngospasm.

It's almost as though nature embedded a fail-safe mechanism whereby hypercapnia and hypoxemia have a tendency to break
laryngospasm. Having said this, we do not recommend that you wait for nature to take its course. Instead, laryngospasm should be treated with the following interventions.

- **FiO₂ 100%**.
- Remove noxious stimulation.
- Deepen anesthesia by increasing the concentration of inhalation agent or with a small dose of propofol or lidocaine. It’s estimated that propofol (0.5 mg/kg) will break laryngospasm in 75% of cases.
- CPAP 15 – 20 cm/H₂O while instituting maneuvers that open the airway (head extension, chin lift, Larson’s maneuver – we will discuss this in greater detail shortly).
- If the aforementioned interventions fail to relieve laryngospasm, then succinylcholine is the first-line treatment.
- If IV access: succinylcholine 2 mg/kg IV (neonate and infant) or 1 mg/kg IV (children or adult). Having said this, it’s been reported that as little as 0.1 mg/kg has been used to successfully break laryngospasm in adult bronchoscopy patients while simultaneously preserving spontaneous ventilation.
- If no IV access: succinylcholine 5 mg/kg IM (neonate or infant) or 4 mg/kg IM (children or adult). Although the deltoid or quadriceps muscles are often used, intralingual or submental administration may produce a slightly faster onset.
- Children < 5 years old should receive atropine 0.02 mg/kg with succinylcholine to prevent bradycardia.

Larson’s maneuver involves the application of firm pressure at the “laryngospasm notch” just behind the earlobe. The laryngospasm notch is bounded anteriorly by the ascending ramus of the mandible, superiorly by the base of the skull, and posteriorly by the mastoid process. Firm pressure is applied bilaterally towards the skull base while simultaneously subluxing the mandible. Pressure should be applied for 3 – 5 seconds then released for 5 – 10 seconds and repeated until the laryngospasm has subsided. It’s important to understand that Larson’s maneuver is not a simple jaw thrust. Indeed, the most common error is to place the fingers on the angle of the jaw or on the lower mandibular ramus.

Although the precise mechanism of action is unknown, Larson’s maneuver is believed to accomplish two goals. First, subluxing the jaw corrects airway obstruction at the level of the tongue. Second, the mechanical (and quite painful) stimulation may affect the airway’s neural pathways, ultimately leading to relaxation of the vocal folds and the vocal cords.

**Airway Fire**

It’s estimated that there are approximately 600 surgical fires each year, where 65% of these instances occur during surgery on the head, neck, face, airway, or upper chest. Recall that there are 3 ingredients required to produce a fire and understanding the interdependence of these factors will help you safeguard your patients from catastrophe. The 3 components of the fire triangle include an ignition source (such as a laser or electrosurgical cautery), a fuel (such as an endotracheal tube, surgical drapes, or other supplies in the surgical field), and an oxidizer (such as oxygen or nitrous oxide).

It’s important to understand that fuel sources that would not otherwise burn in the presence of air can become highly flammable in the presence of oxygen or nitrous oxide.

In the domain of fire prevention, the central role of the anesthesia provider is to control the ambient level of oxygen near the surgical field, and this is of critical importance when open delivery oxygen is used. So, the first question we must ask is, “is supplemental oxygen truly necessary for this patient?” In many cases, the answer is “no” and so the case can proceed without supplemental oxygen. A nasal cannula may still be used to measure end-tidal carbon dioxide. Additionally, this technique also allows the option to administer oxygen if needed, but you must communicate this to the surgeon to make sure that oxygen is not turned on when the electrocautery unit is in use.

If the patient is unable to maintain an adequate oxyhemoglobin saturation, then the airway should be secured with an endotracheal tube or an LMA, as these devices will prevent oxygen from entering the surgical field.

There are some special situations where the surgeon needs to communicate with the patient, but the patient does not tolerate room air. Examples include carotid endarterectomy, pacemaker insertion, or neurosurgery. In these unique
circumstances, best practice suggests blending air with oxygen to maintain the FiO₂ at 30% or less. On most anesthesia machines, the auxiliary flowmeter only delivers 100% oxygen, so if you’re using one of these machines you’ll need to use a different technique to blend air and oxygen. Here are your options. First, an air-oxygen blender can be used to deliver a precise concentration of oxygen, however these devices may not be available in many anesthetizing locations. Another approach is to dial in the desired oxygen concentration (again 30% or less) at the flowmeters and then attach a nasal cannula to the common gas outlet with the appropriate adapter. Since air contains 21% oxygen, there’s some math required to do this correctly, but a handy value to memorize is that adding 200 mL/min of oxygen to 1.8 L/min of air will yield an FiO₂ of 29%. Finally, there are some anesthesia machines that don’t have a common gas outlet, but you can attach a nasal cannula (with its adapter) to the y-piece. A key benefit to this approach is that you can use the oxygen analyzer to measure the FiO₂ delivered to the patient. Also, to ensure that the entire FGF is delivered to the patient, it may help to partially close the APL valve on the anesthesia machine.

With regards to fire prevention, there are several other strategies that can be used to reduce the risk of an airway fire:

- Discuss the risk of airway fire during the surgical “time out.”
- Control the concentration of oxygen under the drapes by blowing air at 5 – 10 L/min and by pinning the drapes away from the patient’s face if surgery allows.
- Allow alcohol-based surgical prep solutions (or any other flammable solutions) to dry completely according to the manufacturer’s recommendations before the surgical drapes are applied. ChloraPrep and DuraPrep should be allowed to dry at least 3 minutes after being applied to the skin and at least 60 minutes after being applied to hair.
- Moisture surgical sponges and gauzes if they’re going to be used near an ignition source.
- When a fiberoptic light source is on the surgical field, do not leave the device turned-on when it’s not in use.

To help you learn more about the subject, we’ve linked to several trusted resources.

Unfortunately, not all airway fires are preventable, so one must be at the ready to rescue the patient if disaster strikes. What should you do in the event of an airway fire? Let’s look to the ASA Practice Advisory for the Prevention and Management of Operating Room Fires for guidance.

Here is the recommended algorithm for an airway fire:

**Steps To Take When Fire Is Present**

1. Stop ventilation and remove the endotracheal tube.
2. Stop the flow of all airway gases.
3. Remove other flammable material from the airway.
4. Pour water or saline into the airway.
5. If the fire isn’t extinguished on the first attempt, then use a CO₂ fire extinguisher.

**Steps To Take After The Fire Is Controlled**

1. Re-establish ventilation by mask. Avoid supplemental O₂ (if possible) or nitrous oxide.
2. Check the endotracheal tube for damage, as fragments may remain in the patient’s airway.
3. Perform bronchoscopy to inspect for airway injury or retained fragments.
4. Assess the patient’s status and create a plan to manage the patient’s injuries.

To help you learn more about the subject, we’ve linked to several trusted resources.
Aspiration

Aspiration most commonly occurs during anesthetic induction and intubation or within 5 minutes of extubation. It causes three potential problems:

- Gastric contents enter the airway → risk of airway obstruction
- Gastric contents cause a chemical burn to the airway and lung parenchyma → risk of bronchospasm and impaired gas exchange
- Infectious material enters the airway → bacterial infection (not all aspiration leads to infection)

Of patients who suffer aspiration in the operating room, 60% remain asymptomatic, 20% require supportive care, and 5% die.

Take a moment to review the factors that can predispose a patient to aspiration.

- Non-fasting status
- Emergency surgery
- Trauma
- Pregnancy
- GI obstruction
- GERD
- Peptic ulcer disease
- Hiatal hernia
- Ascites
- Difficult airway management
- Impaired airway reflexes
- Seizures
- Residual neuromuscular blockade

The primary goals of pharmacology prophylaxis include reducing gastric volume and increasing gastric pH. Pharmacologic prophylaxis is not recommended for patients who are not at risk for aspiration. If the patient is at risk, then the following agents should be considered with an understanding of the pharmacokinetics of each agent.

- Antacids: sodium citrate, sodium bicarbonate, magnesium trisilicate
- H2 antagonists: ranitidine, cimetidine, famotidine
- GI stimulants: metoclopramide
- Proton pump inhibitors: omeprazole, lansoprazole, pantoprazole
- Antiemetics: droperidol, ondansetron

*Anticholinergics are not recommended for aspiration prophylaxis

Recall that many patients who experience aspiration remain asymptomatic. In those that show signs, hypoxemia is the hallmark. Additional findings include dyspnea, tachypnea, cyanosis, tachycardia and hypertension. If the aspiration event is unnoticed, arterial blood gas analysis and chest x-ray may aid in diagnosis, where the most common findings include pulmonary edema and infiltrates in the perihilar and dependent lung regions.

Here is an algorithm for the treatment of aspiration:

- Tilt the head downward or to the side (first action).
- Suction the upper airway to remove particulate matter.
- Lower airway suction is only useful for removing particulate matter. It doesn’t help the chemical burn from gastric acid.
- Secure the airway to support oxygenation if needed.
- Administer oxygen as needed with an understanding that chemical injury to the lungs increases the likelihood of oxygen toxicity.
Key Points

Treatment for laryngospasm includes 100% FiO₂, removing the noxious stimulation, deepening the anesthetic, CPAP, Larson's maneuver, and a neuromuscular blocker, such as succinylcholine.

The 3 components of the fire triangle include an ignition source, a fuel, and an oxidizer.

Fuel sources that would not otherwise burn in the presence of air can become highly flammable in the presence of oxygen or nitrous oxide.

ChloraPrep and DuraPrep should be allowed to dry at least 3 minutes after being applied to the skin and at least 60 minutes after being applied to hair.

Pharmacologic prophylaxis is not recommended for patients who are not at risk for aspiration.

If the patient experiences an aspiration event, routine use of antibiotics is not recommended and should only be used if the patient sustains a fever or increased WBC for more than 48 hours.

If the patient remains asymptomatic after the aspiration event, the patient may be discharged to home so long as he does not experience any of the following within 2-hours of the aspiration event:

- New cough or wheeze
- Radiographic evidence of pulmonary injury
- SpO₂ decrease > 10% of preoperative values on room air
- A-a gradient > 300 mmHg

References

Textbooks: These books are included on the CPC Exam Bibliography published by the NBCRNA


Articles:


Websites:

