INTRODUCTION

Respiratory anesthetic emergencies are the most common complications encountered during the administration of anesthesia in both the adult and pediatric populations. Regardless of the depth of anesthesia, a thorough review of the patients’ health history, including the past medical history, medication list, prior anesthesia history, and complex physical examination, is critical in the promotion of safety in the oral and maxillofacial surgery office. The effective management of respiratory anesthetic emergencies includes both strong didactic and clinical skills.

There are multiple disease states that affect the pulmonary system. These states include asthma, chronic obstructive pulmonary disease (COPD), and respiratory infections. Patients with these types of respiratory diseases present many challenges during the perioperative period in the office-based setting. It is with a thorough knowledge, excellent training, and clinical skills that the oral and maxillofacial surgeon is uniquely qualified to perform both surgical and anesthetic procedures in the outpatient setting.

RESPIRATORY PHYSIOLOGY

The primary function of the lungs is to oxygenate the blood perfusing through the pulmonary vasculature and remove the byproduct of metabolism carbon dioxide. This gas exchange occurs between the alveoli of the lungs and the blood in the pulmonary capillary system. Oxygen diffuses through the capillary walls into the plasma and binds to hemoglobin molecules. To establish gas exchange in the pulmonary system, there must be ventilation of the alveoli, diffusion through the capillary membranes, and circulation or perfusion of the pulmonary capillary bed.

A very important aspect of the use of oxygen during anesthesia is preoxygenation. Preoxygenating patients with 100% oxygen before the induction of anesthesia will maintain higher levels of tissue oxygenation during periods of apnea. The use of preoxygenation will greatly aid the
surgeon during anesthetic induction, when there may be periods of apnea, ventilatory difficulty, and airway control issues.

The respiratory system, as noted earlier, functions by delivering oxygen to the arterial blood supply, which is then delivered to the body’s tissues. The oxygen found in the arterial blood is 98% bound to hemoglobin molecules located in the red blood cells. The remaining 2% is diffused in the plasma. This ratio produces a pressure called the arterial oxygen tension (PaO₂). This pressure gradient is how the unbound oxygen enters the plasma and is delivered to the tissues of the body. There is a commonly known relationship between the hemoglobin saturated with oxygen (SaO₂) and the pressure gradient by dissolved oxygen (PaO₂). This relationship is classically illustrated by the oxygen-hemoglobin dissociation curve (Fig. 1). It is this curve that we use to assess a patient’s oxygenation status.

COMMON RESPIRATORY DISEASES

There are many diseases of the respiratory tract that can alter the physiology of gas exchange and, thus, the administration of an anesthetic. A thorough history and physical examination are critical in the decision-making process of an anesthetic plan and before the induction of that anesthetic. A few of the major disease processes that affect the respiratory system include asthma, COPD, and upper respiratory infections (URI). URIs can adversely affect the airway. For example, in children a URI can cause hyperreactivity of the airway for up to 6 weeks after the infection. For this reason, the recommendation for postponing any anesthetic for 2 weeks after any clinical signs or symptoms is commonplace and recommended by the American Society of Anesthesiologist (ASA).

Chronic pulmonary diseases are characterized as obstructive or restrictive. Obstructive airway disease is the most frequent cause of pulmonary dysfunction. Two of the most common obstructive airway diseases are asthma and COPD. Changes in airway resistance will lead to ventilation-perfusion mismatches. These mismatches result in arterial hypoxemia while on room air. Carbon dioxide is chronically retained, leading to respiratory acidosis. All obstructed airway diseases will manifest dyspnea, coughing, wheezing, and sputum production.

Restrictive pulmonary diseases have decreased lung compliance resulting in decreased lung volumes. This decrease translates to a decreased in vital capacity or forced expiratory volume in the first second of expiration (FEV₁), which is the classic sign of restrictive diseases. The main complaints of patients with restrictive diseases include dyspnea and rapid, shallow breathing. Acute episodes of restrictive pulmonary diseases are caused by leakage of intravascular fluid into the interstitium of the lungs and alveoli manifesting as pulmonary edema. Acute diseases include adult respiratory distress syndrome, aspiration pneumonia, and pulmonary edema. Chronic restrictive diseases are caused by pulmonary fibrosis. Sarcoidosis is the main chronic restrictive disease. Other causes include the interference of lung expansion, which includes pulmonary effusions, obesity, pregnancy, and ascites.

Asthma

Asthma is the most common chronic inflammatory respiratory disease, and it affects upwards of 6%
of the US population. Asthma is defined by the presence of chronic inflammation of the respiratory tract submucosal tissue, hyperreactivity to various stimuli, and reversible expiratory airflow obstruction. The irritability of the airway will manifest as wheezing and coughing. An acute asthma attack can result in bronchospasm.

Asthma is further defined as either intrinsic (nonspecific factors) or extrinsic (allergen mediated). Intrinsic causes include infectious, exercise-induced, or emotional changes. A thorough history can help differentiate between intrinsic and extrinsic.

Frequently asked questions include the following:

1. What causes your asthma attacks?
2. When were you first diagnosed?
3. Have you ever been to the emergency department or hospitalized?
4. When was your last attack?
5. What medications do you currently use?
6. Have there been any recent changes in your medications?
7. When was the last time you used your rescue inhalers?
8. How frequently do you use your inhaler?

The clinical manifestations of asthma are secondary to the edema, mucous production, and constriction of the smooth muscle of the airway. This effect is a reactionary effect from the release of histamine from mast cell degranulation (immunoglobulin E mediated) and cytokines from leukocytes.

The bronchoconstriction is mainly countered by beta (B) agonists, such as albuterol, which stabilize the mast cells and prevent their degranulation. Albuterol is the most common B agonist rescue inhaler used today. There are many other medications used in the treatment of asthma (chronic and acute flare-ups). Other medications used to treat acute asthma attacks include epinephrine in doses of 0.2–0.5 mL of 1:1000 aqueous solution for adults and .01 mg/kg to a maximum dose of 0.5 mg for children. Other medications used perioperatively include corticosteroids, metered dose inhalers, and nebulizer therapy.

A thorough history is important when treating patients with asthma. Other useful tests/studies to consider are pulmonary function tests, chest radiographs, and preoperative medical consultations. Caution should be used when sedating patients with asthma. The control of the asthmatic airway is critical. Consideration should be given to pretreating patients with asthma with B agonist inhalers and corticosteroids. Patients should be instructed to bring their rescue inhaler to their surgical appointment regardless of whether the oral and maxillofacial surgeon has emergency rescue inhalers.

Some medications should be administered with caution in patients with asthma. One such class in particular is the narcotics. Narcotics can cause respiratory depression, rigid chest, and mast cell degranulation, which can manifest as a bronchospasm; emergency measures must be initiated immediately on recognition of these unfolding events.

**COPD**

COPD is a disease process that includes airflow obstruction caused by either chronic bronchitis or emphysema. There are 2 major types of COPD: chronic bronchitis and emphysema.

**Chronic bronchitis**

Chronic bronchitis (blue bloaters) is the chronic secretion of mucous into the bronchi causing increased airflow resistance. These patients develop arterial hypoxemia, hypercarbia, and cor pulmonale. Patients with chronic bronchitis have a chronic productive cough that is present for at least 2 consecutive years.

**Emphysema**

Emphysema (pink puffers) is the abnormal persistent enlargement of the airway distal to the terminal bronchioles along with the destruction of the walls without fibrosis. This condition is characterized by the loss of elasticity causing collapse of the airway during exhalation, which will lead to increased airway resistance. Clinically, patients with emphysema will have dyspnea, cough, sputum production, and decreased exercise tolerance.

Although both asthma and COPD exhibit similar clinical findings, the signs and symptoms are reversible for asthma and irreversible for COPD. COPD typically consists of chronic bronchitis, emphysema, and peripheral airway disease. Patients will exhibit hypercarbia, hypoxemia, and heart failure (cor pulmonale). Clinically these patients can tolerate elevated levels of carbon dioxide and decreased oxygen levels, which are the driving force of respiration. It has been shown that patients can tolerate oxygen concentrations of 40% or less without decreasing the respiratory drive. To maintain adequate oxygen levels under sedation, the use of a nasal cannula or nasal hood at 1 to 4 L/min oxygen can be safely used without affecting hypoxic drive.

**COMMON RESPIRATORY EMERGENCIES IN ADULTS**

**Laryngospasm**

A laryngospasm is a spasm of the intrinsic muscles of the larynx causing closure of the airway at the
level of the vocal cords. It is a protective reflex mechanism that prevents irritants, such as blood, saliva, or irrigation, as well as solid materials from entering the lower airway. A laryngospasm is classified as complete or incomplete (partial). The classic sign is a high-pitched stridor or crowing for a partial laryngospasm and silence for a complete obstruction. Patients with a laryngospasm can also exhibit paradoxic chest wall and abdominal movements and oxygen desaturation.

The cause of a laryngospasm includes local irritants and the depth of anesthesia. In consciously sedated patients, these irritants will cause the spasm of the intrinsic muscles of the larynx, but the swallowing mechanism will clear the airway. In deeply sedated patients, these mechanisms can be absent causing the laryngospasm because of the inability of the musculature to function properly and clear the airway.

Preventing a laryngospasm should include proper airway maintenance. The surgeon routinely uses a throat pack or partition to keep foreign material out of the airway. Proper suctioning techniques aid in airway control. Head positioning (sniffers position) will position the airway in a straight-line physiologic position. Finally, the depth of anesthesia can sensitize the airway causing irritability. This situation is most commonly seen when the sedation is inadequate.

If a laryngospasm is suspected, the surgery shall be stopped and the surgical site packed off. The proper head position will assist in airway control. The airway should be suctioned to clear any foreign bodies, including blood, saliva, and irrigation. Also, 100% oxygen should be administered via a full face mask. By depressing the chest, the surgeon may elicit a huff of air indicating a patent airway.

With a continuing laryngospasm, the next step is to attempt ventilation of patients with a full face mask and 100% oxygen. If patients cannot be ventilated, a small dose of succinylcholine 0.15 to 0.30 mg/kg intravenously (IV) in adults is used to break the spasm and initiate ventilation. This dose will work for smaller individuals or a partial spasm. In larger individuals or a complete spasm, 0.3 to 0.6 mg/kg IV should be considered. If successful, the airway is maintained along with proper ventilatory support until the return of spontaneous respiration. If the spasm continues, an intubating dose of succinylcholine 1 mg/kg should be administered along with endotracheal intubation.

In the office setting, emergency services (911) should be called early in any anesthesia emergency. If there is a suspected familial history of malignant hyperthermia, the drug rocuronium can be used at a dose of 0.6 to 1.2 mg/kg IV. Succinylcholine acts as a triggering agent for MH. The onset of rocuronium is 1 to 2 minutes, and the duration of action is anywhere from 20 to 60 minutes. Therefore, with the use of rocuronium, prolonged ventilator support will be necessary. The reversal agent for rocuronium is Sugammadex. This drug is likely to receive approval by the Food and Drug Administration in 2013.

**Bronchospasm**

A bronchospasm is a reflex bronchiolar constriction that can be centrally mediated or a local response to airway irritation. This constriction can be elicited by stimuli, such as secretions, blood, or foreign bodies. The clinical manifestations include expiratory wheezing and increased airway resistance. Increased airway resistance can make ventilation difficult in deeply anesthetized patients. In consciously sedated patients, tachypnea and dyspnea are commonly seen.

In the oral and maxillofacial surgery office, most patients are anesthetized without the use of a secure airway like an endotracheal tube or laryngeal mask airway (LMA). Further, these patients are spontaneously breathing with supplemental oxygen. If a bronchospasm is suspected, nonsedated or minimally sedated patients may be able to inhale a β agonist inhaler, such as albuterol (4–8 puffs). In moderately to deeply sedated patients, 100% oxygen with a full face mask should be immediately initiated. If patients can be ventilated, nebulized albuterol (6–10 puffs) can be administered.

After the use of a β agonist, if the bronchospasm is still present, subcutaneous epinephrine in doses of 0.3 to 0.5 mg of 1:1000 is used. IV epinephrine should be used carefully in patients exhibiting hypertension because of the potential cardiac side effects. Boluses of 10 to 20 μg of a 1:10 000 solution of epinephrine is titrated to effect. If after all the prior medications are administered and there is still difficulty ventilating patients, intubation should be considered. The airway of choice in this situation is the endotracheal tube. Other reasons for a secure airway in this anesthetic emergency include continuing hypoxemia, muscle weakness, and worsening obtundation.

Once patients are intubated, a β agonist, such as Albuterol, can be given through the endotracheal tube. Albuterol is the most common β agonist used today for the treatment of a bronchospasm in doses of 6 to 10 puffs. Other treatments include deepening the level of anesthesia, especially if using bronchodilating inhalation agents. Further treatments include continued
hydration and humidification of the airway during the use of inhaled gases.

**Airway Obstruction**

Airway obstruction is one of the more common anesthetic emergencies. The obstruction of the airway is usually located in the upper airway (supraglottic region) and is caused by the loss of pharyngeal muscle tone. With the loss of muscle tone, the tongue is displaced posteriorly and occludes the airway. The deeper the plane of anesthesia, the more common the possibility of developing an obstructed airway. Other causes of airway obstruction include foreign bodies, such as teeth, aspirate, prosthetic devices, or surgical instruments.

The clinical signs of obstruction include paradoxical breathing with sternal retraction and abdominal muscle activity. These abnormal movements manifest as a rocking motion. A partial obstruction may also exhibit stridor.

The initial treatment of an airway obstruction includes simple airway opening techniques, including the head tilt–chin lift maneuver. Following the chin lift, the jaw thrust can be used. Grabbing the tongue with gauze, a tissue forceps, or suture and pulling it forward also can be used to open the oropharyngeal airway. If the airway obstruction is not cleared with these positional changes, the next recommended treatment in both conscious and unconscious patients is to deliver chest or abdominal thrusts to increase airway pressure. Producing increased airway pressures produced by the chest or abdominal thrust can force the foreign body into the pharynx. In obese patients or pregnant woman, the chest thrust over the sternum is used instead of the abdominal thrust over the sternum. Complications of the thrust maneuvers include rib fracture and laceration of abdominal or thoracic viscera. The abdominal thrust can be effective in both conscious and unconscious patients.

Blind finger sweeps are no longer used in unconscious patients per the American Heart Association. Another technique that works well is to visualize the airway while performing a laryngoscopy and retrieving any foreign matter with the Magill forceps. If these maneuvers are unsuccessful, attempts to give positive pressure ventilation with a full face mask is initiated. Blind finger sweeps in children are not indicated because it can push the object further down the airway.

Adjunctive airway equipment to be considered includes oral and nasal airways, LMA sized to fit, and endotracheal tube intubation. If the simpler techniques are not effective, more invasive airway management is necessary. There are multiple noninvasive options; but if these are ineffective, then surgical airways are required. These surgical airway options include transtracheal catheterization, cricothyrotomy, and tracheostomy.

**Emesis and Aspiration**

There are many causes of nausea and vomiting, including anxiety, narcotics, pain, and anesthesia. Gastric emptying times can also be increased by any of these. Emesis of gastric contents in anesthetized patients can lead to aspiration. Aspiration can exhibit as hypoxemia, tachycardia, tachypnea, bronchospasm, hypotension, and atelectasis. The volume and the pH of the aspirate dictate the severity of the injury. There are medical conditions that can increase the likelihood of aspiration. These conditions include obesity, hiatal hernia, pregnancy, gastroesophageal reflux disease, and obstruction of the gastrointestinal tract.

The prevention of aspiration during anesthesia includes following the ASA’s fasting guidelines. Most oral and maxillofacial surgeons recommend fasting for 8 hours before the administration of an office-based anesthetic, but the ASA’s recommendations are the following:

<table>
<thead>
<tr>
<th>Ingested Materials</th>
<th>Minimum Fasting Periods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear liquid</td>
<td>2 h</td>
</tr>
<tr>
<td>Breast milk</td>
<td>4 h</td>
</tr>
<tr>
<td>Infant formula</td>
<td>6 h</td>
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<tr>
<td>Nonhuman milk</td>
<td>6 h</td>
</tr>
<tr>
<td>Light meal</td>
<td>6 h</td>
</tr>
<tr>
<td>Fatty meal</td>
<td>8 h</td>
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</tbody>
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The clinical signs of aspiration, including rales, dyspnea, tachycardia, bronchospasm, and partial airway obstruction, will occur with a liquid aspirate. A solid aspirate can cause partial or complete airway obstruction.

When vomiting or regurgitation occurs in anesthetized patients with an unsecured airway, patients should be placed in the Trendelenburg position with the head down. Patients should also be rolled to the right side using gravity and natural anatomy to minimize aspiration damage to the left lung. The oropharynx should be suctioned free of debris, and 100% oxygen via a full face mask should be started. The oropharynx should be cleaned of any solid particulate matter with the finger-sweep technique, forceps, or large-bore suction. Liquid materials are removed with aggressive suctioning techniques.
If patients show signs of respiratory compromise, the airway should be intubated. During the intubation, any solid material should be removed with the aid of Magill forceps and large-bore suction. The patient should be ventilated with 100% oxygen. Care should be taken to watch for signs and symptoms of bronchospasm and treat as necessary.

If the particles are large enough, a bronchoscopy may be necessary to remove the foreign material from the lungs. Antibiotics are only recommended if the aspirate is highly contaminated with bacteria. Steroids are shown not to be useful for treating aspiration. Bronchial lavage has a minimal effect because of the rapidity with which the mucosal surfaces of the lung are damaged because of the low pH aspirate. Hospitalization and the need for aggressive ventilatory support may be required depending on the severity of the symptoms.

**Emergency Protocols**

**Laryngospasm**
- Administer 100% oxygen via nasal or full face mask
- Pack surgical site to control bleeding
- Suction oral cavity, oropharynx, and hypopharynx with tonsil suction tip
- Pull tongue and/or mandible forward
- Depress patient’s chest and listen for rush of air
- Break spasm with positive pressure ventilation with 100% oxygen and full face mask
- Administer IV dose succinylcholine (partial spasm 10–20 mg IV, complete spasm 20–40 mg, or rocuronium 0.6–1.2 mg/kg IV may require prolonged ventilatory support)
- Administer intubating dose of succinylcholine and intubate airway (alternately, use rocuronium)

**Bronchospasm**
- Administer 4 to 8 puffs of B agonist via inhaler or nebulizer (2–4 puffs for pediatric patients)
- 100% oxygen via full face mask
- If sedated, use albuterol nebulizer via face mask
- 0.3 to 0.5 mg epinephrine (1:1000 solution) subcutaneous
- Consider reversal of sedative medications
- Consider intubation to secure airway

**Emesis and aspiration**
- Trendelenburg position with head down at least 15° and rolled to right
- Clear airway of vomitus with suction and Magill forceps
- If no change, intubate airway, 100% oxygen

**Difficult airway**
- Chin lift/jaw thrust
- Pull tongue forward, reposition airway
- Full face mask, 100% oxygen, positive pressure ventilation
- Consider oral and nasal airways, LMA
- Consider intubation
- Consider cricothyrotomy needle versus surgical
- Consider tracheostomy
- See Fig. 2, the difficult airway algorithm

**REFERENCES**

10. AAOMS Parameters of Care 2012.