Management of Complications in Oral and Maxillofacial Surgery

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Ambulatory Anesthesia

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INTRODUCTION

Ambulatory anesthesia is one of the more common adjunctive procedures performed by an oral maxillofacial surgeon (OMS) in private or academic practice. Anesthetic states ranging from mild sedation to general anesthesia are achieved, mainly through the use of intravenous agents but occasionally with inhalational agents as well. When indicated, the provision of anesthesia can greatly facilitate many dentoalveolar and other outpatient surgical procedures, and often enhances patient comfort and satisfaction as well as surgeon efficiency. Ambulatory anesthesia is frequently recommended to patients as an adjunct for particular procedures such as third molar removal, and many patients request anesthesia regardless of the planned surgical procedure. In the special case of pediatric patients, where patient cooperation can be unreliable and anxiety is frequently at a high level, the utility of ambulatory anesthesia can be even greater. In both children and adults, ambulatory anesthesia allows for more procedures to be performed in an outpatient setting that would otherwise require a trip to the operating room.

Given the many benefits of outpatient anesthesia, it is not surprising that a great number of anesthetics are performed each year by OMSs in outpatient settings. Adjunctive anesthesia is provided to thousands of patients per year, and the number of complications reported during the provision of ambulatory anesthesia remains quite low—less than 1% of anesthetic cases.[1] Of these reported complications, serious adverse events make up an even smaller number. Much conscientious effort has gone toward ensuring the safety of ambulatory anesthesia, particularly in the areas of surgeon training, prevention, patient monitoring, and emergency protocols. While OMSs can exhibit confidence in the use and safety of ambulatory anesthesia, we must also maintain a high level of vigilance in order to prevent anesthetic complications and appropriately manage them in the cases when they arise.

Many OMSs who provide anesthesia in an outpatient setting also perform surgery in a hospital operating room (OR), and there is frequently overlap in the types of surgical procedures that are performed in either setting. However, there are some notable differences in the anesthetic as it is conducted in the OR versus an outpatient facility. In the OR, the anesthesia is nearly always provided by someone other than the surgeon—an anesthesiologist or certified registered nurse anesthetist (CRNA). This allows the surgeon to focus single-mindedly on the surgery at hand. In contrast, in outpatient anesthesia, the OMS typically acts as surgeon-operator, or the "operator-anesthetist" model, providing both the anesthesia and performing the surgery simultaneously. Support for this dual role of the OMS can be gleaned from data demonstrating a very low incidence of anesthetic-related complications in outpatient settings where surgeon-operators administered the anesthesia.[1] The administration of outpatient anesthesia requires extra attention from the surgeon who must monitor both the anesthesia and the surgical procedure simultaneously. Maintaining

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this balance of attention can be challenging and may require a different set of skills than those utilized in the OR.

Other important differences between anesthesia administered in the OR and ambulatory anesthesia can contribute to the relative safety of outpatient anesthesia. Two important factors are the greater risk and complexity of surgical procedures performed in an OR setting, and the greater distribution of lower-risk patients (ASA I and II) in outpatient settings versus higher-risk patients (ASA III and above) who may be treated more frequently in the OR setting. These factors emphasize that careful patient and procedure selection contribute to the prevention of complications in outpatient anesthesia.

Lastly, emergency equipment and equipment available for patient monitoring is often more extensive in the OR than outpatient setting, though this difference is decreasing in large part due to the decreasing cost of equipment and technology. Certain invasive modes of patient monitoring, such as arterial or central venous lines, remain confined to the operating room; however, many of the same modalities of monitoring cardiac and respiratory function exist for both OR and outpatient use. In addition, the emergency equipment of the OR has been feasibly reproduced for efficient use in an outpatient setting. The OR, by virtue of being located within the hospital, will retain an advantage in terms of emergency preparedness, access to trained staff, blood and tissue products, and specialist consultation. However, anesthesia in the OR setting can have increased risk due to increased complexity of surgical procedures and/or higher-risk patient populations. These differences are important for the OMS who treats patients in both settings because they have important implications for the prevention and management of anesthetic complications.

PREVENTION OF COMPLICATIONS IN AMBULATORY ANESTHESIA

Patient Characteristics/Selection

The best and most effective management of anesthetic complications is to prevent their occurrence. There is well-documented evidence that certain perioperative patient characteristics contribute significantly to anesthetic and surgical risk. Some of these characteristics, such as patient age, are easy to quantify and have fairly predictable patterns of anesthetic risk. Other patient characteristics such as underlying medical conditions, medications, previous surgical history, allergies, cardiac and respiratory reserve, and body mass index can be more difficult to assign risk. A detailed history and physical examination with appropriate preoperative laboratory workup and communication with the primary care physician are paramount in identification of those patients who may safely undergo anesthesia in an outpatient setting.

Several algorithms and systems of classifying anesthetic risk based on patient characteristics are in common use, with the ASA (American Society of Anesthesiology) criteria being among the most widespread (see Table 1.1). The utility of the ASA classification has been shown in scientific literature that demonstrates a clear association between ASA status (I–V) and the risk of anesthetic complications.[2] The ASA classification is widely recognized and simple to use, and it is a valid starting point into which other patient risk determinants can be incorporated. The Duke Activity Index is another useful measure of a patient's physical status. It presents a functional assessment of physical capacity based on an individual's exercise tolerance and ability to perform various activities of daily living (see Table 1.2). The ability to engage in exercise or everyday physical activities is inversely correlated with risk of anesthetic complications and provides an additional parameter for patient screening.

An adjunctive measure of patient risk for ambulatory anesthesia includes specific classification of the airway. Mallampati's classification is a simple visual classification system, divided into four categories, which attempts to assess the posterior oropharyngeal airway patency based on the visibility of structures of the posterior oropharynx (uvula, fauces, soft and hard palates). The distance between the hyoid bone and the chin can be estimated as an additional, albeit crude, indicator of airway patency and ease of intubation with shorter mental-hyoid distances indicating greater airway risk. In addition, specific characteristics of patient body habitus such as obesity or the presence of a short, thick neck can be general predictors of risk of airway collapse during anesthesia.

Obesity, defined as a body mass index greater than 30, is a recognized risk factor for complications related to anesthesia. Obesity is associated with a decreased respiratory functional residual capacity (FRC) and can

Table 1.1. ASA Physical Status Classification

ASA I	No systemic disease
ASA II	Mild to moderate systemic disease, well-controlled disease states; e.g., well-controlled NIDDM, asthma or epilepsy; pregnancy
ASA III	Severe systemic disease that limits activity but is not incapacitating; e.g., IDDM; history of CVA, MI, or CHF >6 months ago; mild COPD
ASA IV	Severe systemic disease that limits activity and is a constant threat to life; e.g., history of unstable angina, CVA or MI within the past 6 months; severe CHF, severe COPD; uncontrolled DM, HTN, or epilepsy
ASA V	Patients not expected to survive 24 hours
ASA VI	Organ donors

NIDDM: non-insulin-dependent diabetes mellitus; IDDM: insulin-dependent diabetes mellitus; CVA: cerebrovascular accident; MI: myocardial infarction; CHF: congestive heart failure; COPD: chronic obstructive pulmonary disease; DM: diabetes mellitus; HTN: hypertension

Table 1.2. Duke Activity Scale Index

Functional Class	Metabolic Equivalents	Specific Activity Scale
I	>7	Patients can perform heavy housework such as moving furniture or scrubbing floors, and can participate in moderate recreational activities such as bowling, dancing, skiing, or doubles tennis.
II	>5	Patients can do light housework such as dusting or washing dishes, can climb one flight of stairs, can walk on level ground at 4 mph.
III	>2	Patients can dress themselves, shower, make the bed, walk indoors.
IV	<2	Patients cannot perform activities of daily living without assistance; may be bedbound.

lead to an increased incidence of respiratory complications, particularly airway collapse and desaturation. Obese patients have a fourfold increased risk of respiratory complications during ambulatory anesthesia procedures.[3] In the pediatric population as well, obesity has been recognized as a growing problem. A study by Setzer et al. found an increased incidence of respiratory complications and unexpected overnight hospital admission in a group of obese pediatric patients undergoing ambulatory anesthesia for dental surgery procedures (compared to their nonobese counterparts).[4] Patient positioning during surgery may play a role in preventing adverse respiratory complications in obese patients, as a recent study demonstrates an increase in time to desaturation in obese patients who were preoxygenated in an upright (90-degree sitting) position prior to induction of general anesthesia.[5] Maintaining obese OMS patients in an upright position during anesthesia may help to prevent respiratory complications by maximizing FRC and minimizing the effects of gravity on posterior oropharyngeal airway collapse.

Age is also an important determinant of anesthetic and surgical risk. Age is easily quantified and there is evidence that increased risk of complications occur at the extremes of very young and very old age. There is greatly increased risk associated with anesthesia and surgery in the first one month and one year of life.[6] In terms of increasing age and risk of complications, there remains a strong positive correlation though the association is more gradual and progressive. In the very young, much of the increased anesthetic risk can be attributed to the relative anatomical and physiological immaturity of infants and very young children. This makes the mechanics of anesthesia more difficult (airway management, fluid replacement, patient monitoring) while the decreased therapeutic index of anesthetic drugs in small children greatly increases their toxic potential. At the other end of the spectrum, advanced age leads to an increase in medical comorbidities and decreased physiological reserve from the normal aging process. This likewise decreases tolerance for physiologic insults and lowers the therapeutic index of many drugs and interventions.

Aside from patient characteristics, another factor that can help prevent complications in the postoperative period is to ensure that patients will have a responsible adult who can accompany them home and care for them after the anesthesia and surgical procedure.[7]

Procedure Characteristics/Selection

In addition to appropriately screening patients for in-office procedures, it is also important to bear in mind the surgical complexity and length of time needed for the planned procedure. Certain procedures, such as third molar removal, are nearly always performed in an outpatient setting. Other surgical procedures, such as minimally invasive temporomandibular joint procedures (TMJ arthroscopy) and extensive bone grafting or implant procedures, can be performed either in the OR or in an outpatient setting. This is largely dependent upon the preference of the surgeon and patient, the availability of appropriate instruments and equipment, as well as financial issues. The most important consideration in preventing complications is to ensure that the surgical procedure planned is not more complex or lengthy than can be accommodated in a particular outpatient setting. Patient risk factors and procedure risk factors should be balanced such that longer and more complex procedures are avoided in patients who already represent increased surgical risk. Complex or lengthy procedures may benefit from having an additional practitioner or trained person to assist with the anesthetic management of the patient. This will help to offset some of the increased attention required for the surgery itself. With proper planning, a majority of routine OMS surgical procedures can potentially be accomplished in an outpatient setting.

Patient Screening

The goal of patient selection for ambulatory anesthesia procedures is to determine a particular patient's risk factors for anesthesia and to identify those patients who may safely undergo the procedure in an outpatient setting. The first step is to perform a comprehensive history and targeted physical exam. Information to be elicited includes prior anesthetic experiences, prior hospitalizations, emergency room visits, prior surgeries, allergies or adverse reactions to any medications, and any and all medications taken (including over-the-counter medications and vitamins or herbal supplements). Herbal medications are surprisingly common (taken by almost 25% of patients) and garlic, ginkgo biloba, and ginseng (the "three Gs") may be particularly risky when taken perioperatively as they affect platelet function and may increase bleeding risk.[8]

A review of systems can ascertain whether a patient has any undiagnosed medical conditions that could impact the planned anesthetic procedure. In particular, questions designed to elicit underlying respiratory, neurologic, or cardiac disease are especially important. A history of snoring, allergic rhinitis, wheezing, shortness of breath (exertional or spontaneous), and recent upper or lower respiratory infections can provide important information about the possible risk of respiratory complications. Certain medical conditions and risk factors to look for include history of asthma, chronic obstructive pulmonary disease (COPD), and tobacco use. Chung et al. identified asthma with a fivefold increase in respiratory complications during ambulatory anesthesia, and smoking carries an increased fourfold risk.[3] Patients with COPD have twice the risk of respiratory complications during ambulatory anesthesia.[9] Ascertaining a patient's exercise tolerance can provide a great deal of information as well, including signs and symptoms of respiratory or cardiac disease, as well as musculoskeletal complaints or any limitations in range of motion. In patients who do not engage in regular exercise, one can substitute questions about activities of daily living such as walking several blocks, climbing more than one flight of stairs, grocery shopping, doing several loads of laundry, or performing vigorous housework.

It can be helpful to obtain a family history, particularly from patients who are young or present with few medical history findings, especially to ascertain whether anyone in the patient's immediate family has ever had an adverse event related to anesthesia, an unusual genetic illness, congenital heart defect, or premature or sudden unexpected death. Asking about a history of tobacco, alcohol, and illicit drug use is important. In a patient who drinks alcohol regularly, asking about usual intake and effects (e.g., drowsiness, tipsiness) can sometimes provide a crude indication of response to anesthesia. Vital signs should be recorded for every patient prior to the day of the planned procedure as they are helpful for establishing a particular patient's baseline. For example, this may help to differentiate a patient who, on the day of surgery, develops hypertension as a result of anxiety from a patient whose baseline blood pressure is usually elevated.

The history and physical exam forms the basis for deciding whether a patient will need further testing or evaluation prior to the anticipated anesthetic. Further evaluation can take many forms, including laboratory testing, ECG/chest radiography, or consultation with the patient's physician including referral to specialists as needed. Patients who give a complex medical history with multiple chronic conditions, recent surgeries or hospitalizations, multiple hospitalizations in the past year, clearly warrant further testing and consultation with the patient's physician. These types of patients are obviously at higher risk and may or may not represent suitable candidates for outpatient anesthetic procedures. Of more concern, however, may be those patients whose risk for outpatient anesthesia is unclear or unknown. In this case, the role of laboratory testing and other investigations is to clarify whether the patient may be safely sedated in an outpatient setting. Patients who give an unclear or ambiguous medical history obviously fall into this category, as do patients with several positive findings in the review of systems or patients with chronic medical conditions that appear to be poorly controlled. In addition, one should approach cautiously patients who report no medical problems and who have not had a routine medical exam within the past three years or longer, particularly if they are middle-aged or older, or have other obvious medical risk factors. Patients such as these may have undiagnosed medical conditions that could greatly impact the safety of the planned outpatient procedure.

A diversity of laboratory tests may be ordered for a patient, but for routine use, relatively few are necessary. A complete blood count (CBC) and basic metabolic panel represent two of the most common basic laboratory tests. The CBC can give information about the presence of infection or inflammation (elevated white blood cell count), the relative proportions of blood cells, the presence of anemia (hemoglobin and hematocrit) and type (red blood cell size and morphology), and verify an adequate number of platelets for hemostasis. The CBC does not provide information about platelet function or the clotting ability of blood for which a partial thromboplastin time (PTT) and prothrombin time (PT, commonly reported as an international normalized ratio, or INR) are needed. A bleeding time test will give information about platelet function, but it is infrequently used. The basic metabolic panel will provide information about electrolyte and acid/base balance as well as renal function [blood urea nitrogen (BUN) and creatinine levels], and may be substituted by a complete metabolic panel that also includes markers of liver function (typically, aspartate and alanine transaminase liver enzyme levels). Markers of renal and liver function should be considered for patients with diabetes, liver, or kidney disease as they can indicate the progression of disease as well as the potential need for modification of anesthetic drug dosages. In women of reproductive age, some practitioners will also order a beta-human chorionic gonadotropin test (B-HcG) to verify a patient's pregnancy status. A serum B-HcG is more sensitive, but urine B-HcG tests are less expensive and easy to administer. If a B-HcG will not be performed for a patient, it is important to ask about the possibility of pregnancy and document the conversation in the patient record. Laboratory tests performed within the preceding 30 days are generally considered recent enough and do not necessarily need to be repeated. Patients with more rapidly changing conditions, such as patients taking warfarin, will need more recent laboratory tests. B-HcG tests, if indicated, are ideally performed within 1 week of the scheduled anesthetic.

Special considerations exist for preoperative screening of patients with known or suspected cardiovascular disease. Cardiovascular disease is increasingly common and cardiovascular complications of anesthesia are among the most serious. Basic methods of screening for cardiovascular disease include the standard 12-lead ECG and chest radiography. More advanced diagnostic methods include echocardiography and cardiac stress testing. Depending on the institution and surgeon preference, some oral maxillofacial surgery practices routinely order ECGs and chest radiography for patients over a certain age. Sometimes this practice is restricted to patients who are scheduled for OR procedures and sometimes it extends to outpatient anesthetic procedures as well. For low-risk procedures in ASA I (and most ASA II) patients for whom a detailed history and physical exam have been performed, an ECG and chest radiograph are largely unnecessary. Cardiac testing may be considered for patients with clinical risk factors for cardiac complications, as assessed by the American College of Cardiology and American Heart Association in the 2007 *Revised Cardiac Risk Index*. These factors include a history of ischemic heart disease, compensated heart failure or prior heart failure, cerebrovascular disease, diabetes mellitus, or renal insufficiency.[10] Minor predictors of cardiac risk include being over 70 years of age, uncontrolled hypertension, abnormal ECG, and nonsinus rhythm, but these have not demonstrated utility as independent markers of cardiac risk during noncardiac surgery.[10] A patient's functional capacity as measured by "metabolic equivalents" is an important parameter assessed in the 2007 ACC/AHA guidelines on perioperative cardiovascular evaluation. Patients who have poor functional capacity represent a greater risk of cardiac complications than those with good functional reserve. The 2007 ACC/AHA guidelines recommend 12-lead ECG testing and noninvasive stress testing for asymptomatic patients with cardiac risk factors who will undergo intermediate-risk surgical procedures or vascular surgery, but are typically not recommended for low-risk surgeries such as ambulatory surgery. The guidelines were developed based on level of evidence from the professional literature indicating a clinical advantage to preoperative intervention in various patient groups prior to noncardiac surgery.

If additional testing is indicated, the patient's physician should be contacted prior to the planned anesthetic, as patients may have had an ECG or other cardiac test performed recently. Chest radiographs or ECGs that are abnormal are always an indication for further investigation, though further testing may not be needed. If previous ECGs or chest radiographs show an abnormality that has remained stable with time and if the patient's physician has indicated this, further testing is unlikely to change the clinical assessment. However, any abnormal finding that is new or has progressed from previous test results should result in follow-up with the patient's treating physician and additional testing as indicated.

Preoperative testing can help to identify abnormalities and quantify the level and type of disease a patient may have, but the clinician must ultimately gather this data and interpret it in a clinically useful manner. Several algorithms and classification schemes have been developed to aid in converting clinical data into a measure of anesthetic risk that can aid the surgeon in determining the relative risk of a particular patient for undergoing an outpatient anesthetic procedure. One of the most popular, the ASA classification, has already been mentioned. Several risk stratification schemes exist for cardiovascular risk factors in particular, including the most recent guidelines from the American College of Cardiology and the American Heart Association (described above).

Preoperative patient screening not only helps to identify those patients who represent a poor risk for outpatient anesthesia, but for low- and moderate-risk patients it can help to identify any patient-specific risks and aid in planning ahead.

Intraoperative Patient Monitoring

Technological advances have produced an increasing number of new and improved devices for the intraoperative monitoring of patient vital signs and sedation level. Patient monitors not only provide peace of mind that the patient is stable, but they can also provide an early warning when complications begin to occur. Ideally, effective intraoperative monitoring can allow for potentially serious situations to be recognized early and effectively managed. Basic measurements during outpatient anesthesia include pulse oximetry, a heart rate monitor, and intermittent blood pressure monitoring. Additional monitors can include capnography, BIS (bispectral monitoring), and a precordial (esophageal) stethoscope.

Pulse Oximetry

Pulse oximeters are designed to estimate blood oxygen saturation and work via measurements of infrared energy transmission. In smokers, pulse oximetry readings may be artificially increased due to the level of carboxyhemoglobin present in the circulation. This is especially true for those who have smoked tobacco within a few hours of the anesthetic procedure. The pulse oximeter cannot distinguish between carboxyhemoglobin and oxygen-carrying hemoglobin in the blood of smokers and thus provides an overestimate of the true blood oxygen saturation.

The reading provided by pulse oximetry is a good approximation of blood oxygen partial pressure, and 90% oxygen saturation is the standard cut-off value below which desaturation begins to have noticeable clinical effects. There is a time delay between a patient's true oxygen saturation and the pulse oximeter reading, and many oximetry machines will sound an alarm when a patient's oxygen saturation reading drops below 93% or 94% to allow for this. Most healthy adults will have an O_2 saturation of between 98%

and 100% on room air, but occasionally patients with underlying respiratory compromise will have a baseline O_2 saturation of 94–95%. It can be important to know this prior to beginning a procedure to avoid the erroneous assumption that a patient with a low baseline O_2 saturation is experiencing respiratory depression as a result of anesthesia.

Heart Rate and Rhythm Monitoring

A simple heart rate monitor will be sufficient in many circumstances; however, a 3-lead or 5-lead ECG monitor will provide a tracing of the cardiac rhythm, which can be indispensible if a complication arises that involves a cardiac arrhythmia, cardiac depression, or ischemia/infarction.

Blood Pressure

Blood pressure readings should be taken, at a minimum, both before and after an anesthetic procedure as well as prior to discharge. An automatic blood pressure cuff that can be set to take readings at different time intervals [noninvasive blood pressure (NIBP)] is an efficient choice. Routine interval blood pressure measurements are useful in all patients because even low-risk patients may experience anesthetic complications involving blood pressure changes. In higher-risk patients, blood pressure monitoring is especially important, particularly when there is concern about hypertension, hypotension, or changes in cardiac output.

Capnography

Capnography devices utilize a chemical probe that measures the level of expired carbon dioxide and can be used to monitor respirations. Capnography has been extensively utilized in the OR but much less frequently in outpatient settings. It can be extremely useful, however, as it provides a measure of tidal volume, respiratory rate, and respiratory depth. While it does not provide an estimate of blood oxygen saturation, it is more sensitive than pulse oximetry for detecting respiratory depression and apnea.

Precordial (Esophageal) Stethoscope

The precordial or esophageal stethoscope is a bell-type stethoscope that is placed on the pretracheal region of the patient's chest. By listening through one or two earpieces, or using a speaker system, a practitioner can auscultate a patient's respirations and will be immediately alerted to any change in respiratory rate, depth, or quality. While this method of intraoperative monitoring is sensitive, it does not appear to be particularly popular among OMSs. The study by D'Eramo reported only 36% of practitioners used a precordial stethoscope, compared to a 93% utilization rate for blood pressure and pulse oximetry monitoring.[1] The stethoscopes become less reliable in situations of increased ambient noise or excessive patient movement that can displace the bell of the stethoscope. Nevertheless, the esophageal stethoscope can provide additional clinical information regarding a patient's respiratory status. It may be most useful when treating small children (or others at increased risk of rapid respiratory compromise) and obese patients, in whom it can sometimes be difficult to observe chest rise and other signs of ventilatory effort.

Bispectral (BIS) Monitor

Of the available patient monitors, the BIS monitor is unique because it quantifies the level of anesthetic sedation at the level of central nervous system (CNS) activity. Consisting of an adhesive strip that is positioned on the forehead and a monitor that reads EEG activity, the BIS monitor is typically used in an OR setting. It can help to determine a patient's level of sedation and is useful for maintaining a desired level of anesthesia. It is also useful for accelerating emergence from anesthesia. There is some suggestion that the BIS monitor may increase patient safety by decreasing the amount of anesthesia given while also minimizing complications of anesthesia that is too light. However, most of the benefit of the BIS monitor may be outweighed by the cost of the system.

Personnel Preparedness

Specific guidelines, in addition to individual state law specifications, regarding the appropriate number of personnel and specifics of their training requirements when administering outpatient anesthesia exist and should be adhered to strictly. Familiarity with the equipment used for monitoring, as well as emergency

Table 1.3. Emergency Drugs and Equipment

Emergency Equipment:	
Defibrillator	
Suction (portable)	
Oxygen tank with backup	
Face mask (non-rebreathing with ambulance bag)	
Laryngoscope with light source, blades, extra batteries	
Endotracheal tubes, cuffed/uncuffed	
Laryngeal mask airway	
Oral airways	
Nasal airways	
MacGill forceps	
Tracheostomy/cricothyroidotomy set	
Emergency Drugs:	
Epinephrine	Atropine
Vasopressin	Succinylcholine
Nitroglycerin	Glycopyrrolate
Adenosine	Lidocaine
Labetalol	Metoprolol
Esmolol	Diphenhydramine
Lorazepam or diazepam	Hydrocortisone
Glucagon	50% Dextrose
Naloxone	Flumazenil
Albuterol MDI	Aspirin

equipment and setup, medications, and dosages, are crucial for administration of safe outpatient anesthesia. In addition to emergency equipment setup and operation, the treating team should practice, at frequent intervals, emergency scenario response to ensure preparedness and to anticipate and prevent adverse events. In addition, frequent scheduled and unscheduled drug and equipment inventory examinations and testing for expiration dates and malfunctions should be implemented.

Equipment and Emergency Supplies

Some of the most common emergency drugs and equipment that may be needed in an outpatient anesthesia setting are listed in Table 1.3. Emergency drugs are available from the manufacturer in appropriate dilutions that are prepackaged into syringes designed for single-patient use. Though there is an increased cost when purchasing emergency drugs in this form, it allows a practitioner to select and administer an emergency drug as needed without the delays while potentially minimizing calculation errors.

Postoperative Monitoring

When the surgical and anesthetic procedure is completed, the patient is discharged to a postoperative area where patient recovery from anesthesia is typically overseen by someone other than the surgeon. Due to the short-acting nature of most anesthetic drugs currently in use, most patients begin to awaken by the end of the surgical procedure. Some patients may still be significantly sedated upon arriving to the recovery area, however, due to differences in patient response to anesthesia. Vital signs should continue to be monitored postoperatively. A trained staff member should be physically present in the immediate recovery area at all times and should observe the patient's condition including skin color, respiratory rate and effort (chest rise), response to verbal or physical stimulation, and any signs of agitation or inability to be roused. Once patients are reasonably awake, they may be joined by a family member or friend, if space permits in the recovery area.

INCIDENCE OF COMPLICATIONS IN AMBULATORY ANESTHESIA

Though little historical data are available, it appears that ambulatory anesthesia has increased in safety over the past several decades. A recent large study reported an incidence of outpatient anesthetic complications of 1.45%, compared to a 2.11% complication rate for inpatient anesthesia.[11] Improvements in equipment design for the provision of anesthesia and patient monitoring as well as improvements in engineering controls, safety practices, and practitioner training have contributed to the overall low rate of anesthetic complications. Some of the more common complications of anesthesia, such as nausea and vomiting, have relatively low morbidity although the institutional costs may be high. Other complications such as respiratory or cardiac arrest are so morbid that significant effort has been made to adequately prevent and manage them despite their very low incidence. A proportion of complications are due to underlying patient factors such as patient age and medical comorbidities over which the practitioner has little control, but evidence has also shown that many complications are the result of operator error, equipment malfunction, or systems failure. Preventable complications offer an opportunity for the individual clinician and the specialty as a whole to make improvements that increase patient safety and anesthetic success.

NEUROLOGICAL COMPLICATIONS

Syncope

Syncope, one of the most common anesthetic complications, typically occurs in the preoperative setting, but may be observed occasionally postoperatively as well. Syncope is defined as transient loss of consciousness with spontaneous return to consciousness. In a study by D'Eramo, syncope was the most frequently observed complication, occurring in 1 out of 240 parenteral sedation cases and 1 out of 521 general anesthetic cases.[1] It is usually related to patient's anxiety in the preoperative setting and is most frequently observed upon venipuncture for placement of an intravenous line.[12] Syncope responds well to placing the patient in the Trendelenberg position, as this places the patient's head lower than the thoracic cavity and speeds blood return to the brain. Supplemental oxygen is beneficial and should always be given; it is also useful in cases of near-syncope. Ammonia smelling salts may also be helpful and are usually applied in situations where Trendelenberg positioning and supplemental oxygen does not result in a rapid return to consciousness.

In the postoperative period, patients may experience syncope due to vasovagal response or transient orthostatic hypotension when rising too quickly from a seated or supine position. This complication may be prevented by assisting all patients when they stand or begin walking, since syncope under these circumstances carries the additional risk of injury from falling. Management consists of patient positioning, supplemental oxygen and ammonia salts if needed.

Any period of unexpected patient unconsciousness that lasts for several minutes is not considered true syncope. If a loss of consciousness episode lasts more than a few minutes, other causes should be investigated without delay, including the possibility of hypoglycemia, hypotension, dehydration, partial seizure, oversedation, or cerebrovascular accident.

Oversedation

Oversedation is a relatively common event observed during ambulatory anesthesia that can rapidly develop in a potential complication of variable severity. It initially manifests as lack of adequate patient response to appropriate stimuli. For example, a patient who previously responded to loud verbal or forceful physical stimuli may suddenly fail to respond. In cases of profound oversedation, a patient may fail to respond to increasingly painful stimuli, and when the plane of general anesthesia is reached, the patient will have lost protective airway responses. If allowed to progress without intervention, oversedation can rapidly advance to airway obstruction, hypopnea, or apnea leading to hypoxemia. In severe cases, respiratory depression can lead to respiratory arrest and depression of cardiac output will be observed.

Oversedation in ambulatory anesthesia takes two forms: unintended deep sedation or general anesthesia during the procedure, or prolonged or delayed awakening in the postoperative period. Intraoperatively, oversedation is produced by too high a dose of an anesthetic drug or a dose of anesthetic that is administered too quickly. Patient factors often figure prominently in cases of oversedation, as patients who are very sensitive to the effects of an anesthetic or who have greatly decreased elimination kinetics will have a narrowed therapeutic range compared to an "average" patient. It can be quite difficult to titrate anesthetic drugs in such a patient, with the result that oversedation is more likely to occur.

Age is an important factor in a patient's response to anesthesia. Sensitivity to anesthetic drugs and alterations in the dosages are required to achieve specified levels of sedation with extremes of age. While this may seem self-evident in the elderly, research shows that the reduction in required anesthetic dose begins as early as age 40 to 45.[13] For each decade past the age of 40, there is an observed 10% reduction in the dose of fentanyl required while for propofol, the dose reduction is about 8%.[13] The pediatric population in particular has a markedly idiopathic response to anesthetic drugs, and titration of sedation can be more challenging in this age group. Ironically, patients with very high anxiety levels may be prone to oversedation because they typically require a high initial dose of anesthetic to achieve sedation, but often markedly less medication to maintain a given level of anesthesia. Failure to reduce the dosage of anesthesia adequately after the initial induction bolus in these patients can result in oversedation.

Oversedation may be caused when boluses of a drug are given too quickly or too close together. This typically occurs during an anesthetic procedure when a patient begins to awaken or become agitated and additional medications are administered to rapidly deepen the anesthesia. Since all anesthetic drugs take some period of time to exert their effect, failure to wait for the drug to take effect can result in the observation that the dose was insufficient and the administration of an additional bolus. Subsequently, when the additional boluses have had time to take effect, the patient may be in a deeper plane of anesthesia than was intended. This can be partially prevented by the spacing of additional drug boluses and knowing the time to effective onset of the anesthetic drugs utilized. Not all pharmacologic agents demonstrate first order kinetics however, and rate of drug onset can be increased or decreased depending on the patient's plasma drug level.

Oversedation can sometimes result when the level of surgical stimulation is rapidly or dramatically decreased. Since surgical stimulation tends to counteract the sedative effects of anesthetic drugs, a higher dose of anesthesia is typically required for more stimulating surgical procedures. A patient who is at an appropriate level of anesthesia may quickly become over-sedated if stimulation is decreased or discontinued. In situations where changes in the level of surgical stimulation can be predicted, allowing time for the anesthetic drug to wear off or decreasing the rate of infusion can effectively prevent most oversedation in these cases.

Oversedation is a relatively common complication of ambulatory anesthesia which can rapidly develop in severity. It initially manifests as lack of adequate patient response to appropriate stimuli. For example, a patient who previously responded to loud verbal or forceful physical stimuli may suddenly fail to respond. In cases of profound oversedation, a patient may fail to respond to increasingly painful stimuli, and when the plane of general anesthesia is reached the patient will have lost protective airway responses. If allowed to progress without intervention, oversedation can rapidly progress to airway obstruction, hypopnea, or apnea leading to hypoxemia. In severe cases, respiratory depression can lead to respiratory arrest and depression of cardiac output will be observed.

Management of mild oversedation may consist of briefly interrupting the administration of anesthetic drugs and observing the patient for a return to the desired level of anesthesia. If any degree of respiratory obstruction or depression is noted, maneuvers aimed at opening the airway such as a chin lift or jaw thrust should be performed as well. Given the rapid redistribution and short duration of effects of many anesthetic drugs, mild oversedation is self-correcting with supportive measures within a matter of a few minutes.

Although not a mainstay of treatment, administration of reversal agents may be considered as an adjunctive therapy for oversedation. Few drugs used in ambulatory anesthesia have a reversal agent, but naloxone is able to reverse the effects of opioid agonist drugs and flumazenil is an effective antagonist of the benzodiazepine class of drugs. These reversal agents can be effective in reversing the effects of oversedation due to drug overdosage, but they reverse all actions of a drug including desirable effects such as analgesia, hypnosis, and anxiolysis. They may be considered for the treatment of oversedation and prolonged awakening in the postoperative period and are generally well tolerated. Research has not supported the routine use of reversal agents to speed recovery from ambulatory anesthesia procedures.

Seizures

Seizure activity, both partial type and tonic–clonic seizures, represents abnormal CNS excitation. Because anesthetic drugs act by causing depression of the CNS, seizure activity during an anesthetic procedure is unlikely to occur. In patients with seizure disorders, however, seizures may occur in the preoperative and postoperative periods. Management of seizures involves positioning the patient to avoid injury and loosening tight or restrictive clothing as much as possible. Most seizures will terminate after a few minutes and require no other treatment, though benzodiazepines such as midazolam, lorazepam, or diazepam may be given intravenously or intramuscularly to terminate seizure activity. Since patients will typically become hypoxic during the clonic phase of a tonic–clonic seizure, supplemental oxygen may be beneficial in the immediate postictal period.

CARDIOPULMONARY COMPLICATIONS

Respiratory Depression and Respiratory Arrest

The effects of anesthetic drugs are the most common cause of respiratory depression in ambulatory anesthesia. An overdose of anesthesia will produce respiratory depression in virtually all cases, and this may progress to full respiratory arrest if not promptly corrected. Even typical doses of anesthetic drugs will cause some degree of respiratory depression in a proportion of patients.

Primary respiratory depression, caused by the provision of anesthesia itself, refers to a deficit in ventilation or oxygenation or both. Respiratory depression may take the form of mechanical obstruction, caused by collapse of the oropharyngeal soft tissues or occlusion of the airway by the tongue or secretions. Central respiratory depression, characterized by hypopnea or apnea can also occur either separately or concurrently.

Typically, mechanical obstruction occurs more frequently and at lower anesthetic doses than central apnea does, and it occurs to some extent in susceptible persons. Obese patients, those with short thick necks, mandibular retrognathia, and patients with obstructive sleep apnea are among the most susceptible groups. In severe cases, this may render these patients unsuitable for ambulatory anesthetic procedures. In most other cases, patient positioning can play a role in airway obstruction. Respiratory obstruction due to mechanical airway obstruction can be managed by careful suctioning, repositioning of the tongue in a forward position, and either a chin lift or jaw thrust maneuver. If necessary, the level of anesthesia may be lessened, as increasing levels of sedation contribute to the degree of airway impediment. Rarely, an oral or nasal airway may be needed to overcome the obstruction in the posterior pharynx and stent the airway open. Supplemental oxygen can be helpful to decrease any oxygen desaturation associated with mild to moderate obstruction, although oxygen by itself does not alleviate the mechanics of obstruction.

Respiratory depression may also be "central," characterized by a decreased respiratory rate or periods of apnea. Narcotic drugs are most often implicated because of their effects on the medullary respiratory center of the brainstem that results in decrease respiratory drive and response to hypercapnia. At moderate levels of narcotic effect, the decreased respiratory rate is accompanied by a compensatory increase in tidal volume that prevents oxygen desaturation. At higher levels of narcotic sedation, respiratory depression can progress to apnea and respiratory arrest. A brief period of respiratory support in the form of supplemental oxygen via a face mask with cessation of anesthetic drug administration may be all that is necessary in terms of management—particularly with short-acting drugs in a patient with good respiratory reserve. Whenever there is desaturation in a setting of frank apnea, however, the patient's ventilation should be assisted by a positive pressure face mask until spontaneous respiration resumes.

Occasionally, mask ventilation with or without the placement of an oral or nasal airway will not be sufficient to overcome airway obstruction and provide oxygenation. In these cases, other means of establishing an airway and achieving effective ventilation should be employed. These include laryngeal mask airway (LMA) insertion or endotracheal intubation for administration of positive pressure ventilation with high oxygen flow. Because endotracheal intubation is a technically complex procedure and requires specialized equipment, it is subject to high rates of failure, especially in emergency situations. Intubation should only be considered in a patient who is hypoxemic and cannot be effectively mask ventilated. An LMA can be successfully used for the support of ventilation as an alternative to endotracheal intubation and has several advantages over the traditional endotracheal tube (ET). LMAs are quickly and easily inserted without the need for specialized equipment. Use of an LMA poses no risk of inadvertent intubation of the esophagus or mainstem bronchus or injury to the vocal cords. Airway stimulation is minimal and removal of the LMA can be easily accomplished once spontaneous respirations return. Regardless of the method used for airway establishment early recognition, preparedness, familiarity with the available equipment, and skill maintenance for their effective use are critical.

In addition to respiratory depression or arrest caused by anesthetic drugs, other causes of respiratory complications include stroke or myocardial infarction. The signs and symptoms of stroke or acute coronary syndrome can be significantly masked in a patient undergoing ambulatory anesthesia, and respiratory depression or arrest may initially be diagnosed as a case of oversedation. Any respiratory complication that does not respond to moderate interventions or progresses to a need for airway establishment and support of ventilation should be investigated for additional contributing factors or underlying conditions.

Laryngospasm, Bronchospasm, and Acute Asthma

A second group of respiratory complications that may arise in the course of outpatient anesthesia includes reactive airway conditions such as laryngospasm, bronchospasm, and acute asthma. One analysis of complications in ambulatory anesthesia identified laryngospasm, stridor, and obstruction as the most frequently observed adverse events, accounting for 40% of complications.[11] Acute asthma attacks are more frequent preoperatively and may be associated with patient anxiety. Laryngospasm and bronchospasm typically result from the combination of airway irritation and anesthetic sedation.

Acute asthma and bronchospasm are manifested clinically by audible wheezing (more prominent during expiration), tachypnea, shortness of breath, and are usually accompanied by decreasing oxygen saturation. They represent a hyperreactive process of the large airways that results in bronchoconstriction and obstruction to airflow. A number of factors may precipitate an asthma attack or bronchospasm, but in an oral surgical setting anything that causes airway irritation may be the predominant etiologic factor. Some examples include the production of aerosols during a procedure or decreased clearance of secretions that can irritate the airway and stimulate coughing. Laryngospasm, by contrast, is an acute upper airway obstruction that presents with stridor (incomplete laryngospasm) or failure of ventilation (complete laryngospasm with total closure of the glottis). Obstruction of the upper airway due to foreign body aspiration may also present with acute stridor and should be ruled out clinically. Laryngospasm results in reflexive closure of the glottis upon irritation and is a protective airway reflex. It does not occur in awake patients or in patients during general anesthesia, but can occur in a mild or moderate stage of sedation.[12]

Acute asthma attacks may be managed with inhaled beta-2-agonist bronchodilator medications such as albuterol. These drugs are typically administered via a metered-dose inhaler (MDI) either with or without an additional spacer device. Patients who are awake and alert may be allowed to self-administer the inhaled medication, while patients who are sedated may need assistance. In sedated patients, the use of a spacer may be particularly useful to assist delivery of the drug to the lungs and to prevent excess drug deposition in the oropharynx where it is has no therapeutic effect.

Inhaled bronchodilators are also the first choice treatment for bronchospasm and are administered similarly. In intubated patients these inhaled medications may be administered via ET tube or LMA, though the dosage must be greatly increased (up to 10 to 20 puffs) to account for the large amount of drug that coats the airway tube and does not reach the lungs. Both acute asthma and bronchospasm benefit from supplemental oxygen. In severe cases that do not respond to inhaled beta-agonists, intravenous or subcutaneous epinephrine may be considered as a rescue therapy. The adverse effects of epinephrine—particularly tachycardia and increased blood pressure—limit its use for reactive airway disease. It should be used with extreme caution, if at all, in patients with underlying cardiac disease.

The treatment of laryngospasm differs from that of asthma or bronchospasm. Because it occurs in patients who are at "lighter" levels of anesthesia, deepening the level of anesthesia will help to abolish the protective airway reflex and relax the vocal cords to allow the passage of air. Positive pressure ventilation, especially when instituted early in the course of the laryngospasm, is frequently successful at "breaking" the spasm. If it appears that secretions or bleeding in the oropharynx may be contributing factors, a brief period of suctioning with a tonsillar (Yankauer) suction may be helpful. Care should be taken that this does not delay positive pressure ventilation, however, and that the suction itself does not serve to further provoke the laryngospasm reflex. If neither deepening the anesthesia nor positive pressure ventilation proves successful, the treatment of choice for laryngospasm is the administration of the neuromuscular blocking agent succinylcholine. Succinylcholine for the treatment of laryngospasm is typically given at a dose of 20–40 mg initially, with an additional 20–30 mg given a minute or two later if the first dose proves insufficient.[14] This dose is less than the "standard intubating dose" of succinylcholine, but whenever a paralytic agent is given, it is safest to assume that complete paralysis may occur and the practitioner should be prepared to assist the patient's ventilation until the drug has adequately worn off and the patient is ventilating well without assistance.

Aspiration

Aspiration refers to the entry of substances such as blood, saliva, gastric contents, or foreign bodies into the lungs via inadvertent inhalation. Aspiration occurs due to decreased or absent protective airway reflexes and is exacerbated by decreased gastroesophageal tone. Patients with neuromuscular degeneration or history of stroke are at increased risk as are those undergoing sedation and general anesthesia. Additional risk factors include gastroesophageal pathology such as GERD (gastroesophageal reflux disease), hiatal hernia, or achalasia, as well as a history of esophageal surgery or gastric bypass.[15] The greatest risk from aspiration occurs with gastric contents that are due to complications from pneumonia (a chemical pneumonia causing damage to the lungs from the low pH of gastric fluids and the presence of peptic enzymes) or acute respiratory distress syndrome (ARDS). Either passive regurgitation of stomach contents or active vomiting during anesthesia can lead to aspiration. Any patient who begins to retch or vomit during an anesthetic procedure should be placed with their head lowered (Trendelenberg positioning) to prevent aspiration into the lungs, and any vomitus should be suctioned carefully from the mouth and oropharynx. Patients known or suspected to have aspirated vomitus should have their respiratory status carefully monitored as they may require elective intubation with lavage and suctioning of the bronchial tree. The role of steroids and antibiotic therapy in these patients has been questioned and they are not routinely administered. In the absence of signs indicating respiratory compromise, management of aspiration is expectant.

In the case of aspiration of a foreign body, the surgeon may make a careful attempt to visualize and retrieve the object if possible. A laryngoscope and MacGill forceps may be helpful in this situation. If the object cannot be visualized for removal, the patient's respiration should be monitored and supported as needed and the patient transferred to a hospital.

Preoperative Fasting Period (NPO Guidelines)

In order to decrease the risk of aspiration, a preoperative fasting period is typically required of patients undergoing an anesthetic procedure. The usual prohibition is nothing to eat or drink after midnight prior to the day of surgery, with the intent that a patient having surgery in the morning will have a completely empty stomach for the procedure. There has been some debate recently about the preoperative fasting guidelines both in recognizing the need to make them as patient-friendly as possible while also recognizing that due to individual differences in gastric emptying, there may be situations where patients will not have a completely empty stomach despite adhering to the fasting guidelines. Currently, the American Society of Anesthesiologists (ASA) recommends "light" solid food up to 6 hours before and clear liquids 2 to 3 hours prior to undergoing anesthesia. The goal is to minimize the risk of aspiration due to a full stomach while at the same time avoiding dehydration and hypoglycemia from prolonged fasting. Diabetic patients may require individualized fasting guidelines because they are especially susceptible to hypoglycemia and may also have delayed gastric emptying due to gastroparesis. Young children are another group for whom special consideration may be necessary when prescribing preoperative fasting guidelines.

Acute Vascular Events

Acute vascular events are among the most serious perioperative complications and include myocardial ischemia, myocardial infarction, and cerebrovascular accident (stroke). Due to the high prevalence of cardiovascular and atherosclerotic diseases in adults, complications of this nature should be anticipated in any office emergency plan.

Myocardial ischemia and myocardial infarction are most common in the postoperative period[12] and can be related to the surgical procedure, the anesthesia, or both. In a very anxious patient with a history of ischemic heart disease, the preoperative period presents a risk of acute angina. Risk factors for acute vascular events include history of heart disease or cerebrovascular disease, increasing length and invasiveness of surgery, and significant changes in heart rate, respiration, or blood pressure due to anesthetic drugs or surgical manipulation. Though profound fluctuations in heart rate, blood pressure, or respiration should be avoided in any patient, this is critical for individuals with underlying risk factors for acute coronary or cerebrovascular complications. In these patients, vital signs should be maintained close to baseline to avoid hemodynamic decompensation.

Acute angina is characterized by a sensation of pain, tightness, or crushing in the substernal region of the chest and may be accompanied by shortness of breath, anxiety, and diaphoresis. It can be difficult to differentiate acute angina from a panic attack or GERD/acute gastritis unless the patient has a history of angina episodes. Acute angina should be treated by discontinuing any stimulating procedure, administering a dose of sublingual nitroglycerin, applying supplemental oxygen via face mask or nasal cannula, and continuous monitoring of vital signs. If the pain does not subside completely within 10 minutes, a second dose of nitroglycerin may be given. Up to three doses of nitroglycerin have been recommended to alleviate symptoms of angina, but the surgeon should take into account the patient's medical history and level of distress in deciding when to call EMS (emergency medical services). It is recommended that EMS be notified immediately and that emergency medical drugs and supplies be readily available [advanced cardiac life support (ACLS) protocol] in cases of moderate to severe chest pain lasting 30 minutes or more, when the pain appears to be getting worse, if two to three doses of nitroglycerin are not sufficient to provide relief, and in any patient who is hemodynamically unstable.

In situations where a myocardial infarction (MI) is suspected, the patient should be given 325 mg of aspirin (chewed or crushed is preferable as it speeds absorption of the drug), sublingual nitroglycerin, and supplemental oxygen. If morphine is available, this should be given as well, both for pain relief and because it causes peripheral vasodilation, which enhances cardiac output. The patient's vital signs should be monitored continuously until EMS arrives, particularly the ECG (arrhythmias may accompany myocardial ischemia and can signal imminent cardiac arrest) and blood pressure. If the patient deteriorates to a situation of cardiac arrest, the ACLS protocol should commence without delay. (NB: Adequate and uninterrupted chest compressions are now recognized as a key to successful resuscitation efforts. If the patient is in a dental chair without a hard, flat back or which does not recline completely, it is preferable to place the patient on the floor so that adequately forceful chest compressions can be delivered against a firm supporting surface.)

The management of a patient where stroke/cerebrovascular accident is suspected includes notification of EMS and supportive measures. Supplemental oxygen should be given and the patient's vital signs monitored. A brief neurological examination may distinguish true cerebrovascular complications from confusion or disorientation that may result from anesthetic drugs. Aspirin should not be given to a patient suspected of suffering a stroke because intracerebral hemorrhage may be present. Patients who develop signs of neurocognitive deficit in the setting of severe hypertension (systolic >200, diastolic >110 mm Hg) should be treated with medication to decrease blood pressure. Of the intravenous agents, labetalol (a combination alpha- and beta-blocking agent) is frequently preferred for the management of acute severe hypertension (see the section on hypotension and hypertension).

Cardiac Arrhythmias

Cardiac arrhythmias may arise spontaneously or they may be associated with myocardial ischemia, respiratory depression, metabolic disorders, or other physiological derangements. Some anesthetic agents can cause or contribute to arrhythmias, particularly in susceptible individuals. Arrhythmias may be divided based on rate into tachyarrhythmias and bradyarrhythmias, or based on location of supraventricular ectopic rhythm generation versus ventricular arrhythmias. Some cardiac rhythm abnormalities such as premature ventricular contractions (PVC) and premature atrial contractions (PAC) occur spontaneously in an otherwise normal population and require no intervention. Likewise, certain instances of tachycardia (mild, associated with anxiety) and bradycardia (due to chronic treatment with beta-blockers, or in a competitive athlete) may be within acceptable limits. Any arrhythmia that is symptomatic, that carries a risk of conversion to a more dangerous cardiac rhythm, or that is accompanied by hemodynamic instability should be promptly addressed, however. If the arrhythmia is attributable to an underlying physiologic disturbance, efforts should be made to treat the underlying condition. Otherwise, the management strategies for cardiac arrhythmias include pharmacologic interventions or cardioversion/defibrillation.

Tachycardia due to stress, anxiety, or pain usually responds to a deepening of anesthesia and additional analgesia. The administration of a beta-adrenergic blocking medication can be considered for refractory cases. Selective beta-1 medications are preferred so as to avoid undesirable bronchoconstriction. Esmolol is a beta blocker with a fast onset and short-acting duration. Metoprolol is another beta-1-selective medication with a longer acting-duration. Both are available for intravenous use and may be titrated to effect. In general, beta blockers are best avoided in patients with low cardiac output states such as acute MI or acute exacerbation of congestive heart failure due to negative inotropic effects. When tachycardia is secondary to hypotension, hypovolemia, or fever, it is preferable to treat the underlying physiological derangement.

For cases of paroxysmal supraventricular tachycardia, the drug adenosine is typically recommended. Supraventricular tachycardias that do not respond to drug therapy or wide-complex tachycardia (ventricular tachycardia) should be treated with synchronized/unsynchronized cardioversion (electric shock). Cardioversion is also preferred for tachycardia associated with hemodynamic instability. Cardiac rhythms associated with cardiac arrest, i.e., ventricular fibrillation or pulseless electrical activity, should be treated according to the ACLS protocols.

Bradycardia, defined as a heart rate <60 bpm, may occur in sinus rhythm (sinus bradycardia) or as a result of heart block (atrial–ventricular dissociation). Any new onset of heart block is cause for evaluation by a specialist (e.g., chronic heart block can be a stable condition in patients with cardiac pacemakers). Sinus bradycardia during ambulatory anesthesia can be a sign of myocardial depression and is cause for concern. It may be treated with atropine or glycopyrrolate (both vagolytics), or with sympathomimetic drugs such as ephedrine or epinephrine.

Hypertension and Hypotension

During the course of an anesthetic, both hypertension and hypotension may be encountered. Hypertension is typically associated with patient anxiety, painful stimulus, or anesthesia that is too light. Hypertension may also be seen in the hypertensive patient who neglects to take their regular antihypertensive medications the day of the surgical procedure. Hypertension may be treated by deepening the anesthesia or by judicious use of an antihypertensive medication. Labetalol, a combined alpha-adrenergic and beta-adrenergic blocker is often preferred, but selective beta-blocking agents such as metoprolol or vasodilating agents such as hydralazine may also be used. In patients whose baseline blood pressure is elevated (above 120/80), it is important not to decrease blood pressure too rapidly or profoundly so as to avoid inducing a decrease in cardiac output.

Hypotension may also be encountered in the course of an anesthetic. Several commonly used medications such as propofol can induce a transient decrease in blood pressure, particularly when given as a bolus. In a young patient without underlying cardiac disease, small to moderate decreases in blood pressure are usually well-tolerated. However, because hypotension may also be a sign of low volume status or of impending cardiovascular collapse, it should be closely monitored and treated aggressively when indicated. In pediatric patients particularly, hypotension typically precedes cardiac arrest and is an important warning sign.[16] Decreasing the anesthetic depth, increasing the rate of IV fluid infusion, or giving a bolus of IV fluids are all appropriate first steps in the management of hypotension. If these steps are not corrective, a vasopressor medication such as ephedrine or phenylephrine may be given while also investigating for any causative factors such as an underlying medical condition, anaphylaxis/allergic reaction, or increased vagal stimulation.

GASTROINTESTINAL COMPLICATIONS

Nausea and Vomiting

Postoperative nausea and vomiting (PONV) is frequently cited as the most common complication of anesthesia, and it is one that patients frequently complain about. Many drugs used in ambulatory anesthesia are potentially capable of causing nausea and vomiting, particularly the halogenated gases (isoflurane, halothane, sevoflurane) and anticholinesterases. Narcotic medications such as morphine and fentanyl may also cause nausea and vomiting, as do barbiturates. Benzodiazepine medications have not been cited as a cause of PONV, and propofol is known to have antiemetic properties.

In addition to the effects of the anesthetic drugs, there are several patient factors that are known to increase the risk of PONV. Female gender, obesity, gastroparesis, past history of PONV, and a history of motion sickness may all predispose toward nausea and vomiting post anesthesia. Dehydration may also be a factor.

Prevention is an important consideration given that PONV is a frequent cause of delayed discharge to home after ambulatory anesthesia procedures.[12] Treatment of nausea and vomiting once it occurs is more difficult and less successful than efforts at prophylaxis. Avoiding dehydration and hypoglycemia by maintaining a reasonable preoperative fasting period and giving IV fluids during surgery will benefit most patients. In addition, screening prospective patients to identify those at risk of PONV will allow the surgeon to consider pharmacological methods of nausea and vomiting prophylaxis. Several effective medications are available that can be given by mouth or intravenously prior to the procedure in order to prevent and treat nausea and vomiting (see Table 1.4).

ENDOCRINE COMPLICATIONS

Hypoglycemia

Hypoglycemia is a potential complication of ambulatory anesthesia anytime a preoperative fasting period has been observed. Diabetics, young thin females, and the elderly are particularly at risk but any patient may experience signs and symptoms of hypoglycemia. Minimizing the preoperative fasting period and giving IV fluids preoperatively (or having them available) may help to prevent hypoglycemia. In addition, recognizing patients who are at risk (such as diabetics) and monitoring their blood glucose via fingerstick is a very effective management strategy. Hypoglycemia may present with nonspecific signs and symptoms such as dizziness, tachycardia, hypotension, sweating, shaking, or nausea but can be easily diagnosed with a simple handheld glucometer. Hypoglycemia is easily treated with an oral or intravenous sugar source. In situations of severe symptomatic hypoglycemia, an injection of D50 (50% dextrose) or glucagon may be given.

Table 1.4. Common Antiemetic Medications

Dolasetron	5-HT3 receptor antagonist (PO, IV)
Ondansetron	5-HT3 receptor antagonist (PO, IV)
Metoclopramide	Pro-motility agent (PO, IV, IM)
Prochlorperazine	Phenothiazine derivative (PO, IV, IM, PR)
Trimethobenzamide	Acts on chemoreceptor trigger zone (IM, PR)
Scopolamine	Anticholinergic agent (transdermal patch)
Dexamethasone	Adjunct (PO, IV, IM)

PO: by mouth; IV: intravenous; IM: intramuscular; PR: rectal suppository

Adrenal Crisis

Adrenal crisis is a rare but serious complication of suppressed adrenal release of cortisol and can rapidly cause hemodynamic collapse if the cortisol deficiency is not promptly diagnosed and rectified. Risk factors for acute adrenal crisis include both patient and procedure factors. Surgical procedures that are invasive and cause high levels of physiologic stress carry the highest risk. Patients most at risk for adrenal crisis are typically those with a lengthy history of moderate- to high-dose exogenous corticosteroid supplementation, though adrenal crisis has been classically associated with Addison's disease (primary adrenocortical insufficiency). Since most procedures that will be performed in an outpatient setting will be minimally invasive and of short duration the risk of adrenal crisis is low. Patients should be screened for a history of Addison's disease or corticosteroid use, and preoperative adjunctive corticosteroid supplementation should be considered for any patient deemed to be at risk. Acutely, the management of adrenal crisis involves intravenous cortisol administration and supportive measures.

IMMUNOLOGIC COMPLICATIONS

Hypersensitivity Reactions

Hypersensitivity, or allergic, reactions are common in the general population and may be produced in the ambulatory anesthesia setting by a variety of common substances. Patients with a history of allergic asthma, atopy, or autoimmune disease may be most at risk. Mild reactions include urticaria, flushing, and pruritis, while more severe reactions can be characterized by angioedema, wheezing, nausea and vomiting, or anaphylaxis. The most common complication is a localized skin reaction, frequently to an adhesive tape used to secure an IV line, for example. Some of the medications used in ambulatory anesthesia (propofol or succinylcholine) have been implicated in allergic reactions, but this is generally rare.[16] Likewise, a true allergy to local anesthetic agents is very infrequent. Most hypersensitivity reactions will be mild and can be managed symptomatically. More serious reactions involving angioedema or a skin rash covering the full body require more aggressive management such as the use of an antihistamine drug (e.g., diphenhydramine) and possibly corticosteroids. Angioedema or other acute allergic facial swelling should be carefully monitored for the development of airway compromise—an unlikely but possible sequela. Anaphylactic reaction is a life-threatening emergency that is treated with epinephrine, corticosteroids, antihistamines, beta-2-adrenergic agonist inhalers, and cardiopulmonary resuscitation as needed.

PSYCHIATRIC AND EMOTIONAL COMPLICATIONS

Patient anxiety is the most commonly encountered emotional complication in ambulatory anesthesia, but patients may also experience euphoria, delirium, agitation, or hallucinations. Children and the elderly are most at risk, and certain anesthetic medications such as ketamine have been associated with a higher likelihood of emotional or cognitive disturbance. These types of complications may be distressing to the patient but are typically self-limiting and mild. Preventing patient injury due to agitation or delirium is the primary goal of management, and close supervision remains the best strategy.

Many anesthetic medications (particularly the benzodiazepines) produce some degree of amnesia. Amnesia is often an intended effect of anesthesia and therefore not a complication per se, but the practitioner should be aware that any instructions or information given to a patient may be affected by amnesia or cognitive distortion. Patients may not be able to distinguish between dreaming and events that actually occurred during anesthesia, leading to inappropriate associations with the anesthetic experience. It is not known how often this may occur as a complication of ambulatory anesthesia, but whenever medications are given that alter a patient's consciousness and perception there is a risk of cognitive and emotional distortion.

COMPLICATIONS RELATED TO PATIENT POSITIONING

In an outpatient surgical procedure of limited duration, the risk of injury to a patient from malpositioning is relatively small. In susceptible patients, or for longer procedures, special care in patient positioning is prudent to avoid musculoskeletal injury. The provision of anesthesia causes relaxation of the musculoskeletal system that can lead to hyperextension of the joints. Also, prolonged patient immobility can contribute to venous stasis, peripheral blood pooling, and the creation of pressure points. Elderly patients, patients with a history of musculoskeletal injury or arthritis, and obese patients are at increased risk for complications related to patient positioning. Patients with Marfan syndrome, Ehlers-Danlos, or other disorders of joint hypermobility may also be at risk. Down syndrome (trisomy 21) patients have increased range of motion of the cervical spine vertebrae and are at increased risk for vertebral dislocation if the head or neck becomes hyperextended. Of specific concern to oral maxillofacial surgeons is the potential for injury to the temporomandibular joint (TMJ) that can occur in sedated patients due to prolonged or exaggerated opening of the mouth during surgery. Key preventive measures are positioning patients in neutral body positions, minimizing length of surgery in susceptible individuals, and ensuring that dental chairs are cushioned and sized appropriately for the patient.

COMPLICATIONS RELATED TO IV LINE PLACEMENT

Complications related to placement of an intravenous line are some of the most common and troubling to patients. Pain, ecchymoses, and infiltration at the IV site are the most frequently encountered and can be managed symptomatically. More serious complications include phlebitis and thrombophlebitis at the injection site and are associated with certain irritating medications (such as intravenous diazepam), particularly when given in a small vein or at a high concentration. Phlebitis may take several weeks to resolve completely and may necessitate analgesia and anti-inflammatory medications. A rare but potentially serious complication involves the inadvertent intra-arterial injection of a medication, most commonly a barbiturate, with resultant extreme pain and vascular necrosis. With careful IV placement technique and the use of a full IV setup allowing proper dilution of medications, the incidence of complications can be minimized and have a measurable impact on patient satisfaction as well as safety.

ANESTHETIC COMPLICATIONS IN PEDIATRIC PATIENTS

Complications of ambulatory anesthesia in pediatric populations are similar in many ways to those that may be encountered in adults. As higher incidences of adverse events are reported for children with higher ASA classifications, and children less than 1 month old and less than 1 year old are particularly prone to anesthesia-related complications.[17] For pediatric and adult patients, much of the risk of complications from anesthesia can be attributed to underlying disease states and surgical risk factors. Nonetheless, there is an additional element of risk in the pediatric population due to decreased physiological reserve.

Children, far from being miniature adults, are different in fundamental anatomical and physiological ways. The immature cardiac, hepatic, renal, and respiratory systems in the child mean that large differences in drug effects, drug metabolism, and cardiac and respiratory compensations exist. Some of these differences are predictable whereas others are not. In general, the interpatient variability in the pediatric patient can be far greater than in an adult, necessitating more caution in the provision of anesthesia and complicating the titration of common anesthetic drugs.

Since children are smaller and weigh less than adults, the total doses of anesthetic drugs that may be safely given will be less in total. Due to the immaturity of the hepatic liver enzymes at birth, infants do not metabolize drugs as effectively as adults, and the clearance of many drugs can be prolonged significantly, with most individuals attaining full liver microsomal function at about 1 year of age.[12] Other physiologic systems take longer to reach maturity, particularly the cardiovascular and respiratory systems.

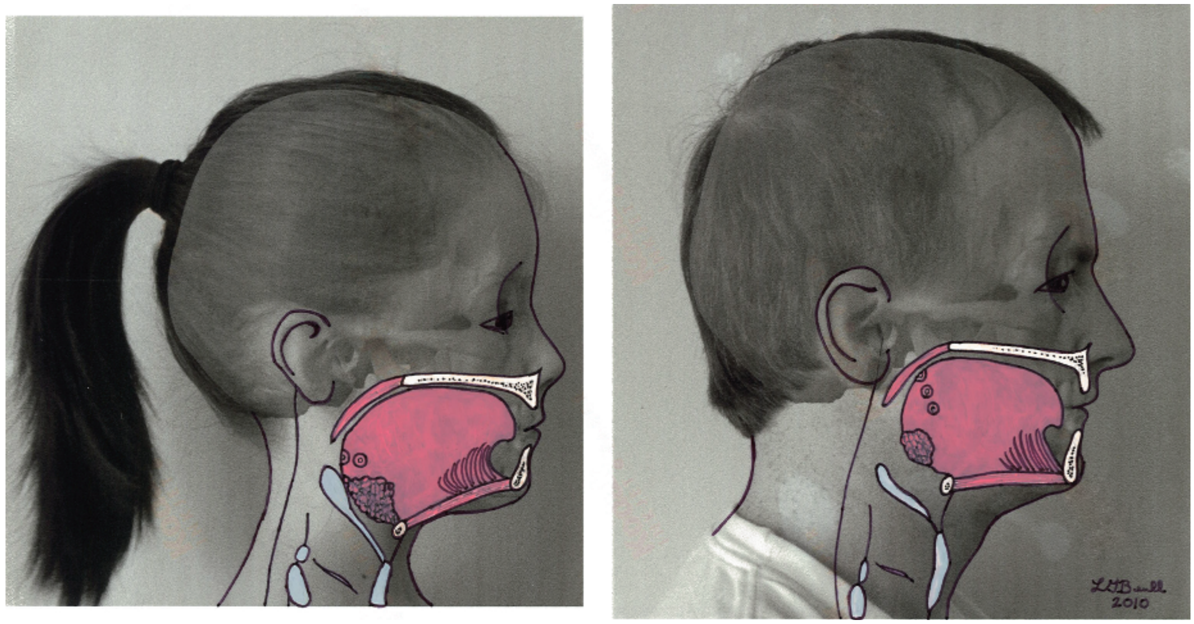

Fig. 1.1. Compared to an adult airway, the pediatric airway demonstrates more cephalad position of the vocal folds, a wider and angled epiglottis, a relatively larger tongue and lymphoid tissue (including lingual tonsil), and a narrower funnel-shaped cricoid cartilage.

The pediatric airway is characterized by a more cephalad position of the larynx, a thicker epiglottis, and angulation of the true vocal folds, which can make direct visualization more challenging (see Fig. 1.1).[16] In addition, the narrowest part of the pediatric airway occurs at the level of the cricoid cartilages just below the vocal folds; in contrast, the narrowest portion of the adult airway is typically the glottis itself. The chest wall and upper airway of the infant and young child are more compliant such that collapse of the airway occurs more easily and leads to airway obstruction.[16] Not only are children more prone to airway obstruction, but their increased oxygen and metabolic demand makes them more sensitive to hypoxia. Respiratory arrest can quickly lead to cardiac arrest if not promptly addressed.

The pediatric cardiovascular system is different from that of adults as well. In children, cardiac output is maintained primarily through heart rate rather than systemic vascular resistance. A sudden or sustained drop in heart rate can precipitate a severe drop in blood pressure and cardiac output in a child due to the relative lack of compensation via increase in peripheral vascular resistance. In practice, this means that most cardiac arrests in children are preceded by bradycardia.

Children also have an increased body surface area relative to their mass and are more susceptible than adults to hypothermia and insensible fluid losses. They may be more prone to hypoglycemia and dehydration and less able to tolerate prolonged preoperative fasting.

Children are frequently less able to communicate effectively, less cooperative, and more prone to anxiety and emotional outbursts. The increased emotional lability of some children can make these patients challenging to manage preoperatively and can complicate and prolong the postoperative recovery period. The age and anticipated level of cooperation of a given child patient often dictates the anesthetic plan, with pediatric patients sometimes requiring oral premedication prior to the planned procedure.

The range of complications that can occur in pediatric patients during ambulatory anesthesia is the same as for adults, though not all complications occur with similar frequency. In children, respiratory complications are among the most frequently reported serious adverse effects. The overall rate of adverse events is higher in children than in adults, ranging from 1.45% to as high as 6% in different studies.[11,18,19]

Pediatric Respiratory Complications

Respiratory complications in the pediatric population are the most frequently observed adverse event and are typically mild in nature, responding well to supplemental oxygen or head repositioning. The most common complication in children is respiratory depression and oxygen desaturation and ranges from less than 1% to 11% of subjects, depending on the study.[19] More frequent respiratory depression and desaturation are observed with combinations of intravenous medications, particularly combinations of narcotics and benzodiazepines or narcotics and propofol.[19] In a recently published report from the Pediatric Sedation Research Consortium on the use of propofol sedation/anesthesia for outpatient procedures, the number of respiratory complications outnumbered other complications significantly and included the following specific events in decreasing order of frequency: desaturation less than 90% for greater than 30 seconds; airway obstruction; cough; excessive secretions; apnea; and laryngospasm.[18] The authors of the study identified 1 in 65 anesthetics as being complicated by adverse respiratory events, and 1 in 70 anesthetics required airway interventions including placement of an oral or nasal airway, positive pressure ventilation, or endotracheal intubation.[18] A study by Kakavouli et al. reports an overall incidence rate of intraoperative respiratory complications of 1.9% with laryngospasm and bronchospasm identified as the most common adverse events.[17] Two separate studies on perioperative cardiac arrest in children list respiratory events[6] and airway-related causes[2] as the main causes of cardiac arrest attributable to anesthesia. Cravero reports two cases of cardiac arrest in children, one of which occurred secondary to laryngospasm and profound hypoxia, and the second that resulted after an apneic episode and bradycardia.[18] These cases underscore the fact that cardiac arrest in children is frequently preceded by respiratory arrest, whereas adults more frequently experience cardiac arrest secondary to MI or arrhythmia.

Pediatric Cardiovascular Complications

Children typically do not suffer from systemic hypertension, coronary artery disease, or congestive heart failure as in adult patients. Though there is always the possibility of undiagnosed congenital heart disease, most children who present for ambulatory anesthesia will be free of cardiac disease. Notwithstanding this, cardiac complications do occur in the pediatric population though at a much lower rate. In the study by Kakavouli et al., cardiac complications accounted for 8.6% of all observed complications.[17] Cravero et al. reported a rate of cardiac complications (defined as a change of more than 30% in heart rate, blood pressure, or respiratory rate) of 60.8 events per 10,000 anesthetic cases.[18] Cardiac arrest, though rare, does occur in children who undergo anesthesia and has a reported incidence rate of between 4.95 per 10,000 (Ref. 2) and 22.9 per 10,000.[6] While the majority of anesthesia-related causes of cardiac arrest are due to respiratory complications, the remainder may be attributed to bradycardia or anesthetic drug-induced cardiac depression (halogenated inhalation agents).

Other Pediatric Complications

In many other regards, the anesthetic complications that may occur in children are similar to those that occur in adults. The rate of aspiration (between 1 and 4 per 10,000 cases) is similar in adults and children as is the rate of postoperative nausea and vomiting, though children may experience more emesis with certain medications such as ketamine. Children may experience a paradoxical reaction and become stimulated or excited when given certain sedative-hypnotic drugs. In addition, children may be more prone to agitation, delirium, or hallucinations upon emerging from anesthesia. Research studies have estimated the incidence of post-procedure agitation, nightmares, and/or behavioral problems in children given ketamine to be between 4% and 17%.[19] Ketamine is also associated with higher rates of postoperative nausea and vomiting (6–12%).[19] The combination of midazolam and ketamine appears to reduce the incidence of emesis but not the incidence of postoperative agitation.[19]

PREVENTION AND MANAGEMENT OF PEDIATRIC ANESTHETIC COMPLICATIONS

Preoperative screening of the pediatric patient will be simpler as most will have an uncomplicated medical history. Laboratory testing is rarely indicated in these patients. Of special interest is a medical history of asthma or recent upper respiratory infection, as both these conditions may predispose toward respiratory complications during anesthesia. Upper respiratory tract infections are notoriously common in school-age and younger children, and adverse airway effects have been noted by some to persist for several weeks after the resolution of acute symptoms.[16] Parents should be asked about any cough, sore throat, or "runny nose," and the procedure should be rescheduled if there is any doubt about the child's condition.

Management of anesthetic complications in children is similar to that of adults with a few differences. The pediatric advanced life support protocol (PALS) mirrors the ACLS protocol for adults, except that PALS guidelines recommend beginning chest compressions for children with significant bradycardia (<60 bpm) and signs of hypoperfusion. Oxygen face masks (bag masks), endotracheal tubes, laryngoscopes, oral and nasal airways, and laryngeal mask airways of appropriate size should be available for use with pediatric patients. A frightened child may become increasingly uncooperative and inadvertently injure themselves at various stages during ambulatory anesthesia. Additional staff members may be required to be present during ambulatory anesthetic procedures to calm and distract the child at the start of the procedure and assist during recovery.

Postoperative monitoring of the pediatric patient is similar to that of adults. Children benefit from a prompt reunion with a parent or caregiver and effort should be made to have parents present in the postoperative recovery area as soon after the procedure as possible. Having a parent or family member present can help to calm an anxious child and may aid in the management of any postoperative drug-induced agitation.

In conclusion, anesthesia in outpatient settings for oral maxillofacial surgical procedures has an admirable track record of safety, and recent advances in the field have increased its safety and reliability. Complications, though infrequent, do occur during ambulatory anesthesia but with adequate knowledge and preparation many serious adverse events can be prevented or managed effectively.

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