Anesthesia can be a challenging time for the anesthetist. Depending on the procedure and the patient, your time can go smoothly or it can be the roughest 90 minutes of your day. Preparation and thinking ahead can save you stress later on and help you cope with anesthetic emergencies as they come up.

The first step to any anesthetic procedure is preparation. Even in emergency situations when the procedure needs to happen immediately, do not skimp on preparation. Start with your equipment.

- Take the time to make sure the correct anesthesia circuit is connected
  - < 4# non-rebreathing circuit
    - Oxygen flow rate must be higher than with circle system to prevent rebreathing; 200–300 ml/kg/min.
  - 4-15# pediatric circuit
  - > 15# adult circuit
    - Oxygen flow rate can be set higher (200ml/kg/min) for the beginning (first 10 min of anesthesia) of the procedure to quickly saturate tissues with inhalant anesthesia and ease transition from injectable induction to inhaled anesthesia. Patient should be maintained at 30–40 ml/kg/min for the duration of the procedure.
- Make sure the reservoir bag is the proper size for the patient
  - 60 ml/kg (round up)

Check the CO2 granules. Do a 10-second leak test. Make sure you have multiple sizes of ET tubes out and their cuffs are checked for leaks. It is also worth the time to make sure your patient is prepared. Get that last set of vital signs before induction. Be aware of any complications that can and may occur during the procedure. Know doses of emergency drugs and fluid bolus doses. Will you need blood products? Will you need additional IV access? Thinking through potential problems and being prepared for them will save you time when you need to be acting on these emergencies.

Determining the Inhaled Anesthesia Levels

Look at the Minimum Alveolar Concentration (MAC) to give you a starting point. The MAC is the concentration of anesthetic that produces no response to pain in 50% of animals exposed to a painful stimulus.

- Isoflurane MAC: dogs 1.28; cats 1.6
- Sevoflurane MAC: dogs 2.4; cats 2.6

Generally speaking, you can refer to the following chart when determining inhaled anesthetic levels and let your patient’s response guide any changes.

- Light anesthesia: 1xMAC
- Moderate anesthesia (surgical): 1.5xMAC
- Deep anesthesia (orthopedic, neuro): 2xMAC

Heart Rate

- Tachycardia: There are a variety of causes for tachycardia and the treatment for these causes varies greatly. It is important to quickly determine the cause so the correct treatment is applied. Is your patient tachycardic due to improper anesthetic depth? Surgical manipulation? Hypovolemia? Hyperthermia? Hypoxia? Anemia? Drugs administered? You will need to quickly go through all of the potential causes for tachycardia and choose the correct treatment. Quickly check your equipment, and then look at other vital signs. How is the blood pressure? The SpO2? Look at the patients. How well are they perfusing? What is their mucous membrane color and CRT? Talk to the surgeon. How do things look in the abdomen? Are the surfaces dry and tacky? Is there more blood than expected? If you can quickly determine the cause of the tachycardia, you can correct it—with oxygen, blood products, a fluid bolus (10 ml/kg), increase in the inhaled anesthesia, or administration of pain medication.
• Bradycardia: Bradycardia is often the result of a deep plane of anesthesia, disease process, or drugs administered. It is important not to treat just a number, but to get the entire picture. How is the patient perfusing? Is the patient’s blood pressure maintaining? Bradycardia can be addressed with anticholinergics (atropine, glycopyrrolate) and monitored closely after those drugs have been administered. The atropine (faster onset, shorter acting) dose is 0.005–0.01 mg/kg in dogs and 0.02–0.04 mg/kg in cats. The glycopyrrolate (slower onset, longer lasting) dose is 0.005–0.01 mg/kg in dogs and cats.

ECG
Familiarize yourself with the common arrhythmias seen and how to treat them. If you are working with a patient where the probability for arrhythmias is high, educate yourself on what they look like. VPCs and 2° AV block are the most commonly seen under anesthesia. Notate when the arrhythmia started, and watch heart rate, blood pressure, and perfusion status.

Respiratory
• Tachypnea: We will see tachypnea in patients mainly due to improper levels of anesthesia (too light), hyperthermia, and hypoxia. Look at other vital signs (such as heart rate and blood pressure) to help you determine the cause. In most cases you can correct tachypnea with a change in anesthetic depth.
• Bradypnea: This is often caused by anesthetic depth too deep, drugs given, patient status (obesity), patient position, disease process, hyperthermia, and severe hypotension. Some of these problems you will have no control over, but thinking ahead to what you can do to alleviate some of the problem can be helpful. Again, look at other vital signs and perfusion status when looking to correct this problem before you make changes to anesthesia.
• SpO2: Hypoxemia is low oxygen content in arterial blood; hypoxia is low oxygen in tissues due to poor perfusion. Both can cause changes in your SpO2 readings and need to be addressed immediately. SpO2 measures the percentage of hemoglobin saturated with oxygen and requires a certain level of perfusion to read in the periphery. Also, if you look at the oxygen hemoglobin dissociation curve, you will see that a SpO2 in the low 90% range means a dramatic drop in PaO2 readings. Do not wholly trust the SpO2 to be the end all and be all in oxygen monitoring. Watch perfusion and check gum color, respiratory rate, and heart rate.
• ETCO2
  o Hypercarbia: The result of hypoventilation (see bradypnea above). If left untreated, hypercarbia can cause central nervous system depression and eventually acidemia. If it is noted, attempt to determine the cause and work to alleviate it while decreasing the patient’s ETCO2. This is accomplished by increasing the respiratory rate. A rapid, sudden drop in ETCO2 can signal impending arrest and should be viewed as an emergency that requires immediate attention.
  o Hypocarbia: The result of hyperventilation (see tachypnea). Hypocarbia can cause a respiratory alkalosis in the patient and should be addressed while attempting to increase the patient’s ETCO2. This is accomplished by decreasing the respiratory rate.

Blood Pressure
• Hypertension: Usually a sign that anesthesia isn’t deep enough, hypertension can be treated by increasing inhaled gas or providing more analgesia. It is important to think about your patients and whether or not they have disease processes that can be causing hypertension. Increased intracranial pressure, chronic renal failure, and metabolic diseases can cause hypertension.
• Hypotension: Low blood pressure is a common occurrence in anesthesia, as many of the drugs used to induce and maintain anesthesia will cause hypotension. Also, hypothermia can contribute to low blood pressure and is common in small animals under anesthesia. When your patient is under anesthesia your goal should be a blood pressure of > 60 mmHg MAP; > 80 mmHg systolic. Get the in the habit of looking at blood pressure and heart rate together, as the heart rate will give you clues as to why the blood pressure is abnormal. You must determine the cause of the hypotension and quickly work to improve perfusion (look for decreased CO, vasodilation, hypovolemia, hypothermia, or a patient being too deep under anesthesia), as the patient can suffer long-term effects of prolonged hypotension.
  o When you are faced with a hypotensive patient it is important to begin treatment as soon as possible and search to find the underlying problem. The mainstay of hypovolemic (the most
common) hypotension treatment is fluid therapy. Relatively easy to start and monitor, every veterinary clinic has the supplies necessary for treating hypotension with IV fluids. Goals are set (reduction in heart rate, increase in blood pressure) and fluids are administered until endpoints are reached.

- Crystalloids, in the form of balanced electrolyte solutions, are administered first, generally starting with a 5 ml/kg bolus. Crystalloids will provide a quick bump in intravascular volume, but remember that they will shift out of the intravascular space and into the interstitial space about 30 minutes after administration. Remember this when monitoring a hypotensive patient—one normal measurement does not equal fixed, if fluid shifts are occurring, the blood pressure may drop again, and it needs to be monitored continuously.
- Colloids are made of larger molecules than crystalloids and will remain in the intravascular space longer than crystalloids. They will also help to draw fluids toward them, thereby increasing intravascular volume. Blood products are also colloids. When dealing with normovolemic hypotensive patients, colloid therapy becomes more common. Patients that are hypoproteinemic may also be on colloid therapy as a way to decrease edema. Colloids can be administered as a bolus (5 ml/kg) with a maximum daily dose of 20 ml/kg.

- With some patients, their hypotension is not caused by a loss of fluid or blood, but by a systemic illness. Septic patients can be hypotensive and normovolemic, and correcting their hypotension with fluid challenges can be detrimental to their recovery. SIRS, anaphylaxis, and cardiac disease patients can present the same challenge when being treated for hypotension, and their condition is important to keep in mind.

- When fluid therapy challenges are not successful in increasing blood pressure, it is time to turn to drugs. In normally functioning patients, the sympathetic nervous system (the fight-or-flight response) will control alpha and beta receptors in the vasculature and heart to vasoconstrict and increase heart rate to compensate for what the animal is experiencing. The body performs this adaptive response to stimulus and keeps cells oxygenated and blood pressure maintained. When this system is not able to keep blood pressure maintained, we can administer drugs that will work on those receptors to give the desired result of increased blood pressure.
  - **Dopamine:** Dopamine will stimulate adrenergic receptors (to stimulate the sympathetic nervous system) and stimulate the myocardium, so by giving dopamine you are causing vasoconstriction and increased cardiac output to increase blood pressure (dose dependent). Dopamine has a very short half-life and so it must be administered as a CRI and the dose changed according to patient response. Most patients will receive a dose range of 5–10 mcg/kg/min but can go > 10 mcg/kg/min. Tachycardia and arrhythmias can occur, especially at higher doses, and the patient should be closely monitored.
  - **Dobutamine:** Dobutamine will stimulate myocardial receptors to increase cardiac output without increasing the heart rate. At high doses, tachycardia and arrhythmias can occur. Dobutamine has a very short half-life and must be administered as a CRI at a dose range of 5–20 mcg/kg/min (dogs).
  - **Norepinephrine:** Norepinephrine plays an important role in the fight-or-flight response of the body. When administered IV, it causes potent vasoconstriction without significantly affecting cardiac output and heart rate. Because of this, it is best to use norepinephrine when you know the patient’s cardiac function, as heart disease can be exacerbated by norepinephrine administration. It can cause sloughing if given outside the vein, so careful attention must be paid to the infusion site. It is only given as a CRI and the effects are dose dependent and titrated until the desired outcome is reached. The dose is started at 0.5 mcg/kg/min.
  - **Vasopressin:** Vasopressin is an antidiuretic hormone in the body. Its role is to conserve body water in times of need. There are vasopressin receptors located throughout the body, and when activated, will cause vasoconstriction. It is recommended to administer vasopressin to patients in septic shock. It is administered as a CRI with a dose range of 0.1–0.4 U/kg/min.
  - CRI math can be challenging, especially in an emergency. Practice CRI math now, and creating a CRI later will not be as intimidating:
• Make the solution so that 1 ml/hr = 1 mcg/kg/min
• Then a 10 kg dog would need 10 mcg/min
• 10 mcg × 60 min = 600 mcg/hr
• 100 ml of NaCl = 100 hrs
• 600 × 100 = 60,000 mcg/100 ml
• 60 mg/100 ml
• Dopamine 40 mg/ml; so 1.5 ml qs 100 ml NaCl
• Now 1 ml = 1 mcg/kg/min for a 10 kg dog and the CRI is easily titratable

Temperature

• Hyperthermia is uncommon under anesthesia but can exist due to infection, inflammation, and drugs given. Opioid administration in cats can cause dramatic (but transient) increases in body temperature. Malignant hyperthermia is a rare genetic disorder that causes muscle tremors and dangerously high temperatures. Hyperthermia can increase heart rate and cause vasodilation and hypovolemia if it goes untreated.
• Hypothermia is probably the most common complication encountered with general anesthesia. Hypothermia will actually decrease the inhaled anesthetic needs of the patient; this should be top of mind in longer procedures where the patient continues to get colder. Hypothermia can also cause ECG abnormalities, decrease coagulation, and/or inhibit platelet function, and eventually can be the cause of death. Upon recovery, hypothermia can prolong the process and cause shivering, which will increase the metabolic oxygen needs. Prevention is the best medicine for hypothermia and should remain on the list for the cause of intraoperative anesthetic complications.

Arrest
Cardiopulmonary arrest can happen in anesthetized patients for a number of reasons. In many patients respiratory arrest will happen first, but if it goes unchecked cardiac arrest will soon follow. As the anesthetist, hopefully you will note any warning signs of arrest (change in respiratory rate/depth, sudden change in heart rate, pale/gray mucous membrane color, drop in blood pressure, drop in ETCO2) and start to make changes prior to arrest. If your patient does arrest on the anesthesia table:

• Turn off any inhaled anesthesia and any opioid CRI medications.
• Reverse any opioid medications using naloxone (0.01–0.04 mg/kg IV).
• Ventilate the patient at 10 bpm—inhale for 1 second then exhale.
• Begin compressions—often the surgeon can cut through the diaphragm and begin internal cardiac massage—at 100–150 bpm.
• Administer drugs as needed (epinephrine, atropine, etc.).

References