

RESPONDING TO ANESTHETIC COMPLICATIONS

General anesthesia poses minimal risk to most patients when performed by a capable anesthetist using appropriate protocols and proper monitoring. However, it is vitally important that the anesthetist remembers that every anesthetic procedure has the potential to cause the death of the animal. In spite of significant advancements in pharmacology & technology, the fundamentals of good patient monitoring and support of organ function are key to minimizing anesthetic risk and assuring a good outcome. Similarly, while knowledge of appropriate responses to an anesthetic emergency is essential, it is even more important to understand why emergencies arise and how they may be prevented.

Common causes of anesthetic complications include:

- Human error
 - Failure to obtain and interpret an adequate history or physical exam.
 - Lack of familiarity with the anesthetic machine or agents being used.
 - Incorrect drug administration (incorrect drug, dosage, route or concentration)
 - Failure to recognize and respond to early signs of patient difficulty.
- Equipment failure or misuse
 - Carbon dioxide absorber exhaustion
 - Empty oxygen tank
 - Misassembly of the anesthetic machine or breathing circuit
 - Endotracheal tube problems
 - Vaporizer problems
 - Pop-off valve problems
- Adverse effects of anesthetic agents
 - Every agent has benefits and contraindications associated with its use.
 - Reducing the potential for adverse effects depends on several factors:
 - Assessment of the patient and any potential risk factors
 - Familiarity with side effects and contraindications of different agents
 - Appropriate protocol choice, often including multi-drug use to achieve balanced anesthesia
- Patient related factors
 - Geriatric patients
 - Pediatric patients
 - Brachycephalic dogs/cats
 - Trauma patients
 - Systemic disease (Cardiovascular, respiratory, hepatic, or renal disease)
 - General poor condition

Both human error and equipment problems are generally preventable complications. Proper training and attention will prevent these situations from arising. If at any time you are uncertain about an animal's status, proper equipment use or protocol, do not hesitate to ask for assistance.

Patient related complications can often be prevented by identifying potential risk factors and modifying the anesthetic plan to address the patient's special needs. Any risk factors noted during the physical exam should be noted in the medical record and brought to the attention of the veterinarian or technician in charge of anesthesia prior to the animal being medicated.

RESPONDING TO PROBLEMS DURING ANESTHESIA

➤ Animal will not stay anesthetized

- Check patient respiration. Prolonged breath-holding or rapid, shallow respiration may lead to arousal as vaporized anesthetic is not entering the lungs. It may be necessary to periodically bag the animal with O₂/isoflurane until adequate anesthetic depth is achieved.
- Often a result of equipment problem: Verify placement and length of endotracheal tube and appropriate cuff inflation. Check vaporizer, oxygen flow settings and level of anesthetic in the vaporizer.
- Check anesthetic machine setup. Follow the flow of O₂/isoflurane through the machine and to the patient, checking each tube and connection.
- If you are unable to readily determine the cause-alert a supervisor!

➤ Excessive anesthetic depth

- Signs include: RR < 8 bpm and/or shallow respiration; mucous membranes pale or cyanotic; CRT > 2 seconds; HR < 60 bpm in a dog or 100 bpm in a cat; hypothermia; flaccid muscle tone. These signs must be interpreted in light of all available information.
- Excessive anesthetic depth is usually a result of a vaporizer setting or drug dose that is too high for the patient. Occasionally the animal may have a pre-existing condition that increases their susceptibility to anesthetic overdose.
- If you are concerned that your patient is too deeply anesthetized, turn the vaporizer setting down or completely off and alert a supervisor.

➤ Pale mucous membranes

- May result from preexisting anemia, blood loss, anesthetic agents which result in vasodilation and hypotension, hypothermia or pain.
- Assess anesthetic depth and other vital signs and alert a supervising veterinarian or RVT.

➤ Prolonged capillary refill time (> 2 seconds)

- Suggests that blood pressure is inadequate to perfuse peripheral tissues.
- Hypotension is one of the most common anesthetic complications and should be suspected in any animal with a prolonged CRT. Pulse and blood pressure should be evaluated. A systolic BP < 80 mmHg indicates hypotension and poor perfusion.
- If pulse or blood pressure is abnormal, the anesthetist should alert a supervisor and closely observe the animal for other signs of shock.

➤ Dyspnea and/or cyanosis

- Dyspnea indicates an inability to obtain sufficient oxygen using normal respiratory effort. Cyanosis indicates inadequate tissue oxygenation.
- Any patient showing signs of dyspnea or cyanosis should be brought to the attention of a supervisor **immediately**.
- The most common causes of respiratory distress during anesthesia include:
 - Equipment problems (empty oxygen tank, flowmeter turned off, damaged circuit)
 - Airway obstruction (ET tube blockage, laryngospasm, aspiration) or respiratory disease (pleural effusion, pulmonary edema, diaphragmatic hernia, etc)
 - Excessive anesthetic depth such that vital functions are compromised.
- Check SpO₂ reading.
- Quickly evaluate other vital signs and anesthetic depth and equipment setup.
- Once oxygen delivery to the patient and patent airway has been confirmed, turn the vaporizer off and ventilate with 100% oxygen until mucous membrane color and SpO₂ readings return to normal.
- Monitor closely during resuscitative efforts to ensure cardiac arrest does not occur.

➤ **Tachypnea**

- Must be differentiated from dyspnea in which respiratory distress is present.
- Evaluate other vitals and anesthetic depth.
- In combination with tachycardia and increased muscle tone or spontaneous movement may indicate inadequate anesthetic depth.
- Can also be seen in deep anesthesia as a result of low blood oxygen and high CO₂ levels or in response to hypotension.
- Check CO₂ absorber crystals to rule out hypercapnia.
- If all other vitals and anesthetic depth are within acceptable limits, continue to monitor- condition will generally correct itself in 1-2 minutes.
- If tachypnea continues or other parameters are abnormal, alert a supervisor.

➤ **Bradycardia (HR < 80 bpm (K9) or 100 bpm (FL))**

- Common causes include increased vagal tone and inhalant anesthetic overdose
- Evaluate other vital signs and anesthetic depth.
- If excessive anesthetic depth is indicated, reduce vaporizer setting and continue to monitor all parameters closely.
- If heart rate remains below 80 bpm in a dog or 100 bpm in a cat, alert a supervisor.

➤ **Tachycardia (HR > 160 bpm (K9) or 200 bpm (FL))**

- Causes include light anesthesia, drug induced tachycardia (as a result atropine or glycopyrrolate administration), preexisting conditions and hypotension.
- An elevated heart rate is a common response to surgical stimulation and does not necessarily indicate that the patient is too light unless accompanied by increased respiratory rate, active reflexes or spontaneous movement.
- Evaluate other vital signs and anesthetic depth.
- If insufficient anesthetic depth, increase vaporizer setting.
- If anesthetic depth is sufficient, the blood pressure should be monitored as an increased heart rate can often be seen as a result of hypotension. A systolic BP < 80 mmHg indicates hypotension which must be addressed.

➤ **Hypotension (systolic BP < 80 mmHg, MAP < 65 mmHg)**

- Normal arterial blood pressure is approximately 120/80 mmHg, with the normal mean arterial pressure between 70-90 mmHg.
- Systolic pressure < 80 mmHg indicates inadequate perfusion and must be addressed.
- The most common cause of hypotension is excessive anesthetic depth. Most anesthetic drugs produce cardiovascular depression, which tends to decrease blood pressure. In most cases this depression is in a dose dependent manner.
- Isoflurane can induce profound hypotension and is the most common cause we see for low blood pressure. If pressure readings are low, turning the anesthetic concentration down may result in rapid improvement.
- Other causes include hypovolemia due to intra-operative bleeding or pre-operative dehydration, hypothermia, hypoxia or decreased surgical stimulation.
- Evaluate other vital signs and anesthetic depth and reduce vaporizer setting.
- If hypotension persists, alert a supervisor immediately.

➤ **Respiratory arrest**

- Brief periods of apnea may be seen as a result of IV anesthetic administration or after prolonged bagging with 100% oxygen (due to decreased blood CO₂ levels)
- If the patient is not breathing spontaneously, **TURN OFF THE VAPORIZER**, alert a supervisor, and then quickly evaluate other vital signs and anesthetic depth.
- If heart rate/rhythm, mucous membrane color and SpO₂ are normal, the patient does not generally require immediate treatment. Occasional breaths of oxygen (1 every 30 seconds) should be administered to prevent hypoxia, however, premature bagging can extend the period of apnea by reducing CO₂ levels, which act as the stimulus for the patient to resume breathing. Closely monitor the heart rate, mucous membrane color and SpO₂ for 1 to 2 minutes before assuming that a serious problem exists.
- True respiratory arrest may result from anesthetic overdose, lack of oxygen flow or preexisting disease and requires immediate action. In this case, other vital signs are often abnormal and SpO₂ values rapidly fall below 90%.
- If respiratory arrest occurs, a supervisor will take over. However, you should be aware of the treatment procedure and prepared to assist as necessary.

➤ **Cardiac arrest**

- If you cannot hear a heartbeat or see respirations--**TURN OFF THE VAPORIZER** and call for help! It is better to have a false alarm than a dead patient.
- If the animal is breathing, she must have a heartbeat. (The reverse is not necessarily true though!) If your patient is breathing spontaneously and you cannot hear the heart, readjust your esophageal stethoscope, listen with your regular stethoscope and feel for a pulse. If you are not able to hear a heartbeat, call for help!
- In an arrest, a supervisor will take over. Your job is to monitor carefully and keep notes on what is being done/drugs being administered, etc. The staff member running the code will tell you what to do, if anything. Otherwise, stay out of the way, and ask questions later.
- You should have a basic understanding of the CPR techniques outlined and be able to follow instructions to assist in resuscitative efforts as needed

HANDLING CARDIAC ARREST

In the event of an arrest, a supervisor will take over. Your job is to monitor carefully and keep notes as to what is being done/drugs being administered, etc. You should have a basic understanding of the CPR techniques outlined here and be able to follow instructions to assist in resuscitative efforts as needed

Warning signs of impending cardiac arrest

- Hypotension, weak pulses, increasingly irregular pulses
- Hypothermia
- Cyanosis
- Decreasing respiratory rate and depth
- Sudden unexplained deepening under anesthesia

Diagnosis of cardiac arrest :

- Absence of a pulse or audible heart beat.
- Apnea or agonal gasping
- Loss of palpebral and corneal reflexes.
- Eyes are fixed, wide open.
- Pupils are dilated and unresponsive to light.
- ECG can be normal when heart is not contracting.
Fibrillation or asystole = no heart beat

Cardiopulmonary Resuscitation-Response Protocol

The goal of CPR is to deliver oxygen to the lungs by artificial ventilation, and then transport the oxygen to body tissues by external cardiac compression. Support is best administered by a team of 3 - 5 people performing the following tasks under the direction of the lead veterinarian:

1. Airway management/breathing
2. Cardiac compression
3. Venous access
4. Drug administration
5. Monitoring vitals and recording events

THE ABC'S OF BASIC CARDIAC LIFE SUPPORT

The essential steps in responding to a cardiac arrest can be summarized with the mnemonic ABCDE (Airway, Breathing, Circulation, Drugs, Evaluation)

Airway (A)

- Check for patent airway by bagging the patient and observing the chest rising.
- Intubate / reintubate if necessary.

Breathing (B)

- Check to see if patient is breathing.
- Administer 2 long breaths, check for spontaneous breathing/pulse
- If not breathing, ventilate with 100% oxygen at a rate of 12-20 breaths per minute (one breath every 3-5 seconds)
- Ventilate to pressure reading of 20 cm H₂O for dogs; 10 -15 cm H₂O for cats, or enough to visualize chest rising.

Circulation (C)

- Check for heartbeat or pulse.
- If no heartbeat, then begin external chest compressions at rate of 80-120 bpm (1-2 compressions per second).
 - Right lateral recumbency for small/medium dogs and cats
 - Dorsal recumbency for large dogs.
 - Hand-over-hand position standing above the patient, exert compression on the chest at the 4th - 5th intercostal space (where elbow meets chest)
 - Thumb and fingers of the same hand can be used for cats/small dogs
 - Displace chest 30% of its circumference
- Coordinating breathing/cardiac compressions
 - One person - two breaths to fifteen compressions
 - Two trained people - one breath to two compressions
- Aim of compressions is to manually force blood through the heart and, ultimately, to the tissues (cardiac pump theory). External chest compression squeezes the heart between the thoracic walls, forcing blood into the aorta. Blood flow depends on the rate and pattern of compression.
- It is also believed that compressions may assist circulation by increasing pressure in the chest, indirectly inducing blood flow (thoracic pump theory). A prolonged compression time (50 -60% of the cycle) favors flow produced by changes in intrathoracic pressure.
- For large dogs, interposed abdominal compression may aid circulation to cranial half of body.
- Each compression should result in a palpable femoral pulse. If a pulse is not detected, the method of compression should be adjusted.
- If external compressions are ineffective-consider open-chest cardiac massage.

Drug (D) administration:

- Intravenous fluids - given at 10 to 20 ml/kg to offset peripheral vasodilation. More rapid rates of fluid administration are not indicated unless severe hypovolemia exists.
- Commonly used emergency drugs:
 - Atropine - Used as treatment for bradycardia.
 - Dexamethasone - Corticosteroid used in the treatment for shock
 - Dopamine - Increases force of myocardial contractions, increases heart rate.
 - Doxapram - Respiratory and CNS stimulant.
 - Epinephrine - Increases rate and force of cardiac contractions. Increases systemic vascular resistance and diastolic blood pressure resulting in improved coronary and cerebral blood flow.
 - Lidocaine-Most commonly used to treat ventricular arrhythmias (PVCs or ventricular tachycardia). Used to raise threshold for fibrillation.
 - Naloxone-Narcotic antagonist.
 - Sodium bicarbonate - Treatment for metabolic acidosis.
- Routes of drug administration
 - First choice is a central venous catheter (jugular) which will provide a more rapid onset of effect compared with administration through peripheral catheters.
 - If peripheral catheter is used, external cardiac massage must effectively establish circulation if the drug is to reach the heart.
 - Administration of certain drugs (epinephrine, atropine, lidocaine) into the endotracheal tube lumen allows prompt absorption across the tracheal mucosa and serves as a useful alternate route for drug administration. This is usually done using 2-5 ml of saline as diluent for the drug (at 2 times the IV dosage) administered into the lumen of endotracheal tube, followed by 2-3 large breaths with artificial ventilation.
 - Intracardiac administration of epinephrine is rarely indicated and in fact discouraged. It may be used when the chest is already open. Other routes which permit rapid uptake of drugs include the intralingual and intraosseous routes.
- If ECG is available we can recognize and treat cardiac arrhythmias. Electrocardiographically, there are *three forms* of cardiac arrest :
 - *Asystole* is the absence of any electrical activity (flat line). Initial drug of choice is epinephrine which increases arterial wall tone and peripheral resistance allowing better intrathoracic arterial flow by reducing the tendency of vessels to collapse from the pressure induced by chest compressions. Epinephrine also increases diastolic pressure and renders the fibrillating heart more susceptible to defibrillation. It also diverts blood flow away from nonvital, towards vital tissues.
 - *Ventricular fibrillation* appears as completely chaotic, irregular, bizarre deflections. There are no recognizable P or QRS waves. The treatment is to defibrillate with DC current. Lidocaine and sodium bicarb may then be tried if fibrillations are still present.
 - *Electromechanical dissociation* is present when there is a normal wave form but no effective cardiac output. This form of cardiac arrest carries a fairly poor prognosis.

Evaluation (E)

- Every several minutes pause to assess the patient
 - Evaluate heartbeat and peripheral pulses, mucous membrane color and CRT
 - Auscult for bilateral lung sounds
 - Run ECG strip
 - Check pupils
 - Arterial blood pressure
- If spontaneous contractions are observed, cardiac compressions should be discontinued, although ventilation must be maintained until spontaneous breathing is established.
- If spontaneous contractions are not observed, external or internal compressions can be resumed, although after 15 minutes they are unlikely to be successful in establishing a heartbeat.
- Resuscitation efforts will be discontinued at the direction of the lead veterinarian.