Introduction & Key Points
Understanding the risk factors associated with anesthetic mortality can give us insights into how we can prevent anesthetic complications.

Factors that increase the risk of peri-anesthetic death in veterinary patients:
1. Lack of a technician monitoring the anesthetized patient
2. Poor patient health status
3. Small patient size (< 5 kg; i.e., most cats)
4. Use of the alpha-2 agonist xylazine
5. Mask induction
6. Major procedure
7. Urgent or emergent procedure

Factors that reduce the risk of peri-anesthetic death:
1. Presence of a technician anesthetist
2. Monitoring of pulse, pulse oximetry, capnography
3. Premedication with acepromazine, opioid, benzodiazepine combinations

Summary
Pets are at risk of developing hypotension, hypoventilation, hypothermia and hypoxemia in the peri-anesthetic time period because anesthetic medications are cardiorespiratory depressants. Regardless of drug choice, the importance of having a trained technician monitor the patient’s vital signs and response to anesthesia and surgery cannot be overemphasized. The presence of a dedicated, knowledgeable anesthetist aids in prompt recognition and treatment of complications that arise. If pets are not monitored during anesthesia, they may experience unrecognized complications that contribute to morbidity or mortality. Continue to monitor patients in recovery and provide supportive care to prevent hypoxemia and hypothermia because the majority of anesthetic deaths in cats and dogs occur during recovery from anesthesia. Monitoring of patients and supportive care (IV fluids, supplemental oxygen, temperature support) are typically withdrawn when patients recover from anesthesia and this likely contributes to morbidity and mortality following anesthesia.

Strategies for minimizing risk of anesthetic complications:
1. **Have a trained technician dedicated to monitoring each anesthetized patient.** This is one of the most important factors in reducing adverse anesthetic outcomes.
2. **Obtain a detailed history and perform a thorough physical examination on the day of anesthesia.** We need to create opportunities to ask clients questions about the health status of their pet(s) at the time of admission for anesthesia and surgery so that we don’t miss seemingly un-related signs of disease (e.g., diarrhea in a patient presenting for dental procedure).
3. **Administer pre-anesthetic medications to achieve analgesia, reduce anesthetic requirements and minimize stress – even and especially in fractious cats.** All patients – healthy and sick – benefit from pre-anesthetic medications. Acepromazine has been found to decrease peri-anesthetic mortality, while xylazine increases risk of death. Full-mu opioids, including morphine, hydromorphone, oxymorphone and fentanyl are appropriate and effective analgesics and pre-anesthetic medications in cats and dogs.
Strategies for minimizing risk of anesthetic complications continued:

4. **Avoid box or mask inductions.** Use of an inhalant for induction of anesthesia is 1) dangerous to personnel (exposure to inhalants associated with numerous adverse health effects including impaired reproductive function), 2) dangerous to the patient (exposure to high levels of potent cardio-respiratory depressant, inability to monitor and support the cardiovascular and respiratory systems during induction, increased mortality), and 3) inhalant inductions are expensive. If you feel you must use an inhalant to induce unconsciousness in some patients, be sure and pre-medicate!

5. **Avoid total injectable anesthetic techniques in feline patients.** Relying solely on injectable anesthetic medications to achieve a surgical plane of anesthesia (ex: combinations of dexmedetomidine + ketamine + an opioid) requires high doses that cannot be adjusted to meet the individual patient’s needs during the procedure. Typically, patients anesthetized with total injectable techniques are denied close monitoring and IV fluid therapy, airway protection, and other supportive measures. For this reason they are at increased risk of adverse events. Injectable anesthetics are useful adjuncts to inhalant anesthesia because they reduce the dose of isoflurane/sevoflurane required and may provide analgesia.

6. **Intubate and inflate cuff safely.** If a patient is at a surgical plane of anesthesia they have lost protective airway reflexes and are at risk of airway obstruction and aspiration. Use clear, cuffed endotracheal tubes (ETTs) with a valve on the pilot balloon and a Murphy eye. Routine use of laryngoscope decreases laryngeal trauma, decreases time required to secure the airway, allows examination of oral cavity and develops skills for emergency intubation. Measure the length of the ETT (from nose to thoracic inlet) for each patient to prevent the tip from entering the thorax. Cats are at increased risk of tracheal trauma resulting from over-inflation of the ETT cuff. To avoid over-inflation of the cuff, test the seal after intubation by delivering a breath to your patient and insuring that there is a slight leak at 20 cmH2O but no leak at lower inflation pressures. A Bain Circuit adapter with an in-circuit manometer is strongly recommended for feline patients because it allows monitoring of intra-thoracic pressure during manual ventilation and facilitates safe inflation of the ETT cuff (see Resources below). In the absence of a manometer, verify that the cuff is sealed with delivery of a normal-sized breath. Do not use back pressure on the cuff syringe, or pressure in the pilot balloon to determine adequate cuff pressure – these indicators are associated with excessive cuff pressure that may damage the patient’s airway. Disconnect the endotracheal tube from the anesthetic breathing circuit when moving patients or changing position to minimize the potential for tracheal tears.

7. **Always place an IV catheter.** Anesthetic medications are potent cardiovascular and respiratory depressants. Anesthetic complications are not limited to long procedures in sick patients. The presence of an IV catheter allows fluid administration and permits efficient and effective interventions if/when adverse events arise.

8. **Provide thermal support with an active warming device to prevent heat loss and minimize hypothermia.** There are many, many adverse effects of hypothermia: prolonged recovery, impaired cardiovascular function, increased infection rates, increased bleeding, risk of cardiac arrest, etc. In addition, cold feline patients are at risk of developing rebound hyperthermia during recovery.

9. **Monitor anesthetic depth, cardiovascular function and respiratory function.** Assessment of anesthetic depth includes monitoring of cardiovascular function (HR, blood pressure), respiratory function (RR, end-tidal CO2, pulse oximetry), jaw tone, palpebral reflex, eye position and response to surgical stimulation. Recommended vaporizer settings are simply guidelines; assess your patient frequently to deliver the appropriate dose to meet each patient’s needs.

10. **Create consistent anesthesia protocols for your practice.** Agree on standard protocols for healthy pets and write them down. Add details related to modifying the standard protocol for specific patients due to illness or pre-existing conditions (examples: geriatric, pediatric, brachycephalic, fractious, pregnant, diabetic).

11. **Install a safety pop-off valve on your anesthesia machine(s).** Recent advances in anesthetic equipment are particularly valuable for improving safe delivery of inhaled anesthesia to veterinary patients. Safety pop-off valves prevent over-presurization of patients’ lungs from an inadvertently closed pop-off valve. These valves make manual ventilation a breeze and give you and your staff peace of mind that the pop-off won’t be left closed.
Strategies for minimizing risk of anesthetic complications continued:

12. **Install a manometer in the non-rebreathing circuit of your anesthesia machine.** This is the second important safety upgrade for your anesthesia machine(s). Non-rebreathing circuit adapters with manometers (aka, Bain Circuit Adapter or Universal Control Arm) can be mounted on any anesthesia machine to allow monitoring of the pressure in your small patients’ breathing system. This facilitates safe inflation of the ETT cuff and aids in delivery of appropriate breaths during manual or mechanical ventilation of patients anesthetized with non-rebreathing circuits. These circuit adapters with manometers also support the anesthesia circuit and reduce the risk of the ET tube being pulled out by the weight of the circuit.

References


Suggested Reading


Equipment Resources for Anesthesia Safety

- **Non-rebreathing circuit adapter with manometer: Bain circuit adapter, also known as Universal Control Arm. Order the adapter that comes with a Safety Pop-Off Valve. Source: Supera Anesthesia (formerly LEI Medical).** http://www.superavet.com/accessories.html ph: 1-503-723-5068 or 877-620-1500 (toll-free in USA)
- Endotracheal tubes: Clear, cuffed PVC ET tubes with Murphy eyes for sizes 2.5 thru 10. Example: AirCare Tubes by Smiths-Medical. Available through veterinary distributors. Cuffed silicone tubes with Murphy eyes for sizes 11, 12, and 14. Source: Surgivet or Jorvet.

**Strongly recommended for practices that anesthetize small patients (< 5 kg (10 lb)).