Anesthesia Equipment – Safety Considerations

Overview
Anesthetic equipment is considered “life-critical” because the health and well-being of patients and staff can be adversely affected if the equipment is not functioning optimally or is used incorrectly. The following safety concerns will be addressed in this lecture: 1) minimizing exposure to anesthetic waste gases, 2) ensuring appropriate delivery of oxygen and inhaled anesthetic, 3) elimination of carbon dioxide from the patient circuit, and 4) preventing physical harm to patients.

1. Scavenging waste anesthetic gases
   a. Active scavenging with pump or fan system is effective and reliable.
   b. Passive scavenging with F-Air-type canisters or “hole-in-wall” is not reliable, and requires active monitoring of efficacy.
   c. Inhalant induction using a mask or box is not recommended because it exposes personnel to excess waste anesthetic gases and is dangerous for pets.
   d. Exposure of staff to low levels of inhalants can cause headaches, irritability, impaired mental function and decreased reproductive function.

2. Vaporizer
   a. Complex, precision instrument used to dilute and deliver precise amount of inhalant
   b. Verify vaporizer output and calibration every 6 – 12 months
   c. Full service (clean inside, replace parts, leak test and re-calibrate) every 1 – 3 years

3. Anesthesia machine
   a. Safety features: manometer in rebreathing and non-rebreathing circuits, spring-loaded or momentary closure (safety) pop-off valves, top-mounted one-way valves for visibility, manufactured of non-corrosive material
   b. Low-pressure leak test machine with breathing circuit prior to every anesthetic
   c. Full service (clean inside, replace parts, low & high pressure leak test) every 6 – 12 months

4. Carbon dioxide elimination
   a. Anesthesia machines and breathing circuits are designed to prevent patients from rebreathing CO₂ if used appropriately. The following features keep patients from rebreathing CO₂:
      1) carbon dioxide absorbent granules (ex: Soda Sorb). 2) one-way valves, and 3) adequate oxygen flow rates for Non-Rebreathing circuits
   b. Replace carbon dioxide absorbent granules after 6 – 8 hours of use. Granules will become dry and absorb CO₂ from the air and, thus, need to be replaced every 2 weeks even if machine not used regularly.
   c. Monitor end-tidal and inspired CO₂ concentrations (ETCO₂ & InspCO₂) with a capnograph. If inspired CO₂ greater than 10 mmHg, then rebreathing of CO₂ is occurring → Check one-way valves; replace anesthesia machine if suspect depleted CO₂ absorbent granules because not safe to replace granules during anesthesia due to exposure to anesthetic gases; increase Oxygen flow rates in Non-Rebreathing circuits.
5. Breathing circuits
   a. Rebreathing circuits allow rebreathing of oxygen and inhalant. Depends upon functional one-way valves and CO₂ absorbent to prevent patient from rebreathing CO₂. Use for patients greater than 3 kg (7 lbs). Maintenance oxygen rates ≥30 ml/kg/min, but never less than 500 ml/min. Higher oxygen flow rates will not harm patients and can accelerate the rate of change in inhalant concentration in the anesthetic circuit. If you have active scavenging, you may need to use higher flow rates.
   b. Non-rebreathing (NRB) circuits depend upon high oxygen flow rates to prevent rebreathing of CO₂. Use for patients less than 3 kg (7 lbs). Oxygen flow rates should be ≥200 ml/kg/min, but never less than 500 ml/min. Higher flow rates will not harm patients. If you have active scavenging, you may need to use higher flow rates.
   c. Never use the oxygen flush valve with a Non-rebreathing Circuit because the high flow and high pressure are applied directly to the patient’s airways and will irreparably damage the lungs.
   d. Minimize excess mechanical dead space – space where inspired and expired gases mix, but no gas exchange occurs. Dead space is found at the patient-end of breathing circuits, in elbow adapters and lengthy ETTs and causes rebreathing of CO₂ and decreases effective tidal volume available for gas exchange.

6. Reservoir bags
   a. Serve as reservoir of oxygen and inhalant, facilitate assisted ventilation, allow visual/tactile monitoring of RR, protect patients against excessive pressure in breathing circuit
   b. Appropriate size = at least 50 - 75 ml/kg

7. Endotracheal tubes
   a. Clear, cuffed endotracheal tubes (ETTs) with valve on pilot balloon and Murphy eye
   b. Red rubber ETTs are not recommended because 1) it is not possible to verify that the lumen is clear of debris, 2) no valve on pilot balloon means very difficult to partially inflate cuff & cannot be fully submerged for cleaning, 3) rubber absorbs disinfectant which is caustic to airway
   c. Routine use of laryngoscope decreases laryngeal trauma, decreases time required to secure airway, allows examination of oral cavity and develops skill for emergency intubation
   d. Measure the length of the ETT (from nose to thoracic inlet) for each patient to prevent the tip from entering the thorax. Do not insert the end of the ETT past the thoracic inlet.
   e. Avoid over-inflation of the endotracheal tube cuff. Test the seal of the endotracheal tube cuff 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. 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.
   f. Disconnect the endotracheal tube from the anesthetic breathing circuit when moving patients or changing position to minimize the potential for tracheal tears.

8. Resources
   c. Non-rebreathing circuit adapter with manometer: Bain circuit adapter, also known as Universal Control Arm. Source: LEI Medical. Ph: 503-723-5068 or 877-620-1500 (toll-free in USA)
   d. Endotracheal tubes: Clear, PVC tubes with Murphy eyes for sizes 2.5 thru 10. Example: AirCare Tubes by Smiths-Medical. Silicone tubes with Murphy eyes for sizes 11, 12, and 14. Source: Surgivet or Jorvet.