The American College of Veterinary Anesthesiologists

Commentary and recommendations on control of waste anesthetic gases in the workplace

Health Hazards

1. Conflicting evidence exists in the scientific literature about the effects of trace levels of anesthetic gases on the health and performance of operating room personnel. Genetic mutations, cancer, complications during pregnancy (eg, spontaneous abortions), hepatic and renal disease, immunological effects, and psychomotor changes have been linked to exposure to trace gases. In most instances, definitive proof is lacking.

2. Even though potential for serious effects on human health and performance in the operating room is probably small, exposure to waste anesthetic gases should not be ignored.

3. Potential hazards exist for all personnel exposed to trace gases-not just women of childbearing age. Thus, measures to control waste gases should be directed to protect all personnel, not a select group.

4. Any veterinary facility using inhalant anesthetics (ie, halogenated hydrocarbons and/or nitrous oxide) should institute and maintain a control program for waste anesthetic gases, based on the possibility that trace gases may adversely affect human health.

General Techniques and Procedures for Decreasing Pollution

1. Anesthesia machines, ventilators, breathing systems, and waste-gas scavenging systems may contribute to environmental pollution with waste anesthetic gases. **Appropriate checkout methods and routine maintenance for such equipment should be standard operating procedures for veterinary facilities that use inhalant anesthetics.**

2. Elimination of the following habits or techniques will decrease anesthetic gas pollution when inhalant anesthetics are used:

•Administering inhalant anesthetics by open drop (eg, periodically dripping liquid volatile anesthetic onto a gauze sponge) or insufflation (eg, delivery of a relatively high flow of anesthetic in oxygen into the trachea or pharynx through a catheter) techniques. If used, such techniques should be conducted in a fume hood.

•Turning on flowmeters and vaporizers before attaching the breathing system to the patient.

•Allowing flowmeters and vaporizers to remain on after the patient is disconnected from the breathing system.

•Using uncuffed endotracheal tubes that do not create a completely sealed airway or using cuffed tubes without inflating the cuff.

•Disconnecting a patient from a breathing system without eliminating as much of the residual gases as reasonably possible through the scavenging system. Systems should be flushed with oxygen (eg, empty the breathing bag through the pop-off valve periodically after the vaporizer has been turned off and employ an increased flow rate of oxygen [2-3 times maintenance flow] during recovery for circle breathing systems). The patient should remain attached - to the breathing system until extubation occurs.

•Spilling liquid anesthetic during the filling of vaporizers, especially during an anesthetic procedure. Ideally, properly functioning, agent-specific, keyed filler systems should be used, and at a minimum, a bottle adapter with a spout to prevent excessive spillage should be used. Routinely filling vaporizers at the end of the workday as personnel are leaving the hospital for the night should reduce exposure to waste gases.

3. The use of masks and closed containers for delivery of inhalant anesthetics should be minimized. If employed, these techniques should be used in well ventilated rooms with nonrecirculating ventilation systems or under a fume hood.

4. **Scavenging systems should be used with all inhalant anesthesia delivery systems to which they are adaptable. Unscavenged delivery systems should not be used except as described previously.**

5. The lowest fresh-gas flow rates, consistent with the proper function of flowmeters, vaporizers, and breathing systems and with patient safety, should be used (as opposed to very high fresh-gas flows). Although scavenging systems should function effectively for both high and low fresh-gas flows, low flows produce less waste gases. From the global perspective, low fresh-gas flow rates are consistent with protection of the earth's environment.

6. Routine filling of vaporizers should be performed with few people in the room and in a well-ventilated area. Filling vaporizers under a ceiling-mounted hood with an active evacuation system is ideal. Agent specific, keyed filler ports for vaporizers and corresponding keyed bottle adapters are available. Keyed bottle adapters with spouts should be employed to prevent excess spillage of anesthetic during the filling of vaporizers with screw-cap filler ports.

Scavenging Systems

1. The use of scavenging devices with anesthesia delivery systems is the most effective way to decrease waste anesthetic gases; an efficient scavenging system is capable of reducing ambient concentrations of waste gases by up to 90%. Anesthesia machines and breathing systems delivering halogenated hydrocarbon anesthetics and/or nitrous oxide should not be operated unless they are equipped with a functional scavenging system.

2. To be effective, a scavenging system must not leak and must control the concentration of trace anesthetics in ambient air. Waste gases should not be discharged into the outside air in an area where reentry into the building is likely.

3. Although some variations exist, a scavenging system consists of a gas collecting device (eg, a scavenging pop-off or overflow valve), transfer tubing, an interface, additional transfer tubing, and a gas disposal system. Both passive and active scavenging systems are effective if set up and used properly.

4. Passive systems that simply vent gases to floor level and rely on inhalant anesthetic gases being heavier than air are unacceptable.

5. Nonrecirculating room-ventilation systems, which provide 12 to 15 air changes/h, can be used for waste-gas disposal by routing transfer tubing to an exhaust grille. In addition, a nonrecirculating room-ventilation system is an excellent adjunct to a scavenging system to reduce the concentration of waste gases that are inadvertently discharged into the room (eg, breathing system disconnect).

6. Recovery rooms can be polluted with significant amounts of waste gases (eg, gases exhaled by the patient after disconnection from the breathing system). Anesthesia machines with functional scavenging systems should be used as long as feasible in patients recovering from inhalant anesthesia. The breathing system should be flushed with oxygen and the reservoir bag expressed into the scavenging system before the endotracheal tube cuff is

deflated or the breathing system is disconnected. Ideally, recovery rooms should have nonrecirculating ventilation systems with a high rate of air exchange.

7. Facilities that utilize open-delivery systems that preclude the use of standard scavenging devices to control waste gases should allow use of such techniques only under a fume hood or similar system that allows rapid elimination of waste gases from the workplace.

8. Masks with activated charcoal filters can be used by operating room personnel who are at special risk (eg, pregnancy) with regard to exposure to inhalant anesthetics (except nitrous Oxide).

9. Canisters containing activated charcoal can be used as waste-gas disposal systems in lieu of other types of scavenging systems, especially when portability is an issue. However, some variation in effectiveness occurs with different brands of canisters and with changes in the rate of gas flow through the canister. Activated charcoal is not effective for adsorption of nitrous oxide. Adsorption methods of scavenging are recommended only if other more reliable techniques are not available.

Evaluation of Anesthetic Equipment

1. One of the most important sources of waste anesthetic gases is inhalant anesthetic equipment. Anesthesia machines and ventilators, breathing systems, and scavenging systems should be checked and maintained to assure that they do not leak anesthetics into the atmosphere of the workplace.

2. The routine maintenance procedures for anesthetic equipment are usually explained in the operations manuals. Many anesthesia textbooks include guidelines for checkout of machines, breathing systems, ventilators, and scavenging systems. The specifics of these evaluations are too extensive for this report. However, each piece of equipment involved in the delivery of inhalant anesthetics should be evaluated regularly to assure its function and integrity.

3. Each veterinarian should become familiar with checkout and maintenance procedures for the anesthesia equipment that he or she uses. It is his or her responsibility to learn such procedures, either by reading the appropriate operations manuals and textbooks or by consulting an expert.

4. The Occupational Safety and Health Administration (OSHA) can require that checkout and maintenance procedures for anesthetic equipment be

logged into a permanent record. Ideally a log of evaluation and maintenance procedures and leakage testing should be maintained for each anesthesia machine, ventilator, and vaporizer.

5. Checkout procedures are important prior to the use of anesthesia equipment, and personnel operating anesthesia equipment should be trained to complete checkout procedures and to recognize indications of equipment malfunction.

6. Procedures for checkout of anesthesia equipment, depending on the equipment to be used, should include the following:

• Status of the high-pressure system, including the oxygen supply (cylinder and central pipeline) and nitrous oxide supply - The nitrous oxide supply should not leak when the cylinder valve is on and the nitrous oxide flowmeter is off.

• Status of the low-pressure system (flowmeter function and evaluation for leaks in the low-pressure system) - A negative-pressure leak test should be performed at the common gas outlet or the outlet of the vaporizer immediately upstream from the breathing system.

• Status of the breathing system (including the condition of chemical absorbent for carbon dioxide, leak tests, and function of the pop-off or overflow valve and one-way valves) - The status of the breathing system should be checked before using the system on each patient. An appropriate leak test for a circle system is to close the pop-off valve, occlude the Y-piece, pressurize the system to 30 cm of h3O with all flowmeters off, and ensure that the pressure does not decrease for at least 10 seconds. Noncircle systems can usually be checked for leaks by applying positive pressure to the system with all ports occluded, with similar guidelines as for circle systems. The quantity of leakage can be measured by determining the flow rate of oxygen necessary to maintain a constant pressure in the system, and the leak rate should be less than 300 ml/min at 30 cm of h3O.

• Status of the scavenging system - The scavenging system should be properly attached at all connectors, and the appropriate vacuum should be assured for active systems. If charcoal canisters are employed for scavenging, they should be changed at appropriate intervals, according to the directions of the manufacturer.

• Status of mechanical ventilators - Ventilators should be connected properly to the anesthesia machine, and an absence of leaks should be assured. Ventilators with an inverted bellows should fill completely (rise to the top of the housing) during expiration, and ventilators with hanging bellows should not fall if the patient port is occluded at the end of inspiration.

Monitoring of the Effectiveness of Antipollution Techniques

1. Monitoring trace-gas concentrations in the workplace provides a quantitative assessment of the effectiveness of a waste-gas control program. Measuring the concentration of anesthetic in the breathing zone of the most heavily exposed workers is the usual procedure. Currently, no regulations require a veterinary hospital to measure waste-gas concentrations regularly However, under the "general duty clause," an employer is required to provide a reasonably safe working environment for all employees.

2. In the United States, OSHA requires individual veterinary hospitals and practices to maintain a system to prevent waste gases from building up in the area of use and can enforce exposure limits that are consistent with recommendations offered by the National Institute of Occupational Safety and Health (NIOSH). The NIOSH recommends that the maximum time-weighted average concentration of volatile halogenated anesthetics should not exceed 2 ppm when used alone or 0.5 ppm when used with nitrous oxide and that nitrous oxide concentration should not exceed 25 ppm.

3. An accredited industrial hygiene laboratory is a source for assistance in establishing an air-monitoring program. Such laboratories are capable of sampling the air in the workplace and assaying such samples for inhalant anesthetics. Industrial hygienists can be found in the yellow pages of the telephone directory under "occupational safety."

4. An air-monitoring program is most appropriately started after anesthesia delivery systems have been equipped with scavenging systems and after other techniques for minimizing waste gas pollution are in place. An ideal approach would include frequent air monitoring, preferably at least semiannual evaluations.

5. Commercial companies offer personal monitoring systems (badges to be worn by individual workers) for the detection of nitrous oxide and halogenated inhalant anesthetics. Purchase of the monitoring badges may include prepaid laboratory analyses. Companies supplying these badges claim to accurately detect concentrations in the range of those recommended by NIOSH. Such monitoring has been recommended for veterinary practices.

6. Use of a portable infrared analyzer for detection of anesthetic gases has been proposed as a way for veterinary practices to monitor the environment

of the workplace. Such a method might be economical if the monitor were shared by multiple practices.

7. **After establishing procedures for control of anesthetic gases, the logical next step for veterinary clinics, hospitals, laboratories, and other institutions is the development of a consistent monitoring program for waste gases that is suitable, both qualitatively and economically, for the particular type of practice.**

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