Anesthesia Case of the Month

History
An 8-year-old 17.7-kg (39-lb) Cocker Spaniel was admitted to the surgery service at Michigan State University Veterinary Teaching Hospital for evaluation and surgical correction of severe otitis externa and media. Additional problems included keratoconjunctivitis sicca, underlying allergies, and possible hypothyroidism.

The dog was scheduled for routine bilateral total ear canal ablation and bulla osteotomy. The dog was medicated with hydromorphone hydrochloride (3.54 mg; 0.2 mg/kg [0.09 mg/lb], IM) and acepromazine maleate (0.7 mg; 0.04 mg/kg [0.018 mg/lb], IM). Anesthesia was induced with ketamine hydrochloride (50 mg; 2.8 mg/kg [1.27 mg/lb]) and diazepam (2.5 mg; 0.14 mg/kg [0.06 mg/lb]) administered IV. Following endotracheal intubation, the dog was connected to a circle system and anesthesia was maintained with sevoflurane (vaporizer settings, 3.5 to 5%) in oxygen (flow rate, 80 to 600 ml/min). The dog was positioned in lateral recumbency, and the first surgery site was prepared. An ECG, pulse oximeter (a finger probe on the tongue), and noninvasive blood pressure monitor were used to monitor the dog. Over the anesthetic period of 4.75 hours, the heart rate varied between 100 and 150 beats/min, and respiratory rate varied from 5 to 30 breaths/min. Blood pressure and hemoglobin saturation were stable and within reference ranges. Cefazolin (400 mg) was administered IV after induction of anesthesia and again 2 hours later.

Two hours after induction of anesthesia, bupivacaine hydrochloride (22.5 mg; 1.3 mg/kg [0.59 mg/lb]) was placed in the first incision, which was then closed routinely. The dog was turned over, the second surgical site prepared, and the second surgery begun. After 2.5 hours of total anesthesia time (15 minutes after the start of the second surgery), an arrhythmia developed (Fig 1).

Question
What is the arrhythmia, and likely cause and what would you do to treat it?

Answer
The arrhythmia is paroxysmal supraventricular tachycardia. Sympathetic stimulation would be the most likely causative factor. Clinical examination revealed that the dog was at a surgical plane of anesthesia. Systolic and diastolic arterial blood pressures were 112 and 52 mm Hg, respectively (mean pressure, 72 mm Hg). Hemoglobin saturation was 98%. Analysis of an arterial blood sample collected from the dorsal pedal artery revealed the following: pH, 7.041 (reference range, 7.35 to 7.45); PaCO₂, 125.7 mm Hg (reference range, 35 to 45 mm Hg); PaO₂, 228.9 mm Hg (reference range, 60 to 500 mm Hg); HCO₃ concentration, 34.3 mmol/L (reference range, 23 to 25 mmol/L); base excess, 3.4 mmol/L (reference range, 0 ± 3 mmol/L); Na⁺ concentration, 142 mmol/L (reference range, 146 to 156 mmol/L); K⁺ concentration, 7.62 mmol/L (reference range, 3.9 to 5.5 mmol/L); and glucose concentration, 248 mg/dl (reference range, 53 to 117 mg/dl).

The dog had been breathing spontaneously for the entire surgical period with rates ranging from 30 breaths/min at the start of the first surgery to 11 breaths/min during the second surgery. The soda lime was a uniform white with no evidence of used (purple) agent. A capnograph was attached to the breathing circle and revealed an inspired CO₂ tension of 9 mm Hg, and the end tidal reading was off the scale. Reference range values for inspired and end tidal CO₂ are 0 mm Hg and 35 to 50 mm Hg, respectively. Another anesthesia machine was obtained and used for the remainder of the surgery and into the recovery period. With the use of the new machine the inspired CO₂ became zero. Controlled manual ventilation commenced with a rate of 10 to 12 breaths/min and chest inflation to a pressure of 20 cm H₂O. The end tidal CO₂ tension

Figure 1—Lead-II ECG from an 8-year-old Cocker Spaniel that developed an arrhythmia during inhalant anesthesia. Paper speed = 25 mm/s; 1 cm = 0.8 mV.
Hyercapnia appears to cause direct depression of the cardiac muscle and vascular smooth muscle and reflex stimulation of the sympathoadrenal system. Plasma catecholamine concentrations increase in response to increases in PaCO₂. Arrhythmias will often develop in the presence of a high PaCO₂; the exact pressure is variable between individuals but constant for a particular patient.

Unless the agent is properly packed in the canister, channeling of gas through granules of the soda lime can occur. Areas of loosely packed soda lime have lower resistance and will tend to be the preferential routes of gas flow and become exhausted first. The use of small granules will decrease channeling but causes more resistance to gas flow through the absorber. Channeling may substantially decrease the absorptive capacity of soda lime, reducing the capacity from 26 L to as little as 10 L of CO₂/100 g of absorbent. With properly functioning indicators the rate of depletion of the soda lime will be more rapid than usual. Where the channel is central in the canister as reported here, there will be no visual cue to alert the operator to this condition.

This dog demonstrated a severe and potentially life-threatening hyperkalemia concurrent with a high PaCO₂. Hyercapnia is usually accompanied by a leakage of K⁺ from the cells into the plasma. Much of the K⁺ comes from the liver, probably from glucose release and mobilization, which occur in response to the increase in plasma catecholamine concentrations. In the dog of this report, plasma K⁺ concentrations had decreased substantially within 1 hour of the return of PaCO₂ to within reference range values. It is important to note that the plasma K⁺ concentration takes an appreciable time to return to reference range values, and repeated bouts of hypercapnia at short intervals can result in a potentially dangerous stepwise increase in plasma K⁺ concentration.

A similar situation with undetected exhausted soda lime causing rebreathing of CO₂ has been recently reported in an anesthetized person. In that report there was also no visual cue to development of the problem. We have encountered soda lime canisters becoming exhausted early due to central channeling of gas in 5 other instances within 6 months of the original episode. The accepted practice of dating the canister and tracking hours of use will not detect early exhaustion of soda lime in this situation. It is recommended that any canister filled with soda lime be tapped gently before use to settle the contents and help remove any accumulated dust. Once we were sensitized to this problem of central channeling, the soda lime became the first item that we checked if the capnograph indicated rebreathing of CO₂. We have decreased rapidly toward reference range values. The arrhythmia disappeared. The dog went on to have a slow but uneventful recovery.

A second sample of arterial blood for blood gas analysis was drawn in the recovery period, prior to extubation and 1 hour after the first sample. The dog was breathing room air. The results were as follows: pH, 7.333; PaCO₂, 31.1 mm Hg; PaO₂, 93.4 mm Hg; HCO₃⁻ concentration, 27.3 mmol/L; base excess, 1.2 mmol/L; Na⁺ concentration, 144 mmol/L; K⁺ concentration, 5.3 mmol/L; and glucose concentration, 138 mg/dl.

Examination of the prepacked soda lime canister taken from the original anesthesia machine revealed a central purple core surrounded by a large ring of yellow-white unused soda lime (Fig 2).
been reminded of the benefits of capnography, because these monitors are essential for detection of exhaustion of soda lime and rebreathing of CO₂. If they are not available, some causes of hypercarbia will go undetected.

References

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