Anesthesia Case of the Month

The dog was premedicated with butorphanol tartrate (0.4 mg/kg [0.18 mg/lb], IM), and anesthesia was induced with propofol (5 mg/kg [2.3 mg/lb], IV, to effect). An orotracheal tube was placed, and anesthesia was maintained with isoflurane in oxygen, delivered through a pediatric circle system. The dog was mechanically ventilated with a tidal volume of 120 mL (15 mL/kg [7 mL/lb]) to a peak airway pressure of 12 cm of water (8.8 mm Hg) at a rate of 12 breaths/min.

Following induction of anesthesia, the dog was transported to the operating room and positioned in dorsal recumbency with ventroflexion of the neck to allow access to the eyes. Intraoperative monitoring included measurement of oxygen saturation (SpO₂) with a pulse oximeter,² continuous monitoring of an ECG,³ indirect oscillometric measurement of blood pressure,⁴ measurement of end-tidal partial pressure of CO₂ (PetCO₂),⁵ monitoring of heart and respiratory rates, periodic measurement of blood glucose concentration, and monitoring of nerve stimulus responses.⁶ The pulse oximeter probe was clipped to the distal second phalanx of the right hind limb. The blood pressure cuff was placed on the left tarsus. Because of the positioning of the patient and the nature of the procedure, use of traditional physical monitoring, including periodic determination of oral mucous membrane color, capillary refill time, ocular reflexes, and jaw tone, was limited.

The heart rate decreased to 30 to 55 beats/min shortly after induction of anesthesia, and atropine (0.018 mg/kg [0.008 mg/lb], IV) was administered. Heart rate increased to 100 to 120 beats/min for 15 minutes but then decreased to 90 to 100 beats/min for the next 90 minutes. Twenty minutes after induction of anesthesia, the blood glucose concentration, determined with a handheld glucometer,⁶ was 59 mg/dL. Therefore, IV administration of 2% dextrose in lactated Ringer's solution was continued. Blood glucose concentration was checked hourly thereafter and was consistently between 50 and 75 mg/dL. For maximal relaxation of the ocular muscles, a dose of cisatracurium (0.4 mg/kg [0.18 mg/lb], IV) was administered. Additional doses were administered approximately hourly, as determined by results of train-of-four nerve stimulus response monitoring.

Approximately 90 minutes after the start of surgery, phacoemulsification of the left cataract was completed and the dog was repositioned to allow access to the right eye. Approximately 2 to 3 minutes after this position change, the pulse oximeter and blood pressure monitor ceased functioning. Although dorsal pedal pulses were palpable bilaterally, the pulse oximeter was not detecting a consistent pulsatile signal and was displaying erratic SpO₂ values ranging from 85% to 93% (reference range, 95% to 100%). The blood pressure monitor repeatedly displayed a time-out error. The ECG continued to display normal sinus rhythm, with a heart rate of 80 to 90 beats/min, and PetCO₂ was within expected limits with a normal waveform. Quality of the dorsal pedal pulse was

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History

A 10-year-old 7.9-kg (17.4-lb) spayed female Miniature Schnauzer was referred to the University of Minnesota Veterinary Medical Center for phacoemulsification of bilateral cataracts. The dog had a history of diabetes mellitus that reportedly was diagnosed with insulin (dosage and type unspecified). The dog also had a history of seizures for which the owners declined diagnostic testing and treatment.

For 3 weeks prior to surgery, the dog was treated topically with 0.33% flurbiprofen ophthalmic solution (1 drop in each eye 4 times daily) and 0.2% cyclopentolate ophthalmic solution (0.25-inch strip in each eye twice daily). Additionally, as part of routine preoperative preparation, the dog was treated topically with the following medications during the 90 minutes immediately preceding surgery: 10% phenylephrine solution (1 drop in each eye every 20 minutes for 4 doses), 1% prednisolone solution (1 drop in each eye every 20 minutes for 4 doses), 0.03% flurbiprofen solution (1 drop in each eye every 20 minutes for 4 doses), and 1% tropicamide solution (1 drop in each eye every 20 minutes for 4 doses).

Biochemical testing was performed 18 hours before surgery. Abnormalities included high blood glucose (254 mg/dL; reference range, 75 to 117 mg/dL), total plasma protein (8.7 g/dL; reference range, 5.8 to 7.2 g/dL), and serum globulin (3.6 g/dL; reference range, 1.7 to 3.5 g/dL) concentrations; high serum alkaline phosphatase activity (311 U/L; reference range, 8 to 139 U/L); and low serum chloride (105 mmol/L; reference range, 109 to 118 mmol/L), sodium (141 mmol/L; reference range, 145 to 153 mmol/L), and phosphorus (3.2 mmol/L; reference range, 3.3 to 6.8 mmol/L) concentrations. Results of a preoperative CBC were within reference limits.

During a physical examination the morning of surgery, the dog appeared bright and alert. No abnormalities except for the bilateral cataracts were identified, although the femoral pulse was somewhat difficult to palpate, most likely because of the dog’s physical stature. Food had been withheld for approximately 12 hours before surgery, and the owners had given the dog half its usual morning dose of insulin. A blood sample was obtained at the time of preoperative IV catheter placement, and blood glucose concentration, measured with a handheld glucometer,⁶ was 32 mg/dL. The dog was given an IV bolus of dextrose (127 mg/kg [57 mg/lb]) diluted in lactated Ringer’s solution, and administration of 2% dextrose in lactated Ringer’s solution (10 mL/kg/h [4.5 mL/lb/h], IV) was begun.

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had been administered topically to the right eye when ophthalmologists revealed that 10% phenylephrine solution was being used in the anesthetic monitor in this anesthetized dog? What was the cause of the sudden, apparent malfunction in the pulse oximeter and blood pressure monitor in this anesthetized dog?

**Answer**

During a conversation after surgery, the ophthalmologists revealed that 10% phenylephrine solution had been administered topically to the right eye when the patient was repositioned, but it had not been administered immediately prior to surgery on the left eye. The profound systemic vasoconstriction caused by the phenylephrine likely led to a marked increase in blood pressure and the lack of pulse oximeter function.

**Discussion**

Phenylephrine is a sympathomimetic drug that acts as a post synaptic α1-adrenoceptor agonist. Phenylephrine is used topically during ophthalmic surgery to cause mydriasis and conjunctival vasoconstriction. These effects may be especially desirable during cataract surgery, as they allow ready access to the lens. Preoperative topical administration of a combination of atropine and phenylephrine is frequently used to achieve maximal pupil dilation. 1, 3, 4

Adverse effects following topical administration of ophthalmic drugs have been reported. 1, 4 In particular, through its action as an α1-adrenoceptor agonist, phenylephrine causes hypertension by constricting peripheral efferent arterioles. This raises blood pressure while decreasing perfusion in peripheral tissues, such as skin. The associated bradycardia is vagally mediated and reflexive. One previous report described 3 dogs that developed systemic effects following repeated topical administration of phenylephrine, including 1 dog that received 10% phenylephrine solution and 2 that received 2.5% phenylephrine solution. Hyper tension has also been reported in human patients receiving phenylephrine topically. 5 Each drop of the commercially available 10% phenylephrine solution manufactured for topical ocular use contains approximately 5 mg of phenylephrine. 6 Assuming complete absorption, administration of a single drop of 10% phenylephrine solution would be equivalent to a dose of 633 mcg/kg (288 mcg/lb) in a 7.9-kg dog. In contrast, when phenylephrine is given as a constant rate infusion, the typical dosage is in the range of 1 to 3 mcg/kg/min (0.45 to 1.4 mcg/lb/min). 6 Although phenylephrine is not completely absorbed following topical ocular administration, there is a potential to exceed the recommended dose. The need for appropriate pH balance of medications administered topically to the eye precludes the use of commonly available 1% phenylephrine solutions made for IV administration.

The anesthetic monitoring difficulties in the dog described in the present report were likely due to the systemic effects of topically administered phenylephrine. Pulse oximeters require substantial pulsatile blood flow through a capillary bed to accurately assess oxygen saturation. 7, 8 Pulse oximeters operate by emitting a single-wavelength light signal. The light travels through the tissues and is absorbed by a sensor capable of detecting light at 2 wavelengths: 660 nm (red) and 940 nm (infrared). 7, 8 Oxygenated hemoglobin absorbs more light in the infrared band, whereas reduced (deoxygenated) hemoglobin absorbs more light in the red band. Thus, the oximeter is able to calculate the proportion of hemoglobin that is oxygenated by calculating the ratio of the light signals at these 2 wavelengths. An elaborate filtering mechanism that depends on detection of pulsatile blood flow is incorporated in the pulse oximeter to differentiate between absorption of light by arterial blood and absorption of light by surrounding tissues, such as venous blood, skin,

**Question**

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and supportive tissues. In the presence of peripheral arterial vasoconstriction, however, the sensor is unable to detect this pulsatile blood flow and, therefore, is unable to accurately measure arterial oxygenation.1,2

The dog described in the present report was positioned in dorsal recumbency with cervical ventrolflexion to allow access to the eyes. However, this positioning can increase the risk that the orotracheal tube will be inadvertently dislodged, which would decrease both the inspired oxygen fraction, leading to hypoxemia, and the inspired concentration of isoflurane, leading to increased patient awareness. Alternatively, this positioning could increase the risk of endobronchial intubation,3 which would result in ventilation-perfusion mismatching and decreased oxygenation. In this patient, the \text{PetCO}_{2} waveform appeared normal and the mucous membranes of the vulva appeared pink. However, assessing mucous membrane color was difficult because of dimmed light in the operating room, and patients with pink mucous membranes may still have clinically important hypoxemia (ie, \(S_pO_2 \leq 90\%\)). Cyanosis is visible only when the concentration of reduced hemoglobin is \(\geq 5 \text{ gm/dL}\), and the Hct in this dog was 52.6\%, which corresponded to a hemoglobin concentration of 17.8 gm/dL. Thus, cyanosis may not have been evident until \(S_pO_2\) was < 71\%.

However, results of arterial blood gas analyses indicated that the patient was appropriately oxygenated, despite the lack of reliable pulse oximetry values.

Cervical ventrolflexion can also increase the risk of inadvertent orotracheal tube kinking.4 Evidence against kinking of the orotracheal tube in the dog described in the present report was the continued normal \text{PetCO}_{2} waveform, with values consistently in the range of 30 to 42 mm Hg. The waveform would have changed shape and \text{PetCO}_{2} values would have been low, with corresponding high blood \(P_aCO_2\) values, if the orotracheal tube had been substantially kinked. Additionally, the peak inspiratory pressure required for mechanical ventilation would have increased or the delivered tidal volume would have decreased, and neither of these changes was identified.

Apparent malfunctioning of the blood pressure monitor in the dog described in the present report can also be attributed to phenylephrine-mediated hypertension. The indirect oscillometric blood pressure monitor that was being used has a pump that inflates a blood pressure cuff to a predetermined pressure and then slowly releases the pressure. Sensors monitor oscillations in the cuff that are created by pulsations in the artery beneath the cuff. Typically, following initial inflation of the cuff, the pressure exerted over the artery is sufficient to occlude flow, so that no oscillations are detected in the cuff. As the pressure is slowly released, oscillations are again detected, with the amplitude of those oscillations increasing to a maximum and then decreasing. The algorithm used by each machine to calculate blood pressure is complex, but generally, the pressure at which oscillations are initially detected is the systolic blood pressure and the pressure at which they are no longer detected is the diastolic blood pressure.5,6 The mean blood pressure is approximately the pressure when the oscillations have the greatest amplitude. If the cuff is not inflated to a high enough pressure to occlude blood flow, then the monitor will not be able to detect the pressure at which oscillations begin and will inflate the cuff to a higher pressure during the next cycle. However, if the machine has a set time cycle, it will attempt to obtain a reading only for a certain amount of time and will display a time-out reading if no reading can be determined during this period.

In the dog described in the present report, the high blood pressure that resulted from phenylephrine-induced peripheral vasoconstriction meant that the monitor could not determine a reading during its preset time cycle when the initial inflation pressure was only 90 mm Hg. When the machine was reset to an initial inflation pressure of 150 mm Hg, high blood pressures were reliably detected. In this instance, because pulses were palpably strong, use of a Doppler ultrasonic flow detector would have been an appropriate alternative if problems with the oscillometric blood pressure monitor had continued.

Topical use of phenylephrine during ocular surgery is somewhat controversial, and the frequency and desirability of its use varies among veterinary ophthalmologists. Although topical administration of phenylephrine results in pupil dilatation, it can potentially lead to adverse effects.7,8 Importantly, these adverse effects may go unrecognized or be attributed to other causes because of the variable use of phenylephrine. Also, the incidence and severity of these adverse effects are unpredictable. In the case described in the present report, not everyone was aware of the intraoperative use of phenylephrine on the second eye until the procedure was complete. With so many factors potentially affecting patient well-being during anesthesia and surgery, close communication among operating room personnel is integral to managing unexpected issues that arise during the anesthetic period.

References