Anesthesia for Endoscopy in Small Animals

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KEYWORDS

• Anesthesia • Endoscopy • Small animals • Monitoring
• Drug recommendations

Endoscopy is the process of looking inside the body by inserting a rigid or flexible tube into the body and examining an image of the interior of an organ or cavity. An additional instrument may be inserted to take a tissue biopsy or retrieve foreign objects. It is considered a minimally invasive diagnostic or medical procedure in animals, but most endoscopic procedures in dogs and cats will require general anesthesia nevertheless. Endoscopic procedures are often used to examine the respiratory system (laryngoscopy/tracheoscopy/bronchoscopy), gastrointestinal (GI) system (upper and lower GI endoscopy), thoracic cavity (thoracoscopy), abdomen (laparoscopy), urinary tract (cystoscopy), or joints (arthroscopy). Many of the potential complications of endoscopic procedures are related to general anesthesia.[1] Some endoscopic procedures require special anesthetic considerations, whereas some (arthroscopy, cystoscopy) tend to be more straightforward. A thorough understanding of the physiologic changes produced by various endoscopic procedures is necessary to properly support an anesthetized patient. Many endoscopic procedures require the use of an insufflation gas to facilitate visualization, with resulting physiologic changes to the patient. Body position of the patient during the procedure may also have profound effects on the cardiovascular and respiratory systems. A complete knowledge of all anesthetics and adjunctive drugs is necessary to support patient care.

GENERAL CONSIDERATIONS

Patients undergoing general anesthesia should have food withheld for 12 hours before the procedure. The patient should have access to water up to an hour before the start of general anesthesia. Pediatric patients and other patients at risk for hypoglycemia should have a shorter fasting period. Baseline data include a complete blood count (CBC), chemistry panel with electrolytes, and urinalysis. Other ancillary tests that may be considered include thoracic and abdominal radiographs, ECG,

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echocardiogram, and blood gas analysis, depending on the body systems affected and the planned procedure.

Drug choices should be individualized. Premedication tranquilizers/sedatives such as acepromazine or benzodiazepines help calm patients before catheter placement and improve recovery conditions. Opioids will add analgesia and sedation. The use of premedications will reduce the amount of injectable and inhalant anesthetics needed by the patient, thus improving cardiovascular performance. Anticholinergics (atropine, glycopyrrolate) should be used when patients require an increase in heart rate; they can counteract the increase in vagal tone produced by administered drugs (opioids) or procedure (cystoscopy). Injectable anesthetics include propofol, thiopental, ketamine, or etomidate. Isoflurane or sevoflurane may be used as a maintenance inhalant agent. **Table 1** lists sample protocols for various endoscopic procedures. Specific drug concerns are discussed in each section.

Monitoring of the anesthetized patient undergoing a minimally invasive procedure is just as important as if they were undergoing major surgery. Invasive or noninvasive blood pressure measurement, pulse oximetry, capnometry, and ECG can be useful for assessing and maintaining normal physiologic parameters in the anesthetized patient. Mean arterial pressure should be maintained higher than 60 mmHg in dogs and cats. End-tidal CO_2 should be between 35 and 45 mmHg and SpO_2 greater than 95%. Crystalloid fluids should be administered to patients undergoing inhalant anesthesia for minimally invasive procedures, as inhalant anesthetics cause vasodilation and decreased venous return, regardless of the anticipated amount of blood loss. Crystalloid fluids are generally administered at a rate of 10 mL/kg/h unless the patient is hypoproteinemic, has cardiac disease, anuria, and so forth. Patients that are dehydrated before the procedure should have their volume deficit corrected before general anesthesia.[2] Some patients may benefit from the administration of colloids while undergoing the procedure.

LARYNGOSCOPY/TRACHEOSCOPY

Many patients undergoing this diagnostic procedure will have signs of obstructive upper airway disease. They are dyspneic and easily stressed. Thoracic radiographs should be added to the minimum database if the images can be obtained without excessive stress to the patient. Evaluation of laryngeal function is most frequently done under a light plane of general anesthesia.[3] A variety of injectable anesthetics have been used. All sedative drugs and deeper planes of anesthesia tend to diminish arytenoid function with much individual variation. The perfect technique of general anesthesia for laryngeal function evaluation has yet to be established, as the depth of anesthesia must be sufficient enough to open the jaw and protect the examiner and equipment, yet still maintain arytenoid cartilage movement for evaluation. False-positive examinations can occur with most sedatives and anesthetic combinations.

Preoxygenation of the patient by way of an oxygen mask or flow-by oxygen with the breathing circuit is helpful. Two to 3 L/min of oxygen should be given for 5 minutes immediately before drug administration. This procedure allows increased time for examination of the airway before the patient desaturates. A variety of injectable anesthetic protocols have been evaluated. One study showed that arytenoid motion at recovery was significantly greater with thiopental compared with propofol alone, acepromazine with thiopental or propofol, and ketamine and diazepam.[4] This is comparable with what has been shown in people, in whom propofol has been reported to have a more detrimental effect on vocal cord motion than thiopental.[5] Another study did not show any difference between thiopental, propofol, or diazepam-ketamine

Table 1
Sample anesthetic protocols for selected endoscopic procedures.

1. Bronchoscopy
Premedication: acepromazine (0.02 mg/kg)
Induction: propofol 6 mg/kg IV to effect
Maintain: isoflurane or sevoflurane if endotracheal (ET) tube >7
Propofol CRI (0.15–0.4 mg/kg/min) or intermittent bolus
Postprocedure: oxygen therapy
2. Upper GI endoscopy
Premedication:
Acepromazine (0.02 mg/kg) or midazolam (0.1–0.2 mg/kg)
Butorphanol (0.2 mg/kg) or hydromorphone (0.05–0.1 mg/kg) or buprenorphine (0.005–0.015 mg/kg)
Induction: propofol 6 mg/kg IV to effect or ketamine (5 mg/kg)/diazepam (0.2 mg/kg)
Maintain: isoflurane or sevoflurane
Postprocedure: repeat opioid
3. Rhinoscopy
Premedication: acepromazine (0.02 mg/kg) or dexmedetomidine (0.0025–0.005 mg/kg) or midazolam (0.1–0.2 mg/kg) IM or subcutaneous (SC)
Hydromorphone (0.1 mg/kg) or morphine (0.5 mg/kg) IM
Induction: propofol 6 mg/kg IV to effect or ketamine (5 mg/kg)/diazepam (0.2 mg/kg)
Maintain: isoflurane or sevoflurane
Intraop: fentanyl 1–3 μg/kg bolus
Infraorbital block: lidocaine 0.25–0.5 mL
Postprocedure: repeat opioid, give additional acepromazine or dexmedetomidine as needed for sedation
4. Laparoscopy or thoracoscopy
Premedication: acepromazine (0.01–0.02 mg/kg) or midazolam (0.1–0.2 mg/kg)
Opioids:
Hydromorphone (0.05–0.1 mg/kg) IM or IV
Morphine (0.25–0.5 mg/kg) IM
Fentanyl (1–3 μg/kg bolus, then 5–10 μg/kg CRI)
Buprenorphine (0.01 mg/kg)
Butorphanol (0.2–0.4 mg/kg)
Induction:
Propofol (6 mg/kg) IV to effect
Diazepam/ketamine (0.2 mg/kg)/(5 mg/kg) IV
Diazepam/etomidate (0.2 mg/kg)/(1–2 mg/kg) IV to effect
Maintenance:
Isoflurane
Sevoflurane
Post procedure:
Repeat opioid
Administer regional anesthesia: lidocaine patch application

when evaluating laryngeal function in dogs premedicated with butorphanol and glycopyrrolate.[6] Other disease conditions of the patient should be taken into consideration before the final selection of anesthetic agent, as well as the conditions under which the examiner is accustomed to doing the evaluation. It is helpful for an assistant to announce inspiration by the patient while evaluating arytenoid abduction. Propofol may be administered at 6 mg/kg intravenously (IV) or thiopental at 12 mg/kg to good effect. Administration of supplemental oxygen during the examination is useful, as is pulse oximetry to monitor oxygen saturation. Some authors recommend doxapram administration (2–5 mg/kg IV) at the end of the examination to stimulate more vigorous respiratory movements and eliminate false positives.[4]

Although general anesthesia is most frequently used for laryngoscopy and laryngeal function evaluation, a transnasal approach under sedation has been used to diagnose laryngeal paralysis in large breed dogs.[7] An opioid analgesic and acepromazine were given to each animal intramuscularly (IM) and lidocaine applied topically to the left nasal passage 30 minutes after sedation, to facilitate passage of the endoscope.

General anesthesia is used for tracheoscopy and bronchoscopy in animals to minimize laryngospasm and coughing and protect the endoscope. Tracheoscopy/bronchoscopy is performed without an endotracheal tube in small patients or with the endotracheal tube in patients with sufficient tracheal diameter (size 7 or 8 endotracheal tube). Inhalant anesthesia can be used to maintain the patient during bronchoscopy if the patient is large enough for an endotracheal tube, using a special T-shaped adapter to accommodate the scope as well as administer oxygen and anesthetic gas.[8] There should be sufficient room inside the endotracheal tube for exhalation of gases without resistance.

Injectable anesthetics can be used to maintain anesthesia in patients with small tracheal diameter, whereas oxygen is administered through the scope or through a catheter placed beside the scope if there is sufficient room. A variety of injectable protocols may be used, depending on the patient condition. In general, an injectable protocol that has minimal cardiovascular effects and allows rapid recovery is preferable, as many patients undergoing bronchoscopy have significant respiratory impairment. Short-acting opioids can be used for premedication, such as fentanyl or butorphanol. Butorphanol is a potent cough suppressant. Acepromazine has little respiratory depression and is useful at low doses to calm patients with upper respiratory disease. Propofol has little accumulative effect[9] and can be administered in intermittent boluses or by constant rate infusion (CRI) to maintain anesthesia. The use of anticholinergics to dry up small airways is no longer recommended. Oxygen supplementation post tracheoscopy or bronchoscopy is important to support patients through the recovery period until airway reflexes are normal.

Oxygen saturation should be monitored by pulse oximetry throughout the procedure, with the goal of maintaining saturation greater than 95%. Mean arterial blood pressure should be greater than 60 mmHg. Administration of balanced, isotonic crystalloid fluids should be used with inhalant anesthesia and propofol CRI of moderate duration.

UPPER GASTROINTESTINAL ENDOSCOPY

Anesthetic drugs may alter intestinal motility, sphincter function, and promote vomiting. Upper GI endoscopy is impossible to perform without general anesthesia in dogs and cats. The esophagus, stomach, and upper duodenum can be visualized and a biopsy taken if warranted. If the patient has experienced prolonged vomiting, the animal should be carefully examined for dehydration or electrolyte disturbances. Volume depletion and electrolyte imbalance should be corrected before general

anesthesia. The animal may be sedated with a mild tranquilizer like acepromazine if not dehydrated. Full μ opioid agonists like morphine, oxymorphone, or hydromorphone may promote vomiting if administered IM. Drugs that potentiate vomiting should be avoided in cases of esophageal or gastric foreign bodies. κ opioid agonists such as butorphanol are less likely to promote vomiting. The animal should be induced with an injectable anesthetic and intubated quickly to avoid aspiration. Propofol, thiopental, ketamine, or etomidate may be used for this purpose, depending on the rest of the animal's condition. The patient may be maintained on inhalants after intubation. An appropriately inflated endotracheal tube cuff should be maintained at all times to avoid inadvertent aspiration of fluid during the procedure.

Balanced, isotonic crystalloid fluids (such as Normosol-R [Norm-R] or lactated Ringer's solution [LRS]) administered at 10 mL/kg/h should be used for patients with normal oncotic pressure and plasma proteins. Hypoproteinemic patients may benefit from colloid administration. Plasma or hetastarch can be used to assist in maintaining sufficient oncotic pressure. Hetastarch can be used at a rate of 5 mL/kg/h along with crystalloid fluid administration during the procedure. Care must be taken to avoid fluid overload.

Insufflation of the stomach with air must be carefully monitored to avoid overinflation and attendant cardiovascular and respiratory compromise.[10] Pulse oximetry, blood pressure, and capnometry are helpful to monitor anesthesia in these patients. Frequently respiration must be supported with intermittent positive pressure ventilation if abdominal pressure is increased. The size of the stomach should be continuously monitored during gastroscopy.

Care must be taken to avoid aspiration of gastric contents. The endotracheal tube cuff should be properly inflated on intubation and maintained throughout the procedure. The cuff should not be deflated until the patient is extubated, ensuring that the patient can swallow and the airway is protected.

The cardiac and pyloric sphincters can impede endoscopy.[11] Comparison of premedication with atropine, glycopyrrolate, morphine, meperidine, acepromazine, and saline before general anesthesia for gastroduodenoscopy in dogs resulted in more difficulty in entering the pyloric sphincter when a combination of morphine and atropine was used.[12] This has led to the suggestion that all full μ opioid agonists be avoided when duodenoscopy is performed. The use of atropine in dogs as a premedication does not facilitate duodenal intubation and may inhibit it.[13] α2 agonists such as medetomidine do not hinder the passage of the endoscope through the pylorus in dogs, although vomiting may be an issue in some patients.[14]

More recent work has evaluated the effects of various premedications on ease of duodenoscopy in the cat.[15] Their results suggest that hydromorphone (a full μ opioid agonist), glycopyrrolate (anticholinergic), medetomidine (α2 agonist), or butorphanol (agonist antagonist opioid) are all satisfactory for use as a premedication before gastroduodenoscopy in the cat.

Experienced clinicians may not have any difficulty passing the endoscope into the duodenum, despite the anesthetic protocol used. Butorphanol may be used without difficulty and has the additional benefit of not inducing as much vomiting as a full μ agonist when used as a premedication. Its short duration is helpful in avoiding excessive post anesthetic sedation.

COLONOSCOPY

Colonoscopy is often performed in patients with signs of large bowel or rectal disease.[16] To adequately visualize the colonic mucosa, the bowel is prepared for

the procedure with food withdrawal, administration of a GI lavage solution (eg, GoLYTELY, Braintree Laboratories, Braintree, Massachusetts) and a series of enemas.[16] This preparation can cause dehydration in some patients. Careful evaluation should be performed to ensure adequate hydration before general anesthesia. Volume deficits should be corrected before general anesthesia with IV administration of crystalloid fluids.

Complications associated with colonoscopy are reported to be rare in dogs, with minor and major complications developing in 30 out of 355 procedures (8.5%).[17] Minor complications were most frequently associated with vomiting of GoLYTELY. Anesthetic complications such as bradycardia that resolved after the anesthetic episode were also reported under minor complications. Major complications may also be associated with general anesthesia. Aspiration of vomited GoLYTELY was responsible for mortality of one patient in the study and has been reported in humans.[16,18] Care must be taken to protect the airway during the procedure.

RHINOSCOPY

Rhinoscopy patients need to have good analgesia in their anesthetic protocol, as the procedure requires a surgical plane of anesthesia.[19] A full μ opioid agonist such as hydromorphone, morphine, or oxymorphone can be administered as part of the premedication in addition to a tranquilizer such as acepromazine or an $\alpha 2$ sedative. Short-acting potent opioids such as fentanyl can be bolused intravenously before biopsy to prevent excessively high vaporizer settings. Regional anesthetic techniques such as infraorbital blocks with lidocaine, mepivicaine, or bupivicaine will also improve patient comfort. Postprocedure bleeding can be minimized if the patient is well sedated after biopsies are taken, as excessive head shaking and activity can lead to continued bleeding and increased irritation of the area.

The endotracheal cuff should be properly inflated before rhinoscopy and the procedure halted any time there is a concern about the cuff. It can be helpful to extubate the patient with the cuff partially inflated to assist in clearing blood from the airway if it has not been packed before beginning the procedure.

LAPAROSCOPY

Laparoscopic noninvasive surgery has become common as more procedures are attempted in a noninvasive fashion. To perform this type of surgery, a pneumoperitoneum is established to allow room to place the trocar and cannula assemblies safely and improve visualization.[1] Several gases have been used to insufflate the abdomen: carbon dioxide, nitrous oxide, or room air. Carbon dioxide is most frequently chosen as the insufflation gas for laparoscopy.[20] The use of medical air has increased potential for air embolism and increased potential to support combustion if electrocautery is used. Carbon dioxide is able to diffuse across the peritoneal cavity and enter the blood stream, whereby it stimulates the sympathetic nervous system to release endogenous catecholamines. Higher levels of arterial CO_2 tend to increase heart rate, blood pressure, and cardiac output. Excessively high levels of CO_2 will lead to narcosis, arrhythmia, acidemia, and myocardial depression. Nitrous oxide does not alter the patient's acid-base status.

Regardless of the type of gas used, insufflation of gas increases intraabdominal pressure (IAP) in the patient, with the potential to cause decreased tidal volume and hypoventilation. Functional residual capacity and lung compliance decrease during general anesthesia.[21,22] The increase in IAP from gas insufflation causes cranial displacement of the diaphragm. All of these factors contribute to the need for

increased ventilation support for the anesthetized patient undergoing laparoscopy. Depression of ventilation increases with increasing IAP and IAP less than 20 mmHg is recommended.[23]

Increased IAP also leads to decreased venous return and a reduction in cardiac output. Tissue blood flow may be compromised with increased IAP as elevated IAPs are associated with decreased hepatic blood flow and oliguria.[24] Anesthetic conditions for the patient will be improved by using the least amount of IAP necessary to complete the procedure.

Changes in body position have the potential to adversely affect the anesthetized patient, especially if coupled with abdominal insufflation. Inhalant anesthetics alter the baroreflex, leading to a depressed reflex control of circulation in response to changes in body posture.[24–26] Head down tilt of a dorsally recumbent patient (Trendelenburg position) allows for better exposure of the caudal organs in the operative field. Reverse Trendelenburg position (head up and dorsally recumbent) is used if improved exposure of cranial organs is desired. The head down tilt position has more effect on respiratory and cardiovascular mechanics, leading to decreases in minute ventilation and cardiac output, amongst other things. Mean arterial pressure may increase. The head up tilt position will also affect cardiovascular mechanics, leading to reflex vasoconstriction, and increased heart rate and arterial blood pressure in dogs.[27]

Excellent monitoring of the anesthetized patient undergoing laparoscopy is essential. Increased IAP results in hypoventilation, so the use of a mechanical ventilator is helpful to provide pulmonary support as normocapnia should be a monitoring goal. If CO_2 is the insufflation gas used, absorption of CO_2 across the peritoneal membrane will lead to higher $PaCO_2$, regardless of the respiratory status of the patient. End-tidal CO_2 monitoring and pulse oximetry will provide continuous monitoring of the respiratory system. Invasive blood pressure monitoring is warranted in more critical patients undergoing laparoscopy, whereas noninvasive methods (Doppler or oscillometric cuff-based monitors) can be used in healthy patients undergoing elective laparoscopic procedures. Arterial catheter placement will allow easier sampling for blood gas analysis if CO_2 is the insufflation gas. Abdominal insufflation must be monitored and the rule of 15s is a good general guideline: no more than 15 mmHg IAP or 15 degrees of tilt.[24]

General anesthesia is most frequently used for laparoscopic procedures in small animals, but it is important to consider the increased stress to the patient of abdominal insufflation and tilted body posture. These effects are aggravated by general anesthesia. A recent study compared the cardiopulmonary effects of laparoscopic-assisted jejunostomy feeding tube placement during sedation with epidural and local anesthesia versus general anesthesia. Sedation and local anesthesia provided satisfactory conditions for the laparoscopic procedure and less cardiopulmonary depression.[28] Thus, sedation and epidural anesthesia may be considered for critical patients requiring a laparoscopic procedure. Conversion to general anesthesia may be necessary if the duration of the procedure is extended and mechanical ventilation needed to offset increases in $PaCO_2$.

Complications of laparoscopy include hemorrhage, pneumothorax, or puncture of an organ with placement of the veress needle. Splenic enlargement will occur if thiopental is used as the induction agent. Serial packed cell volume (PCV) determination and total protein measurement can help assess the need for blood replacement products. Packed red blood cells and plasma, or whole blood transfusion should be considered if the PCV decreases to less than 20 and the total protein less than 4. Postoperative analgesic needs can be met with parenterally administered opioids. Lidocaine patch application at the port sites can be used to provide regional analgesia without systemic effects.[29]

THORACOSCOPY

When an instrument is placed in the thoracic cavity, the negative pressure of the thorax is compromised. Deliberate collapse of the lung on the operable side is attempted in many instances to improve surgical conditions. One-lung ventilation may be achieved either through selective intubation of one bronchus or the use of a bronchial blocker to improve conditions for endosurgery. Selective intubation can be done blindly or with the aid of an endoscope. Thoracoscopy may also be performed with a more conventional two-lung ventilation technique and the use of smaller tidal volumes to improve surgical conditions. The use of bilateral ventilation techniques decreases general anesthesia time, as selective intubation is not done. Although complete lung collapse does not occur, this tends to be the simplest way to manage the anesthesia for the patient.[30]

One-lung ventilation has minimal cardiopulmonary effects on healthy dogs with an intact chest.[31] Nevertheless, opening the thoracic cavity will have adverse effects on gas exchange and may compromise the patient's oxygenation ability.[32–34] Significant decreases in arterial oxygen partial pressure (PaO_2) and oxygen content can be expected.[32] Significant increases in shunt fraction and physiologic dead space can occur. Arterial partial pressure of carbon dioxide may not be affected.

Whereas laparoscopy requires insufflation of the abdominal cavity, thoracoscopy can be performed with or without carbon dioxide insufflation. Thoracic insufflation decreases cardiac output at low insufflation pressures (3 mmHg) and sustained insufflation should be used with caution.[35]

Monitoring of patients undergoing general anesthesia for thoracoscopy should include capnometry, pulse oximetry, ECG, and blood pressure monitoring. Invasive blood pressure monitoring has the added advantage of arterial catheter placement for easier blood gas analysis. Particular attention should be paid to the patient's ventilation and oxygenation status.

A thoracoscopy procedure in people has the advantage of reduced chest wall trauma, reduced postoperative pain, decreased patient morbidity, and decreased hospitalization time.[36] Thoracoscopy has been used in dogs for the biopsy of pulmonary structures, identification, and ligation of the thoracic duct, pericardectomy, and lung lobectomy, amongst other things.[37–40] However, most of the cardiopulmonary research studies on thoracoscopy have been conducted on healthy dogs. Clinical candidates for thoracoscopy usually have pulmonary compromise, which can hamper their ability to withstand a sustained thoracoscopic procedure. Conversion to thoracotomy may be necessary for patients who desaturate or deteriorate with a lengthy general anesthesia time. One of the most common reasons for conversion to thoracotomy is insufficient lung collapse and visualization of the operative site.[40]

Many of the complications of thoracoscopy are the same as conventional thoracotomy surgery. Decreases in arterial oxygen tension and hypoventilation should be anticipated. The use of 5 cmH_2O of positive end expiratory pressure (PEEP) may help with desaturation, especially if one-lung ventilation is used. A mechanical ventilator will help sustain ventilation and free up personnel to monitor the patient. Hemorrhage at the surgical site may occur and the patient should be monitored with serial PCV/total protein measurements. Blood products should be administered if necessary. Plasma or hetastarch can be helpful in maintaining a robust intravascular volume if cardiopulmonary compromise is anticipated.

Animals that experience thoracoscopy may have less pain than patients who experience lateral thoracotomy or median sternotomy, but have analgesic needs that should be addressed nevertheless. Full μ agonist opioids are appropriate analgesic

choices for most patients, despite the respiratory depression produced by the drug. Oxygen therapy post procedure may be warranted in many clinical cases.

REFERENCES

1. Richter KP. Laparoscopy in dogs and cats. Vet Clin North Am Small Anim Pract 2001;31:707–27.
2. Seeler DC. Fluid, electrolyte, and blood component therapy. In: Tranquilli WJ, Thurmon JC, Grimm KA, editors. Lumb & Jones' veterinary anesthesia and analgesia. 4th edition. Oxford: Blackwell; 2007. p. 185–201.
3. Holt D, Brockman D. Diagnosis and management of laryngeal disease in the dog and cat. Vet Clin North Am 1994;24:855–71.
4. Jackson AM, Tobias K, Long C, et al. Effects of various anesthetic agents on laryngeal motion during laryngoscopy in normal dogs. Vet Surg 2004;33:102–6.
5. Baker P, Langton JA, Wilson IG, et al. Movements of the vocal cords on induction of anesthesia with thiopentone or propofol. Br J Anesth 1992;69:23–5.
6. Gross ME, Dodam JR, Pope ER, et al. A comparison of thiopental, propofol, and diazepam-ketamine anesthesia for evaluation of laryngeal function in dogs premedicated with butorphanol-glycopyrrolate. J Am Anim Hosp Assoc 2002;38:503–6.
7. Radlinsky MG, Mason DE, Hodgson D. Transnasal laryngoscopy for the diagnosis of laryngeal paralysis in dogs. J Am Anim Hosp Assoc 2004;40:211–5.
8. Johnson L. Small animal bronchoscopy. Vet Clin North Am Small Anim Pract 2001;31:691–705.
9. Branson KR. Injectable and alternative anesthetic techniques. In: Tranquilli WJ, Thurmon JC, Grimm KA, editors. Lumb & Jones' veterinary anesthesia and analgesia. 4th edition. Oxford: Blackwell Publishing; 2007. p. 273–99.
10. Tams TR. Gastroscopy. In: Small animal endoscopy. 2nd edition. St Louis (MO): Mosby; 1999. p. 97–172.
11. Zoran DL. Gastroduodenoscopy in the dog and cat. Vet Clin North Am Small Anim Pract 2001;31:631–56.
12. Donaldson LL, Leib MS, Boyd C, et al. Effect of preanesthetic medication on ease of endoscopic intubation of the duodenum in anesthetized dogs. Am J Vet Res 1993;54(9):1489–95.
13. Matz ME, Leib MS, Monroe WE, et al. Evaluation of atropine, glucagon, and metoclopramide for facilitation of endoscopic intubation of the duodenum in dogs. Am J Vet Res 1991;52(12):1948–50.
14. Sap R, Hellebrekers LF. Medetomidine/propofol anaesthesia for gastroduodenal endoscopy in dogs. J Vet Anaesth 1993;20:100–2.
15. Smith AA, Posner LP, Goldstein RE, et al. Evaluation of the effects of premedication on gastroduodenoscopy in cats. J Am Vet Med Assoc 2004;225(4):540–4.
16. Willard MD. Colonoscopy, proctoscopy, and ileoscopy. Vet Clin North Am Small Anim Pract 2001;31:657–69.
17. Leib MS, Baechtel MS, Monroe WE. Complications associated with 355 flexible colonoscopic procedures in dogs. J Vet Intern Med 2004;18:642–6.
18. Marschall H, Bartels F. Life-threatening complications of nasogastric administration of polyethylene glycol-electrolyte solutions (GoLYTELY) for bowel cleansing. Gastrointest Endosc 1998;47:408–10.
19. Noone KE. Rhinoscopy, pharyngoscopy, and laryngoscopy. Vet Clin North Am Small Anim Pract 2001;31:671–89.

20. Quandt JE. Anesthetic considerations for laser, laparoscopy, and thoracoscopic procedures. Clin Tech Small Anim Pract 1999;14:50–5.
21. Don HF, Robson JF. The mechanics of the respiratory system during anesthesia. Anesthesiology 1965;26:168–78.
22. Nunn JF. Effects of anaesthesia on respiration. Br J Anaesth 1990;65:54–62.
23. Gross ME, Jones BD, Bergstresser DR, et al. Effects of abdominal insufflation with nitrous oxide on cardiorespiratory measurements in spontaneously breathing isoflurane-anesthetized dogs. Am J Vet Res 1993;54(8):1352–8.
24. Bailey JE, Pablo LS. Anesthetic and physiologic considerations for veterinary endosurgery. In: Freeman LJ, editor. Veterinary Endosurgery. St. Louis (MO): Mosby; 1999.
25. Kotrly K, et al. Baroreceptor reflex control of heart rate during isoflurane anesthesia in humans. Anesthesiology 1984;60:173–9.
26. Jois J, et al. Hemodynamic changes during laparoscopic cholecystectomy. Anesth Analg 1993;76:1067–71.
27. Abel F, Pierce J, Guntheroth W. Baroreceptor influence on postural changes in blood pressure and carotid blood flow. Am J Physiol 1963;205:360–4.
28. Hewitt SA, Brisson BA, Sinclair MD, et al. Comparison of cardiopulmonary responses during sedation with epidural and local anesthesia for laparoscopic-assisted jejunostomy feeding tube placement with cardiopulmonary responses during general anesthesia for laparoscopic-assisted or open surgical jejunostomy feeding tube placement in healthy dogs. Am J Vet Res 2007;68(4):358–69.
29. Weil AB, Ko J, Inoue T. The use of lidocaine patches. Compend Contin Educ Vet 2007;29(4):208–16.
30. Gross ME, Dodam JR, Faunt KK. Anesthetic considerations for endoscopy. In: McCarthy T, editor. Veterinary endoscopy for the small animal practitioner. Philadelphia: WB Saunders; 2004. p. 21–9.
31. Cantwell SL, Duke T, Walsh PJ, et al. One-lung versus two-lung ventilation in the closed-chest anesthetized dog: a comparison of cardiopulmonary parameters. Vet Surg 2000;29:365–73.
32. Kudnig ST, Monnet E, Riquelme M, et al. Cardiopulmonary effects of thoracoscopy in anesthetized normal dogs. Vet Anaesth Analg 2004;31:121–8.
33. Faunt KK, Cohn LA, Jones BD. Cardiopulmonary effects of bilateral hemithorax ventilation and diagnostic thoracoscopy in dogs. Am J Vet Res 1998;59:1494–8.
34. Kudnig ST, Monnet E, Riquelme M. Effect of one-lung ventilation on oxygen delivery in anesthetized dogs with an open thoracic cavity. Am J Vet Res 2003; 64:443–8.
35. Daly CM, Swalec-Tobias K, Tobias AH, et al. Cardiopulmonary effects of intrathoracic insufflation in dogs. J Am Anim Hosp Assoc 2002;38:515–20.
36. Lin J, Iannettoni MD. The role of thoracoscopy in the management of lung cancer. Surg Oncol 2003;12:195–200.
37. Swanson SJ, Batirel HF. Video-assisted thoracic surgery (VATS) resection for lung cancer. Surg Clin North Am 2002;82:541–59.
38. Radlinsky MG, Mason DE, Biller DS, et al. Thoracoscopic visualization and ligation of the thoracic duct in dogs. Vet Surg 2002;31:138–46.
39. Dupre GP, Corlouer JP, Bouvy B. Thoracoscopic pericardectomy performed without pulmonary exclusion in 9 dogs. Vet Surg 2001;30:21–7.
40. Lansdowne JL, Monnet E, Twedt DC, et al. Thoracoscopic lung lobectomy for treatment of lung tumors in dogs. Vet Surg 2005;34:530–5.