Thoracoscopy: Basic Principles, Anesthetic Concerns, Instrumentation, and Thoracic Access

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Abstract: Thoracoscopic surgery offers an exciting method for treating a variety of thoracic disease processes. To date, several thoracoscopic procedures have been described in veterinary patients. This article discusses the basic principles of thoracoscopic surgery and thoracic access, anesthetic concerns, and required instrumentation. A companion article discussing the surgical techniques of thoracoscopic pericardial window creation, subphrenic pericardectomy, thoracoscopic lung biopsy, lung lobectomy, thoracic duct ligation, and cranial mediastinal mass excision will be published in the February 2013 issue.

Thoracoscopy, otherwise known as video-assisted thoracic surgery (VATS), offers an exciting method for treating a variety of thoracic disease processes. To date, several thoracoscopic procedures have been described, including creation of pericardial windows, subphrenic pericardectomy, thymoma resection, ligation of a patent ductus arteriosus and vascular ring anomalies, thoracic duct ligation, and pulmonary lobe resection, as well as diagnostic procedures. In humans, proven advantages of VATS include a reduction in the time that thoracic drains are in place, less postoperative pain, a shorter hospital stay, and a more rapid return to normal function. Limited objective comparisons of open thoracotomy and VATS procedures have been reported in the veterinary literature, but advantages of VATS are likely to be similar for small animal patients. One study using a pericardectomy model showed that dogs undergoing thoracoscopic pericardectomy had lower pain scores and decreased requirements for analgesic medications than dogs undergoing open thoracotomy.

Practitioners who wish to perform thoracoscopic procedures should have some experience in minimally invasive surgery and be familiar with thoracic surgery. Many opportunities currently exist for obtaining advanced training in minimally invasive surgical techniques. Experience, combined with careful case selection, can help ensure a high level of success and a low conversion rate to an open approach. Referral to a surgical specialist is advised if experience in the field is limited or the required instrumentation is not readily available.

Instrumentation for Thoracoscopy

Routine Instrumentation

In common with other types of flexible and rigid endoscopy, thoracoscopy requires the use of components usually housed on an endoscopic tower. These include a medical-grade monitor, camera, light source, and data recording device. A mechanical insufflator, frequently used for creating pneumoperitoneum during laparoscopic procedures, is not necessary for most thoracoscopic interventions unless carbon dioxide insufflation is used because the ribs form a rigid frame that maintains a working space in which the surgeon can manipulate organs and operate instruments. Most surgeons performing VATS procedures in veterinary medicine do not use carbon dioxide insufflation routinely.

Rigid telescopes used for thoracoscopy are the same rod lens telescopes used for laparoscopy and come in a number of different diameters and tip angulations. The most frequently used telescope diameters are 5 and 10 mm. The 5-mm telescope is suitable and all that is required for almost all sizes of dog and cat, although 10-mm telescopes (the principal size used in human endosurgery) are often available to practitioners and are perfectly adequate for most sizes of patient if a 5-mm telescope is not available. A 3-mm diameter, 14-cm telescope exists that provides excellent visualization within the thoracic cavity of very small dogs and cats (<10 kg). Telescopes that are 2.7 mm in diameter are sometimes used for arthroscopy and can also be used in smaller patients. However, arthroscopes that are smaller than 2.7 mm are unlikely to offer adequate illumination of the thoracic cavity. Angulation of the tip of the telescope dictates the direction of the field of view. A 0° telescope provides an image of what lies directly in...
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Choosing trocar-cannula assemblies for thoracoscopic procedures is based on somewhat different considerations than those for laparoscopy. During thoracoscopy, if insufflation is not used, cannulae are not essential because an airtight seal is unnecessary. In theory, the telescope and instruments can be passed through chest wall incisions without cannulae. However, I strongly recommend the use of thoracic cannulae. Iatrogenic damage to the body wall (especially the intercostal arteries and veins) or lungs is more likely when instruments are repeatedly inserted and withdrawn through unprotected thoracic wall incisions. Additionally, it can be difficult to pass the telescope through an unprotected port incision without contaminating the lens with blood, resulting in loss of optimal visualization. Thoracic cannulae can be simple in design because they do not need to incorporate a one-way valve to prevent loss of insufflation. Disposable (e.g., Thoracoport, Covidien Inc., Mansfield, MA) and nondisposable (Karl Storz Veterinary Endoscopy) options exist. Thoracic cannulae with threaded shafts are especially helpful in preventing cannulae dislodgment during instrument exchanges (FIGURE 2). Preoperatively, thought should always be given to the size of the instruments necessary to complete any given procedure so that cannulae of corresponding sizes can be used.

A routine set of minimally invasive instrumentation for thoracoscopy usually includes Metzenbaum scissors, hook scissors (for cutting suture), a blunt probe, Kelly or Blakesley dissection forceps, Babcock forceps, a biopsy punch and/or cup forceps, and a knot pusher (if extracorporeal knot tying is anticipated). Other, more specialized instruments that might be necessary for certain procedures include right-angle dissection forceps, a fan or other type of minimally invasive retractor, and needle holders (if intracorporeal suturing is anticipated).

Hemostasis within the thoracic cavity can be achieved using hemoclips, pretied suture loops (Endoloop, Ethicon Endosurgery Inc., Cincinnati, OH), extra- or intracorporeally tied sutures, or vessel-sealing devices. The Ligasure device (Covidien) and the Enseal (Ethicon Endosurgery) are two bipolar vessel-sealing devices that are indicated to seal arteries and veins up to 7 mm in diameter. They can be used effectively within the thoracic cavity for hemostasis and to section the mediastinum, perform pericardectomies, and aid in the dissection of pulmonary or mediastinal masses. When using vessel-sealing devices, care should always be taken not to cause thermal damage to surrounding organs. The devices mentioned have a lateral thermal spread of 1 to 3 mm.14

Special Instrumentation

Several disposable items are helpful when planning advanced thoracoscopic procedures. Use of endoscopic stapling is mandatory for certain thoracoscopic procedures. The most common stapler used is the EndoGIA (Covidien), a 12-mm-diameter device that must be passed through a 12-mm or larger cannula. The EndoGIA stapler places two triple rows of staggered staples that are separated by a cutting blade, thus allowing secure sealing on each side of the cut and preventing back bleeding or spillage of contaminated material into the surgical field (FIGURE 3). EndoGIA cartridges are available in lengths of 30, 45, and 60 mm. The staple leg lengths are 2.0, 2.5, 3.5, and 4.8 mm. The 4.8-mm leg length staple units must be passed down a 15-mm cannula and are used less frequently in veterinary applications. Use of the EndoGIA has been described for lung lobectomy for the removal of lung masses or bullae/blebs.9,10 The most frequently used cartridge in these reports was 30 to 60 mm in length with a 3.5-mm staple leg

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*To watch the videos referred to in this article, please visit www.vetlearn.com.
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length and allowed effective lung resection with little morbidity. I have found the 3.5-mm staple leg length to be highly effective in sealing lung tissue at midlobe level (during partial lung lobectomies) as well as at the pulmonary hilus (for total lung lobectomies). Prettied or extracorporeally tied ligature loops can also be used for ligation of small, peripheral areas of lung tissue when a biopsy of the lung is required. They are not recommended for complete lung lobectomy.

A suction/irrigation device can be very helpful in thoracoscopy. Disposable single-use suction/irrigation catheters come preattached to tubing that hooks into motorized fluid pumps or fluid bags that can be placed in pressure bags, thus allowing rapid, large-volume irrigation of surgical sites followed by reaspiration. They are also very useful for aspiration of "nuisance" hemorrhage that may obscure the surgical field. Nondisposable devices have the advantage of being significantly less expensive because most disposable suction irrigators are difficult to resterilize.

Specimen retrieval bags are used to assist in withdrawing tissue specimens through port-site incisions. Commercially manufactured bags are available from a variety of different medical device companies. For small samples, the thumb of a surgical glove can be used as a cheaper substitute. Specimen retrieval bags should be used when tissue that could be neoplastic or infected is to be removed through a small port incision. The sample is placed in the bag before being withdrawn through the incision (FIGURE 4). Specimen retrieval bags help to minimize the risk of port site metastases by preventing seeding from the pathologic specimen to the thoracic wall during removal. Due to the significant traction that can be created, they also allow large tissue samples to be withdrawn through much smaller incisions than would otherwise be necessary.

As is routinely performed with open thoracic surgery, a thoracostomy tube should always be placed after thoracoscopic surgery to drain any fluid, blood, or air.

Anesthesia for Thoracoscopy

For many thoracoscopic interventions, such as pericardial window creation, thoracic duct ligation, and lung biopsy, the pneumothorax that forms within the chest when the first cannula is placed and air is allowed to enter the pleural cavity provides adequate working space for the procedure to be completed safely. For these procedures, anesthesia concerns are similar to those for open thoracotomy. Intravenous access should be established and an indwelling arterial catheter placed for direct measurement of arterial blood pressure and arterial blood gas measurement, if possible. Variables monitored during the procedure include heart rate and rhythm (by electrocardiography), oxygen saturation (by pulse oximetry), end-tidal capnography and/or intermittent blood gas analysis, and continuous arterial pressure. Positive-pressure ventilation, preferably with a mechanical ventilator, is mandatory for anesthetic maintenance, as it is for open thoracic surgery.

Several techniques can be used to increase the working space in the thoracic cavity during more advanced thoracoscopic procedures. Thoracic insufflation with a closed chest can be performed if thoracic cannulae with one-way valves are used. However, significant cardiopulmonary depression has been observed in dogs when CO₂ is insufflated, even at low insufflation pressures (3 mm Hg). Insufflation is, therefore, rarely used as the modality of choice for increasing working space. One-lung ventilation (OLV) is most surgeons’ preferred method for increasing the visual field during more advanced thoracoscopic interventions (FIGURE 4). Improved visualization may also help avoid iatrogenic trauma to tissues, which can occur when visibility is impaired by repeated lung inflation. Whenever OLV is used, a significant ventilation-to-perfusion mismatch occurs as a result of nonventilated lung remaining perfused and significant physiologic changes must be anticipated. However, studies have shown no large effect on oxygen delivery during OLV in healthy dogs. The use of OLV has been reported for creation of pericardial windows, subphrenic pericardectomy, lung lobectomy, and thymoma excision. In my experience, most dogs without significant cardiopulmonary disease tolerate OLV very well. Various techniques can be used to create OLV,
including use of bronchial blockers (FIGURE 5), selective intubation, or double-lumen endobronchial intubation (FIGURE 6). All usually require bronchoscopy-assisted placement. Whenever OLV is used, great care needs to be taken in monitoring anesthesia.

**Principles of Thoracic Access**

The major difference between minimally invasive procedures in the thoracic and peritoneal cavities is that thoracoscopy does not require insufflation because the ribs form a rigid frame that maintains a working space in which the surgeon can manipulate organs and operate instruments. For the same reason, there is no need to maintain a tight seal around cannulae that are placed into the thoracic cavity. To allow pneumothorax to develop, access to the thoracic cavity can be initiated either with a Veress needle or with a cannula without a diaphragm placed directly into the thoracic space. Blunt trocars (e.g., ThoraPort, Covidien) or blunt-tipped trocarless cannulae (e.g., EndoTIP, Karl Storz Endoscopy) should always be used to avoid iatrogenic trauma to intrathoracic structures.

Instrument ports are generally placed in a triangulating pattern around the area of interest. Port positions for different techniques are somewhat determined by surgeon preference. When establishing instrument ports for thoracoscopy, it can be helpful to make a small skin incision with a scalpel blade and then use mosquito or Kelly forceps to bluntly dissect a small hole that penetrates the pleural cavity before passing the instrument cannula under direct visualization (VIDEO 3). Once the first cannula has been positioned, the telescope enters the chest and further instrument ports can be placed as needed under visual guidance. In procedures that are performed with the patient in dorsal recumbency (pericardectomy, lung biopsy, some lung lobectomies and thymoma resections, cranial mediastinal mass excision), the first step after access to the thoracic cavity has been established is to section the ventral mediastinal attachments. These are usually thin “curtains” of tissue that hang down from the sternum and are generally poorly vascular. However, because any hemorrhage can cause significant loss of visualization, these ventral mediastinal attachments are best sectioned using a vessel-sealing device or electrocautery. Once this tissue has been sectioned, access to both hemithoraces is established and the surgical procedure can proceed.

**Figure 6.** A double-lumen endobronchial tube. The translucent balloon resides in the trachea, whereas the blue balloon is inflated within the mainstem bronchus. One lumen terminates at a point between the balloons and the other terminates at the tip of the bronchial end. This arrangement allows ventilation of either hemithorax depending on which lumen is used for patient ventilation.

**References**

1. Rigid telescopes used for thoracoscopic surgery in dogs and cats are frequently ____ mm in diameter.
   a. <2.0
   b. <2.5
   c. 5 or 10
   d. none of the above

2. Why are thoracic cannulae beneficial during thoracoscopic surgery?
   a. They reduce the risk of infection.
   b. They reduce tissue trauma associated with repeated instrument insertion.
   c. They prevent pneumothorax.
   d. all of the above

3. Routine instrumentation for thoracoscopy includes all of the following except
   a. Babcock forceps.
   b. right-angle dissection forceps.
   c. Metzenbaum scissors.
   d. Blakesley dissection forceps.

4. During thoracoscopy, pretied or extracorporeally tied ligature loops are best for ligation of
   a. bronchi following lung lobectomy.
   b. small, peripheral areas of lung tissue.
   c. large arteries.
   d. all of the above

5. Which is a potential disadvantage of using disposable suction irrigators?
   a. They do not perform as well as nondisposable ones.
   b. They are more likely to cause infection.
   c. They tend to cost more because most cannot be resterilized.
   d. all of the above

6. Which statement is true regarding specimen retrieval bags?
   a. They are used for withdrawing tissue specimens through port-site incisions.
   b. They should be used for removing specimens that could be neoplastic or infected.
   c. They allow relatively large tissue samples to be withdrawn through smaller incisions.
   d. all of the above

7. Which statement is false regarding anesthesia and anesthetic monitoring for veterinary patients undergoing thoracoscopic surgery?
   a. Monitoring oxygen saturation is not necessary because mechanical ventilation prevents hypoxia.
   b. End-tidal capnography or blood gases should be monitored.
   c. Positive-pressure ventilation is required.
   d. none of the above

8. Which statement is true regarding carbon dioxide insufflation for veterinary patients undergoing thoracoscopic surgery?
   a. Cardiopulmonary depression does not generally occur.
   b. It is commonly used to increase visualization and work space.
   c. It is possible if thoracic cannulae with one-way valves are used.
   d. It is not effective unless insufflation pressure exceeds 3 mm Hg.

9. Which statement is false regarding use of one-lung ventilation to improve visualization during thoracoscopic surgery?
   a. A ventilation-perfusion mismatch always occurs.
   b. The resulting ventilation-perfusion mismatch makes this a less desirable method than carbon dioxide insufflation.
   c. Most dogs without significant cardiopulmonary disease tolerate the procedure well.
   d. Double-lumen endobronchial intubation is one way to accomplish one-lung ventilation.

10. Which statement is true when performing thoracoscopic surgery?
    a. If the patient is in dorsal recumbency, the ventral mediastinal attachments should be sectioned to allow access to both hemithoraces.
    b. Placement of a double-lumen endobronchial tube can generally be performed without bronchoscopic assistance.
    c. Instrument ports are generally not placed in a triangulating pattern, to reduce the chance of perforating a lung lobe.
    d. The ventral mediastinal attachments can generally be sectioned without risk of hemorrhage, so use of a vessel-sealing device or electrocautery is not required.