Key Points

- Minimally invasive surgery (MIS) of the thoracic cavity can be diagnostic or therapeutic, with distinct advances made in the treatment of pericardial effusion, restrictive pericarditis, right atrial neoplasia, persistent right aortic arch, chylothorax, and perhaps patent ductus arteriosus.
- Procedures include ligation and division of the ligamentum arteriosum, pericardial window with fenestration, subtotal pericardectomy, excision of the right atrial appendage, thoracic duct ligation, and cisterna chyli ablation.
- Success of MIS procedures is equal to those reported with an open approach, and magnification and lighting are greater than with open surgery.
- Be prepared and have equipment available to convert to the open approach on an emergent basis and have adequate devices to augment and speed surgery (vessel sealer, endoscopic staplers).
- Remember to evaluate for hemorrhage and air leakage as would be done for open surgery and place a thoracostomy tube for monitoring and local anesthetic administration.

Pericardectomy was the first procedure that advanced the use of minimally invasive surgery (MIS) of the chest and is rapidly becoming standard of care. It and the other procedures described in this session does not require one lung ventilation, greatly simplifying the use of MIS of the chest. Both pericardial window and subtotal pericardectomy may be done. A hybrid version has been described, which involves formation of a pericardial window and longitudinal fenestrations of the pericardium to minimize the risk of adhesion or closure of the window. This technique may also be used for minimizing the effect of the pericardium on diastolic pressure and lack of filling in cases of pericardial tamponade and restrictive pericarditis.

Either an intercostal or transdiaphragmatic approach may be used, but a transdiaphragmatic approach is preferred by this author and is required for subtotal pericardectomy. OLV is also used for subtotal pericardectomy, which would be difficult without it. Tilt the patient 10 - 15° to aid in retraction of the heart by gravity. Ports can be placed on one side of the chest or on both, depending on the surgeon's preference, and more ports can always be added if necessary. Be sure that ports are placed ventral to the pulmonary excursions to decrease the risk of inadvertent trauma. The pericardium may be incised with endoscopic scissors connected to monopolar cautery; however, use of a vessel sealing device with cutting capability greatly speeds the process. If an intercostal approach is used, place the patient in left lateral recumbency and place the camera port in the ventral 1/3 of the 6th or 7th intercostal space (ICS) with instrument ports in the 4th and 8th ICS. Access to the right atrial appendage may be easier with the lateral approach.

A pericardial window is usually made in the cranial aspect of the pericardium toward the pericardial apex. A window that is 3-4 cm in diameter has been described, but the size should not matter so long as adequate tissue is excised for histopathology and culture. Fenestrate the pericardium longitudinally at least 3 times in the pericardium that is readily available for stabilization with forceps. This obviates the need for subtotal pericardectomy. If only a window
is made, be certain to avoid a moderately large window through which the heart could herniate and result in atrial compression.

Persistent right aortic arch can be treated easily with MIS. Flexible esophagoscopy should be done to confirm the diagnosis: the aorta can be seen to the right of the narrowed esophagus, and often the right subclavian is seen coursing from left to right cranially along the dorsal esophagus. Ports can be placed in the lateral thorax and triangulated from ventral to dorsal to provide a view similar to that of a lateral 4th intercostal thoracotomy or they can be placed caudally in the chest for a caudal to cranial view and dissection of the ligamentum arteriosum. Dissect the ligamentum from the esophagus and place at least 1 vascular clip dorsal and ventral. Transect the ligamentum and have forceps available in the case of inadequate clip application and patency of the ligamentum/ductus. Periesophageal fibrous adhesions are visible and easily bluntly dissected from the esophagus. The site can be checked with a balloon dilation catheter and viewed thoracoscopically.

Chylothorax can be treated with MIS. The outcome of treatment for idiopathic chylothorax approaches that reported with the open approach and has the benefit of magnification and lighting beyond that of the open approach. Prepare the entire chest, left side of the abdomen, and both popliteal fossae with the patient in sternal recumbency. Thoracic duct ligation (TDL) is done with a uni- or bilateral thoracoscopic approach. The bilateral approach reduces the risk of missed left-sided branches and allows suture ligation of the structures dorsal to the aorta and ventral to the sympathetic trunk for en bloc ligation. It is important to note that en bloc ligation is not 100% successful in the open approach, so we colorize the lymphatic system following thoracoscopic TDL.

Place a port in the middle of the chest in the 10th ICS. Explore the thorax and use visualization to triangulate placement of 2 more ports that will allow dissection perpendicularly across the aorta between 2 intercostal arteries. TDL is started with a longitudinal incision of the mediastinum parallel to and along the ventro-lateral aspect of the aorta using Metzenbaum scissors. Attach monopolar cautery to the scissors to minimize mediastinal hemorrhage during the initial incision. Dissect the mediastinum from the aorta laterally and dorsally. Place a port in the left hemithorax directly across from the dissection site. An assistant in the left hemithorax guides dissection into the left side of the chest, which was where branches were missed in experimental animals. Retract the aorta ventrally and continue the dissection across the aorta from right to left. The assistant on the left side guides the surgeon verbally to ensure that the dissection window exits on the ventrolateral aspect of the aorta on the left. Make another incision on the right side ventral to the sympathetic trunk and dissect from right to left perpendicularly across the mediastinum; the assistant on the left can guide the surgeon to avoid the left sympathetic trunk. Pass nonabsorbable suture from right to left. A second port on the left allows the assistant to grasp the suture and pass it back to the surgeon on the right. Tie the suture with an intra- or extra-corporeally made knot. We also clip the thoracic duct from right to left and left to right. The largest available endovascular clips may not span the mediastinum dorsal to the aorta in giant breed dogs, so the suture not only ligates the thoracic duct, it also gathers the tissue for clip application.

We then perform a mini-approach to a popliteal lymph node along its convex surface. Stabilize the lymph node for injection with methylene blue. Dilute methylene blue 1:60 to 1:100 and place the needle of a butterfly catheter in the lymph node. Inject the lymph node until obvious swelling is present. When the swelling decreases, inject more dye and repeat the process until distention and blue coloration reach the caudal thoracic duct. If blue coloration
passes the TDL site, dissect and apply clips to the branches. Examine the entire diaphragm and dorsal hilar region for missed branches, and clip them as necessary. If distention and blue coloration reach the areal caudal to the TDL, no further ligation is required. Place a thoracostomy tube and close the port sites routinely.

Cisterna chyli ablation (CCA) is done next. Place a port in the middle of the abdomen using a modified Hasson technique. Mild peritoneal insufflation (6 mmHg) allows examination of the right kidney and right renal artery. Successful TDL and infusion of methylene blue results in a readily visible cisterna chyli. Place 2 ports in the dorsal 1/3 of the abdomen percutaneously with the abdomen insufflated with CO2 to 12 mmHg. Decrease insufflation to 6 mmHg once all ports are in place. Dissect the aorta dorsal and cranial to the right renal artery and perform CCA bluntly, making certain that all veil-like remnants of the cisterna are removed. Desufflate the abdomen and infuse methylene blue, which should rapidly flow into the abdomen with no resistance. Close the port site routinely.

We follow TDL and CCA with a paraxiphoïd approach for pericardial window and fenestration. The results of TDL and paricardectomy were successful in 85% of dogs with idiopathic chylothorax; one death occurred in a dog with chronic chylothorax and positive bacterial cultures due to SIRS in the immediate postoperative period. As expected, surgery time was long for the procedures but should decrease with experience, as should complications and need for conversion to an open approach. The results of TDL, CCA and paricardectomy performed thoracoscopically are not known, but missed branches could result in failure, thus diaphragmatic and hilar examination following TDL and infusion of methylene blue.

Patent ductus arteriosus (PDA) has been described using a completely thoracoscopic or thoracoscopic-assisted approach. The main limitation is the size of available vascular clips (12 mm), which are not large enough to span a large ductus. A lateral approach to the PDA is done for dissection of the cranial and caudal aspects of the ductus; the medial aspect is avoided, perhaps decreasing the risk of hemorrhage.

For all thoracoscopic procedures, evaluate for hemorrhage (including the port sites and intercostal vessels) and air leakage. Treat each appropriately as for an open surgery; the use of vessel sealing devices can speed and decrease risk of hemorrhage dramatically. Place a thoracostomy tube for postoperative monitoring and instillation of local anesthetic. Postoperative management is similar to that of open surgery, with the expectation of less morbidity following MIS. There are many available procedures for MIS of the thorax, and constantly challenging ourselves to develop more procedures will constantly expand our use of this less-invasive alternative to thoracotomy.