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THORACOSCOPIC SURGICAL ONCOLOGY: LUNGS AND MEDIASTINUM

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INTRODUCTION

Read the introduction to the previous text: "Laparoscopic Surgical Oncology".
Thoracoscopy allows direct visualisation of the thoracic cavity, including the lung parenchyma, mediastinum, pleura, pericardium, heart and great vessels, which is essential in surgical oncology. The visualisation obtained during thoracoscopy is far superior to that obtained during open thoracotomy due to the magnification achieved, the light source used and the possibility of bringing the optics closer to the thoracic structures, in places that are inaccessible to the surgeon via thoracotomy.

This manuscript will discuss the applications of MIS (minimally invasive surgery) for oncological procedures, focusing solely on the lung and mediastinal masses.

THORACOSCOPIC LUNG SURGERY

Thoracoscopic approaches for lung neoplasia include lung lobectomy for primary neoplasms, as well as metastasectomy. In humans with non-small cell lung cancer, lung lobectomy through thoracoscopy-assisted (UniportalVATS) and robot-assisted (UniportalRATS) approaches is widely reported. Oncological outcomes (including disease progression and overall survival) have been shown to be similar between robot-assisted pulmonary lobectomy and video-assisted thoracoscopic surgery (VATS) for non-small cell lung cancer. In addition, better perioperative outcomes, such as reduced complication rates and shorter hospital stays, have been demonstrated with robotic and VATS pulmonary lobectomies compared to open lobectomies.

Total thoracoscopic and VATS approaches to pulmonary lobectomy have been described in dogs and cats with neoplastic and non-neoplastic lung disease. Important considerations regarding case selection for minimally invasive pulmonary lobectomy and approach include tumour size and lesion location in relation to the pulmonary hilum. Furthermore, while spontaneous pneumothorax and pyothorax may be indications for open surgery, in cases of pneumothorax/pyothorax secondary to a solitary pulmonary mass, a MMI approach may still be feasible, although conversion may be necessary if the pneumothorax/pyothorax does not improve with excision of the mass and/or if there are adhesions.

Advanced imaging, such as computed tomography (CT), is ideal for assessing the extent of disease and guiding the approach. One-lung ventilation (OLV) may be beneficial for thoracoscopic lung lobectomy, but it is not necessary for VATS approaches (the author does not routinely or frequently perform this technique). The author prefers carbon dioxide insufflation to assist during thoracoscopy, especially in obese patients or when the pleural space is limited. In this situation, special care must be taken not to insufflate too much gas, which could cause the patient to become hypoxemic. Insufflation above 2-4 mmHg is not recommended.

Although a para/subxiphoid approach (with the patient in the supine position) may be
considered for the evaluation of bilateral lung lesions, access to the pulmonary hilum is limited and the tracheobronchial lymph nodes are generally not accessible through this approach.

In cadaveric dogs and cats, optimisation of the approach and placement of cannulas for thoracoscopic pulmonary lobectomy has been described in relation to each pulmonary lobe. In general, a lateral approach with 3-4 intercostal cannulas is used; cannulas are ideally placed within the same intercostal space to minimise pain, and incisions may be connected to allow removal of the pulmonary lobe after lobectomy. Cannulas are generally placed caudally (intercostal space 8 or 9) for a cranial or middle pulmonary lobectomy and cranially (intercostal space 3 or 4) for a caudal pulmonary lobectomy.

In a study of 61 dogs with pulmonary tumours undergoing a CMI approach for pulmonary lobectomy, OLV was used in 52/61 (85.2%) cases, and conversion from a total thoracoscopic approach to VATS or open surgery was performed in 16/61 (26.2%) dogs. In that study, large tumour diameter (≥ 5 cm) and lymphadenopathy were associated with an increased risk of conversion. The median maximum tumour diameter was 4.2 cm, and the largest tumour had a maximum diameter of 12.5 cm.
Intraoperative complications, including haemorrhage, air leak, and mass rupture, occurred in 10/61 (16.4%), and postoperative complications, including air leak, aspiration pneumonia, and surgical site infection, were documented in 5/61 (8.2%) dogs.

As an alternative to a full thoracoscopic approach, VATS can be used with a minimal intercostal approach, followed by placement of a wound retractor device to allow exteriorisation of the lung lobe and stapling/transection via the mini-thoracotomy. The use of a wound retractor device or specimen recovery bag should be implemented in an effort to minimise neoplastic seeding and reduce the risk of portal site metastasis, a rare but possible sequela after CMI resection of intrathoracic neoplastic disease.
In a recent study on the use of VATS for pulmonary lobectomy in dogs for any indication, OLV was attempted in only 7/30 (23.3%) cases (and was successful in 4/7 cases), and conversion to an open approach was required in 6/30 (20.0%) dogs due to adhesions, difficulty in manipulating lung tissue through the mini-thoracotomy, and oxygen desaturation. Of the dogs with a lung tumour, the median tumour diameter was 4.3 cm and the maximum tumour diameter was 10 cm.

The author's team presented a study entitled "Thoracoscopy-assisted mini-thoracotomy (TAMT) for pulmonary lobectomy in canine primary lung tumours: 16 cases (2016-2022)" at the European College of Veterinary Surgeons (ECVS) congress in 2023. This study included dogs operated on for the removal of a primary lung tumour using a TAMT approach (with a mini-thoracotomy with muscle preservation from the start of surgery).
Regarding the results: 16 dogs with a solitary pulmonary mass (main location in the caudal lobes, 11/16). The median tumour size was 4.1 cm. The median surgical time was 80 minutes. The histological diagnosis was papillary adenocarcinoma (15/16) with clear margins in all cases. The median chest drainage time and hospitalisation time were 16 hours and 1 day, respectively. No complications were recorded. All dogs survived to discharge. The surgical time in this study was shorter than that previously reported for VATS (120 minutes) and TT (total thoracoscopy) (108.8 minutes). The median hospitalisation time was 1 day, compared to 2.5 or 2 days for OT (open thoracotomy) and VATS, respectively. These findings may be due to the mini-thoracotomy technique, which preserves the musculature from the start of surgery under direct thoracoscopic visualisation, and the use of an atraumatic intercostal circular wound retractor, which protects the muscles and nerves. This study concludes that TAMT for complete lobectomy is a safe, feasible, and rapid approach that offers the benefits of minimally invasive surgery, increases surgical exposure, and reduces surgical time.

Lung metastasectomy, often performed using minimally invasive approaches, is an established treatment that can improve outcomes in human patients with many types of tumours, although careful case selection is required.

With regard to metastasectomy in veterinary patients, clinical benefit has been predominantly described for dogs with stage III osteosarcoma that meet the following criteria: adequate local control of disease with adjuvant chemotherapy, disease-free interval > 275 days, < 3 pulmonary metastatic lesions, and metastatic lesion doubling time > 30 days (although this is not used as a criterion in all studies). Most metastatic

osteosarcoma lesions are peripheral, subpleural, and amenable to partial lobectomy or marginal excision techniques. To date, there are minimal data regarding MCI approaches for metastasectomy in dogs. However, with the advent of MMI techniques and the described perioperative advantages of MMI as opposed to open thoracotomy procedures, further investigation into the indications and role of metastasectomy in relation to oncological benefit is warranted. The minimally invasive approach required for metastasectomy is variable and depends on the location and number of lesions. For cases with bilateral lesions, supine positioning with a multi-port technique including a transdiaphragmatic/subxiphoid cannula as well as several parasternal cannulas may be considered; alternatively, for unilateral disease, a lateral approach with intercostal ports may be preferred.
Ultimately, however, a total thoracoscopic approach should be feasible for most cases due to the generally small size of the lesion and relatively peripheral locations.

Intrathoracic lymph node dissection
Given the prognostic importance of nodal staging in dogs and cats with lung tumours, lymph node biopsy (excision) at the time of pulmonary lobectomy has generally been recommended. As thoracoscopic approaches to pulmonary lobectomy and intrathoracic tumour resection become more widespread in small animals, the development of minimally invasive techniques to identify and biopsy or remove lymph nodes for accurate staging will also be important. Both thoracoscopic and robotic approaches for intrathoracic lymphadenectomy have been described in human patients for staging with reported benefits of a minimally invasive approach. A VATS approach for tracheobronchial lymph node removal has been reported in 8 healthy dogs. The dogs were placed in the lateral decubitus position and OLV was used; ports were placed in a variety of locations, although typically one camera port was placed in the fifth intercostal space and 2-3 additional ports were placed in a triangular pattern. The ipsilateral tracheobronchial lymph node was identified in 7/8 cases, and the central tracheobronchial lymph node was only identified in cases that underwent a right-sided approach. Complications included haemorrhage and OLV challenges; conversion was not performed in any case, although lymph nodes were not identified in 1 dog.
In addition, intraoperative sentinel lymph node (SLN) mapping using a VATS approach has been described in a clinical dog with pulmonary adenocarcinoma, using indocyanine green. In this dog, the tracheobronchial lymph node was the sentinel node. It was identified as the sentinel node using indocyanine green (ICG) imaging and near-infrared (NIR) imaging.
Another technique recently described in cadaveric dogs involves a single-incision mediastinoscopy approach for the evaluation of tracheobronchial and cranial mediastinal lymph nodes. Low-pressure carbon dioxide insufflation was used to improve the working space, and mediastinoscopic sampling was feasible for the left tracheobronchial lymph node in 7/7 cases and the right tracheobronchial lymph node in 4/7 cases.

RESECTION OF CRANIAL MEDIASTINAL MASS

Thoracoscopy-assisted (Uniportal VATS) and robot-assisted (Uniportal VATS) approaches are commonly performed for thymoma excision in humans. Compared to sternotomy for thymoma excision, VATS has been associated with less blood loss, shorter hospital stays, lower postoperative pain scores, and fewer postoperative complications, with no significant differences in survival times.

Minimally invasive resection of cranial mediastinal masses has been reported in dogs and cats. A cellular diagnosis is needed to determine the type of tumour and the indication for surgery, as mediastinal lymphoma requires medical treatment and thymoma requires surgical treatment.

It is very important to perform advanced imaging such as CT to determine the extent of the disease and evidence of macroscopic invasion into locoregional soft tissue or vascular structures to subsequently guide the approach. Typically, the VATS approach is performed with the patient in the supine position through a subxiphoid port and bilateral parasternal ports. Considerations for case selection include tumour size, macroscopic invasion, and patient size/conformation. The maximum tumour size reported to have been resected using a VATS approach in a dog was 8.5 cm in diameter.

Anecdotally, dogs with barrel chests have less working space for thoracoscopic mediastinal mass excision compared to dogs with deep chests. Although not necessary in all animals, OLV can be used to improve working space, particularly in patients with barrel chests.

In a study of VATS for resection of cranial mediastinal masses in 18 dogs, conversion to open thoracotomy was required in 2/18 (11.1%) dogs, and major intraoperative complications occurred in 1/18 (5.6%) dogs in which the vena cava was lacerated, resulting in death.

Major postoperative complications occurred in 6/7 (85.7%) dogs with paraneoplastic myasthenia gravis and megaesophagus in that study.
In a recent study of thoracoscopic excision of cranial mediastinal masses in 49 dogs, in which the author collaborated on 25% of the cases, the median maximum tumour diameter was 4.7 cm, and OLV was used in 8/49 (16.3%) dogs. In that study, conversion to an open approach was required in 4/49 (8.2%) dogs, no major intraoperative complications were reported, and major postoperative adverse events, including aspiration pneumonia and pulmonary thromboembolism, occurred in 5/49 (10.2%) dogs.

Another important postoperative sequela involves the potential for metastasis at the portal site, which has been reported after VATS for excision of malignant (invasive) thymoma in a dog. This highlights the important need to implement techniques and equipment, such as endoscopic specimen retrieval bags and wound retractor devices, to minimise the risk of tumour seeding with MCI procedures. A VATS approach has been successfully performed in a cat for resection of a thymoma, and low-pressure carbon dioxide insufflation was used to improve the working space in that case.

FUTURE DIRECTIONS AND CONCLUSIONS

Substantial advances have been made in the field of MCI for veterinary oncology patients in recent years. However, considerable development is still needed to determine feasibility, optimise techniques, guide case selection, and evaluate the potential advantages and disadvantages of MCI approaches in dogs and cats with a variety of neoplastic diseases.

One such area of potential growth in the field of veterinary MIS involves robotic surgery. Robotic and robot-assisted oncologic procedures have become widespread with demonstrated benefits over open surgery and, in certain studies, also over laparoscopic/thoracoscopic procedures. The advantages of robotic surgery over traditional MCI include improved dexterity of instruments with dual articulation and 7 degrees of freedom, improved access in confined workspaces, and 3D magnification. Its main limitation is cost.

As minimally invasive procedures for veterinary oncology patients become more routine, it is also necessary to describe and study minimally invasive SLN mapping techniques, likely using concurrent NIR imaging, in relation to efficacy and impact on oncological outcomes.

In addition to the usefulness of NIR imaging for SLN mapping, applications of targeted NIR imaging following intravenous injection of fluorescent imaging agents with selective uptake or activation by neoplastic tissues are being actively studied in human oncological surgery, with the overall goal of improving the ability to obtain tumour-free margins, identify hidden synchronous/metachronous lesions that are otherwise undetectable intraoperatively, and accurately differentiate metastatic lesions from benign lesions for concurrent resection.

Targeted NIR imaging is particularly applicable to CMI for cancer patients, as thorough examination with palpation of all intrathoracic/intra-abdominal tissues is limited compared to that of open surgical procedures.

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