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Advanced Surgical Procedures for Advanced Practitioners Mini Series

Session 2: Take a Dip into the Chest and Lose the Fear!

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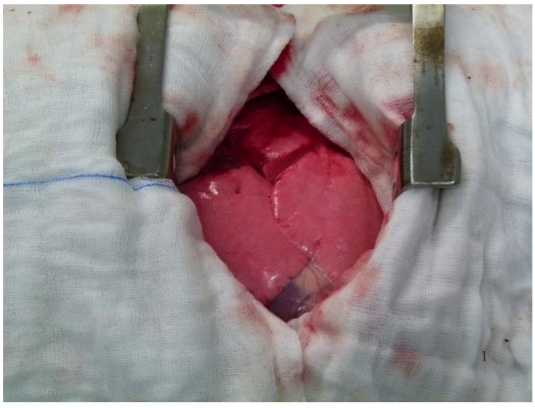

Approach to the thorax

Anatomy of the thoracic wall

The skeletal structure of the thorax of the dog and cat is made up of 13 pairs of ribs, 13 vertebras and 9 sternebras. Each rib has two joints, the proximal or costo- vertebral; and the distal; the first nine ribs have a synovial joint with the sternon. The movement of this joints plus the curvilinear shape of the ribs permits the expansion of the thoracic cavity.

The chest wall is made up of the following muscles:

- Cutaneous trunci: it's a thin muscle that covers the whole body of the dog and cat. This muscles is normally incised as we cut into the skin and subcutaneous tissue.
- Lattisimus dorsi: it originates in the lumbodorsal fascia and extends from the spinous processes of the lumbar and caudal-lumbar vertebras. The muscles follow a craneo-ventral direction inserting in the medial fascia of the forelimb.
- Scalenus: it extends from the transverse process of the cervical vertebras inserting between the fifth and sixth rib.
- Serratus ventralis: the thoracic portion inserts between the 7^{th} and 8^{th} rib. It has a very distinctive serrated portion. This muscle is normally incised between its muscle bellies.
- External abdominal oblique: it originates in the fifth-sixth and seventh rib.
- External intercostal muscle: its fibers are directed in a craniodorsal to caudo ventral direction
- Internal intercostal muscle: its fibers are directed in a caudodorsal to cranio ventral direction. In its medial portion the pleura can be identified.
- Abdominal rectus: it originates in the costal cartilage and it extends in a caudal direction inserting in the cranial portion of the pubic bone. This muscle is rarely identified in the thoracic approach.
- Pectoral superficial and deep muscles: they can be identified in the ventral aspect of our incision.

The intercostal artery and vein originate in the aorta and azigos vein respectively, they can be identified in the caudal aspect of each rib and continue with the internal thoracic artery and vein, which goes lateral to the sternon.

The intercostal nerves originate from the ventral branch of the thoracic nerve and then they join the intercostal nerves. We have to remember that in the cranial aspect of the ribs we can also identify intercostal artery, veins and nerves, which are smaller than the caudal ones.

Surgical approach to the thorax

The approach to the chest can be done from the simple approach that we can do with a chest drain to more complex approaches. The three most common approaches are:

1. Intercostal thoracotomy
2. Median sternotomy
3. Transdiaphragmatic incision

- The majority of the approaches to the chest are performed through a intercostal thoracotomy.
- In patients in which both hemithorax need to be explored or we have to access the mediastinum we will use a median sternotomy.

Intercostal Thoracotomy

Indications:

- Any procedure we need to perform in a hemithorax
    - Pulmonary procedures: biopsy, partial or total lobectomies
    - Cardiac procedures: pericardectomies, PDA ligation, vascular anomalies
    - Access to the mediastinum, chest wall, pleural structures, esophagus, trachea, thoracic duct, etc
- Compared with a sternotomy, an intercostal thoracotomy gives us a better access to the dorsal thoracic structures, the pulmonary hilus, thoracic duct, and peribronquial lymph nodes.
- The most important point with this approach is performing our incision in the correct intercostal space, because through this approach we have a very limited access to the thorax. Due that the ribs can not be distracted too much limiting the exposure.

Table 27–1. Location of Thoracic Structures Through Intercostal Thoracotomy

	Intercostal Space*	
Thoracic Structure	*Left*	*Right*
Heart and pericardium	4, 5	4, 5
Ductus arteriosus (patent ductus arteriosus, persistent right aortic arch)	4 (5)	
Pulmonic valve (pulmonic stenosis)	4	
Lungs	4–6	4–6
Cranial lobe	(4) 5	(4) 5
Intermediate lobe		5
Caudal lobe	5 (6)	5 (6)
Esophagus		
Cranial		3, 4
Caudal	7–9	7–9
Caudal vena cava	(6–7)	7–9
Thoracic duct		
Dog	(8–10)	8–10
Cat	8–10	(8–10)

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Surgical Procedure:

The patient is placed in lateral recumbency, being right or left depending what side is going to be the approached. The selected hemithorax is prepared surgically. The clipping should go from the dorsal spinal processes up to the sternum; and from the cranial part of the scapula up to the last rib. The forelimb are tied cranially, to displace the scapula and forelimb muscles forward, this will improve our approach. A sandbag or rolled up towel is positioned under the chest at the level of the chosen intercostal space, this will separate the ribs and bring closure to the incision the internal structures, improving the internal exposure.

Before performing our incision it is very important for us to know exactly what intercostal space we want to access. We will count the intercostal spaces for then perform the skin incision in the space selected. In the case of right 4th or 5th intercostal thoracotomy, the skin incision would be performed 2 cm caudal to the scapula. The incision is started ventral to the transverse process of the vertebras extending up the costocondral junction. Following this an incision is made in the subcutaneous muscle and subcutaneous tissue, exposing the latissimus dorsi muscle. Here we have two options, one we can incise the muscle to access the next layer of muscles; or if we have a second surgeon the muscle can be retraced dorsally. This second maneuver gives you less access but it is possible that it will cause less postoperative pain. From the point of affecting the function of the forelimb there is no difference. Before incising the latissimus, we will wet our finger and bluntly dissect this muscle from the underlying tissue, we will direct our finger cranially to palpate the first rib and from here we can count exactly the intercostal spaces, and make sure we are in the correct space. Also at this time we will perform an intercostal block with local anesthetic (lignocaine, bupivacaine).

Once satisfied that we are in the correct space we will incise the lattissimus dorsi, exposing the Serrato ventralis muscle. We will try and dissect this muscle between its muscle bodies; this will be less traumatic and will give us a more hermetic closure.

The following layer is the Scalenus muscle, this muscle inserts between the 5th and 6th rib, and this can helps also with the correct identification of intercostal spaces. As we incise this muscle we will leave a small piece of the tendon attached to the rib to be able to suture back together this muscle.

We will try to incise separately through the external and internal intercostal muscle, leaving the pleura intact. This way we can identify the lungs under the pleura and decrease the chance of iatrogenic damage of this organs. At this moment we can ask the anesthetist to stop ventilating the patient, this will collapse the lungs permitting for us to incise safely the pleura. The approach does not need to be extended ventral to the costocondral junction as if we do this there is a higher risk of damaging the internal thoracic artery, but if we need to have a better exposition then the artery and vein can be identified and the approach extended, being careful not to damage it as this will produce a profuse bleeding.

Next will use laparotomy swabs to protect the borders of the chest wall, and we will introduce Finochietto retractors to improve our exposure. If we dont have Finochietto retractors, Gelpi retractors can be used. They work well in small dogs and cats but in large dogs they will limit the exposure we need.

The ribs have a bigger capacity of displacement cranially than caudally, because of this, if we are not sure what intercostal space we need, its better to perform an incision in a more caudal space a we will be able to displace more the rib cranially.

Closure:

Before closing our surgical incision we will count swabs and will place a chest drain. We will pre-place between 4-6 circumcostal monofilament absorbable sutures, size 2-0/1 UPS, depending on the size of the patient, this sutures will be tagged with hemostats. As we place the sutures it's important not to damage the intercostal vessels and nerves, which are localized to the caudal aspect of the ribs. We should always have a good control of the needle as we pass into the chest, the lungs will be protected with our hand, and we will coordinate our suturing with the ventilation cycle to prevent any damage to the internal organs. Once all the sutures are placed our assistant will pull two sutures in opposite directions, closing the intercostal space and relieving tension, making our suturing easier. The intercostal muscles don't need to be sutured, you could probably suture them in large breed dogs but even then it's not necessary.

The serratus ventralis and scalenus, or external abdominal oblique muscles are closed in a simple continuous pattern followed by the latissimus dorsi and its fascia in a simple continuous pattern. The subcutaneous tissue and skin are closed routinely.

Median Sternotomy

Indications:

- This approach is used when we have to explore both hemithorax, we need a bigger exposure for resection of large mediastinic masses (thymoma), access to the right ventricle and in patients that the abdomen is also going to be explored.
- Lung lobectomies can be performed through this approach; due to the depth of the pulmonary hilus it makes this procedure slightly more technical than performing it through an intercostal thoracotomy.
- This access is not indicated for exploration of the esophagus, caudal vena cava and peribronchial lymph nodes.

The postoperative morbidity is decreased if we can perform a longitudinal osteotomy of the sternum in its midline, without causing fractures. This permits a more stable closure, improving healing of the sternum. Sternal instability produces pain in the postoperative period and a prolonged recovery, with the possibility of a malunion. To improve this stability it's also important if we can leave the manubrium or the xifoides intact, this will increase stability.

Surgical Procedure:

Patient preparation. Clipping will extend from the middle of the cervical region caudal to the umbilicus, laterally it will extend dorsally to a midpoint in the thorax; remembering that we will have to place chest drains. The patient is positioned in dorsally recumbency, the forelimbs can be left as they fall or better tied caudally making it easier for dissection in the cranial aspect of the thorax and caudal portion of the neck. We have to remember to free the forelimbs once we are suturing to decrease tension on our incision.

An incision is made in the ventral midline, incising skin and subcutaneous tissue. We will use electrocautery to stop bleeding originating from branches of the internal thoracic artery. At this time we can perform a para-sternal block with local anesthetic. The pectoral muscles are separated from its origin of the ventral surface of the sternum, keeping always on midline. Once we have the sternebras exposed we can use electrocautery to mark the midline where we are going to perform our osteotomy.

We will perform the midline sternal osteotomy with an oscillating saw; in small dogs or cats bone cutters or a mallet and hammer can be used if we haven't got an oscillating saw, but this is not ideal. We will start our osteotomy midline and advance cranially or caudally, depending what area of the thorax we want to expose, remembering that we want to leave some sternum intact to give stability. If we use an oscillating saw we will use irrigation to prevent burning the bone, as this could affect healing.

Once that we have cut full thickness through a couple of sternebras, we will place a gelpi retractor, this creates tension helping with the osteotomy but also will permit visualization of the thoracic cavity; making sure there is no adhered organs to the sternum that we could damage as we perform the approach. If we access through the cranial aspect of thorax we need to identify the internal thoracic artery and vein so we don't damage it and if necessary this can be ligated. Once the osteotomy has been performed we will place large laparotomy swabs and the Finochietto retractors to improve exposure.

Closure of the Sternotomy:

A chest drain is placed. The sternum can be closed with cerclage wire (18-22g) using a peristernal figure of "8". If the patient is less than 10 kg absorbable or non-absorbable sutures, size 0-1 can be used. The sutures are pre-placed and sutured, the pectoral muscles are sutured with an absorbable simple continuous pattern, followed by a routine closure of all the layers.

Transdiaphragmatic Thoracotomy

In certain circumstances we need to enter the thoracic cavity when we perform a celiotomy.

Indications:

- Disease that is localized to the abdominal cavity but extends into the thoracic cavity
- Ligation of a portoazygos shunt or intrahepatic shunt
- Ligation of the thoracic duct
- Caudal oesophagostomy
- Temporal occlusion of the vena cava
- Placement of an epicardial pacemaker
- Treatment of a diaphragmatic rupture, this is the most common cause

The entry will be performed by incising on the central tendon or by incising on the lateral areas of the diaphragm. Before performing the incision we need to identify caudal vena cava and esophagus. Following this an incision is performed on the ventral aspect of the diaphragm, extending dorsally. The closure of the incision of the diaphragm is performed by using a simple continuous absorbable suture, size 2-0/3-0 UPS.

Post operative care

After performing any of this techniques, during the postoperative period the patients should be continuously monitored. Especially because all this patients will have a temporary chest drain, and if there is a complication this could cause the death of the patient.

During this period the HR, RR, arterial pressure and oxygen saturation should be analyzed in a regular basis. Initially we would start every 4hr, and then spread it as the patient recovers. During this initial period blood glasses could also be performed.

Respiratory management: Ventilation can be affected by pain, bandages, primary pathology or secondary atelectasia due to the positioning of the patient during the procedure. Managing pain correctly is probably one of the most important factors in ventilation. During the first few hours oxygen should be supplemented via an oxygen cage or nasal oxygen prongs.
Chest drain: the frequency of aspiration will depend on the pathology and the amount of liquid or air that is producing. Normally the initial frequency will be every 4hr, but if the amount of fluid or air is very large this could be done every hour, or a continuous suction system can be used. The amount of air and liquid should be measured and recorded, so we know what is the tendency and this will help in deciding when the chest drain will be removed.

During the recovery mild exercise is good to stimulate ventilation and the elimination of secretions.

Analgesia: an analgesic plan is essential in the management of this patients, the objective is for this patients to return to normal activity as soon as possible. A correct management will improve ventilation, as it helps with the expansion of the chest wall. The presence of pain can cause hypoventilation, hypoxemia and atelectasia. A combination of opioides (methadone, morphine, fentanyl, buprenorphine) in an intermittent or continuous form should be used in combination with local analgesic introduced through the chest drain or a diffusion catheter. Other analgesics that could be used would be nsaid, alpha 2 agonists, NMDA agonist (ketamine). Normally a combination of all this analgesics are used.

Management of the surgical incision: the mayority of the incisional complications are minor and self limiting (seroma, haematoma, small dehiscence or secretions). Some patients may suffer a small limp in the forelimb as they extend it due to the incision in the latissimus dorsi, this are normally minor and self limiting.

In conclusion:

The approach and closure of the thoracic cavity is a surgical procedure that most veterinarians can perform, but it needs certain experience and training. It is also very important to have the appropriate anesthetic, surgical and postoperative facilities, as a minimum equipment to make sure that we have the desired outcome.

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Lung Surgery

Anatomy:

The left lung of dogs and cats are divided into cranial and caudal. The left cranial lung lobe is divided into a cranial and caudal portion but shares a common lobar bronchus. The right lung lobe is divided into four distinct lobes, cranial, middle, caudal and accessory. The accessory passes dorsal over the caudal vena cava and is located medial to the plica vena cava.

The trachea divides into two main bronchus, which in turn subdivide into lobar bronchi that supply each lung lobe. Within each lobe they divide into segmental bronchi followed by subsegmental bronchi, terminal bronchioles and respiratory bronchioles. Respiratory bronchioles give rise to alveolar ducts, alveolar sacs and pulmonary alveoli.

The pulmonary artery follows the lobar distribution in close proximity to the cranial dorsal aspect of each bronchus. The pulmonary vein follows the caudal ventral aspect of the bronchus.

Specific pathologies

Cysts, Bullae and Blebs

Cysts: they are characterized for a thin cavity inside the pulmonary parenquima. Cysts can contain air or fluid and they are covered by a respiratory epithelium. The most common cause is trauma to the thorax and pulmonary contusions. In some occasion the cyst can get infected and become an abscess destroying the respiratory epithelium.

Bullae and blebs: they are similar to cysts but they are not lined by a respiratory epithelium, but they are surrounded by a fibrous wall. Bullae are large air spaces that develop within the lung parenchyma and blebs are small accumulations of air between the parenchyma and visceral pleura. These cavities develop from traumatic rupture and coalescence of alveoli and frequently secondary to obstructive lung disease.

Diagnosis:

Bullae and blebs present different type of complications: infections, abscess formation, rupture which result in pneumothorax development and compression of the pulmonary parenquima. This patients develop with dyspnea, exercise intolerance and abdominal breathing. On auscultation may reveal decreased ventilation sounds on the affected side.

In patients with spontaneous pneumothorax it is very important to look for this lesion on thoracic radiography. Thoracic radiographs will reveal pneumothorax, sometimes pneumomediastinitis and on some occasions bullae, blebs or cysts. TAC is more sensitive for detecting this lesions.

Treatment:

Patients with spontaneous pneumothorax can be treated conservatively for 2-3 days. Chest drain are placed and emptied as needed depending on the respiratory rate and effort. The majority will improve with conservative treatment, but a high proportion will reoccur. If there is no big improvement in 3-5 days then an exploratory thoracotomy is recommended.

The treatment is a partial or total lung lobectomy. The surgical approach will be a median sternotomy as in most patients there is more than one lesion, and many lesions are bilateral. If we can't identify easily the cause of the pneumothorax, the thoracic cavity can be filled up with warm sterile saline and the patient ventilated, this should hopefully show up the leaks. Visual lesions are resected by a partial or total lung lobectomy, ideally a lung lobectomy will be performed with a stapler.

Consolidated lung lobes and abscess

The lung consolidation is normally due to secondary pneumonia or to a foreign body, bacterial or fungal infection or parasites. Lung abscesation is more common in cats that dogs, although it is uncommon in both species. Abscess can be caused by thoracic penetrating wounds, vascular obstruction, or central necrosis of a pulmonary neoplasm. Secondary to the abscess a pyothorax can results due to rupture of the abscess or intrapleural leakage.

Diagnosis:
Thoracic radiography: can aid in locating the involved region. The pleural space may have to be drained before a definitive radiographs diagnosis can be made. An abscess has a water density unless it has ruptured and drained. Consolidated lung lobes results in an alveolar pattern with air bronchogram generalized to the entire lobe. CT: has been used to identify pulmonary foreign bodies or further localize the lesion.

Bronchoscopy: purulent exudation can be observed in the affected bronchus and in some occasion the foreign body can be observed and even removed.

Treatment:

Medical management: thoracic drainage may be necessary to relieve respiratory distress and to obtain samples for cytology and culture. Medical management should always be performed before surgical treatment to stabilize the patient. Appropriate antibiotics are administered for at least 2-3 weeks. If there is pleural effusion a thoracostomy tube should be placed and pleural lavage is performed during the initial period of treatment. If the condition does not improve after the first week of treatment or if the patient is deteriorating then an exploratory thoracotomy and removal of the affected lung lobe should be performed.

Surgical treatment: compared to medical treatment a prompt surgical approach will decrease recovery time by removing the initiating cause.

A median sternotomy is performed to be able to explore both hemithorax. It is possible that adhesion have occurred to the thoracic wall. They can be dissected free by careful digital pressure and sharp dissection without significant lung damage except if the adhesion is well organized. Once the affected lung lobe is identified a partial or total lung lobectomy is performed. If several lobes are affected several lobectomies can be performed, but resection should be limited to 50% of the total lung volume.

Prognosis:

Bacterial pneumonia is dogs as a cause of consolidate lung lobes seems to have a higher mortality rate than abscess from foreign body or fungal infections. In a study the mortality rate was 20% and was correlated with the amount of lung parenchyma removed. If only one lung lobe was resected the mortality rate was 14%.

Lung laceration

Blunt or penetrating trauma to the thorax can induce lung lacerations and this subsequently produce pneumothorax. Trauma can also result in lung contusions that can make worse the clinical presentation. Rib fractures can also produce lung lacerations. Another cause of lung rupture is explosive ruptures due to lateral compression of the chest wall with a closed glottis resulting in a rapid increase in airway pressure. Lung lobe laceration may also occur with diagnostic and therapeutic produces such as lung aspirates and chest drain placement.

Conservative management in the initial treatment with traumatic pneumothorax and lung laceration. Small lung lacerations usually resolve on their own or with the use of thoracic drainage to control the pneumothorax. During this initial treatment oxygen supplementation via oxygen cage, mask or nasal catheter may be required. If the pneumothorax is affecting ventilation a chest drain will need to be placed. If a wound is present, it should be explored and debrided as soon as the patient is stabilized. If the thoracic wall is not intact, it should be repaired to establish negative pressure in the pleural space.

If after 3-5 days of conservative treatment there is no improvement, surgical exploration should be performed. The preferred approach would be a median sternotomy, as this will permit exploration of the entire thoracic cavity and each lung lobe. If the air leak is not easily observed the chest can be filled with warm saline and the bubbles observed as we ventilate the patient. The air leakage can be repaired with a mattress pattern of absorbable 4-0/5-0 sutures, if they are small lacerations. If the damage were extensive partial or total lung lobectomies would be indicated.

Lung lobe torsion

Lung lobe torsion is an uncommon condition in dogs and cats. Large dogs with a deep and narrow chest then to have a higher incidence and the tendency for the torsion to occur in the right middle lung lobe or left cranial lung lobe, but any lung lobe can be affected. Lung lobe torsion can be spontaneous or occur secondary to other conditions. Lung lobe torsion has also been reported in cats, and specially in pugs. In pugs the condition tends to be spontaneous and affect the left cranial lung lobe.

The cause of the condition is poorly understood but may results from partial collapse of the lung lobe, permitting increased mobility. Lung lobe torsion has been associated with chronic respiratory disease, chylothorax, trauma, thoracic surgery and neoplasia. Most torsion will cause venous. Lymphatic and bronchus obstruction with continued arterial blood flow, resulting in edema, hemorrhage and necrosis. Subsequently the lobe becomes severely congested and consolidated as fluid moves into the interstitial tissue and airways. Pulmonary venous hypertension and decreased lymphatic drainage lead to pleural effusion.

Diagnosis:

Clinical signs can be related to local and systemic effect of the consolidated or necrotic lung lobe and accumulation of fluid in the pleural space. Patients can have acute or chronic presentation. Duration of clinical signs can go from 2 to 120 days.

Thoracic radiographs: will reveal pleural effusion and lung consolidation. Consolidated lobes may reach inflated size but early in the condition can appear smaller than normal. Early in the process air bronchograms are noted, however the air is absorb and replaced with fluid. Radiographically torsed lung lobes have increased fluid opacity and 97 % are emphysematous. Other signs are displaced bronchus, mediastinal shift and dorsal tracheal displacement.

Changes can be better observed in CT. on CT bronchi are narrowed, collapsed or occluded and all have abrupt terminations. the bronchus to the affect lobe is air filled with a tapering termination angle proximal or distal to the region of collapse. Vesicular emphysema can also be identified.

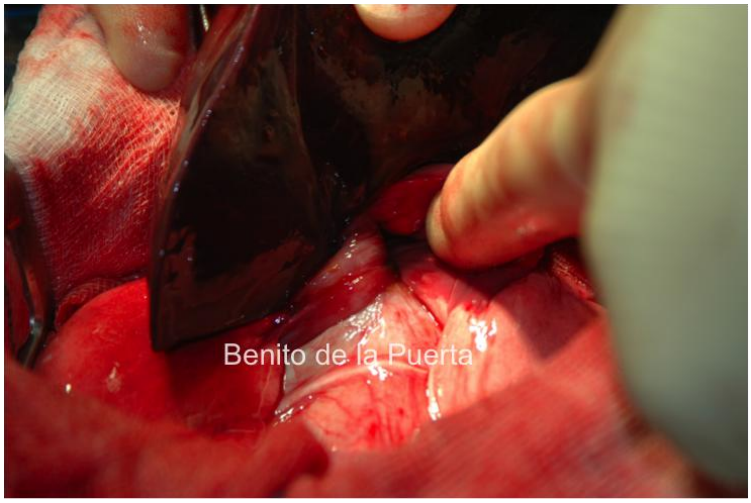
On ultrasonography the affected lobe has the consistency of a soft tissue mass, pleural effusion and gas bubbles with in the lobe may be detected.

Bronchoscopy the obstructed or torsed orifice of the main bronchus may be observed.

Treatment:

Initial therapy is symptomatic with the objective to stabilize the patient. If we know the lung lobe affected the approach will be an intercostal thoracotomy, if not we should perform a median sternotomy. The treatment of choice will be a lung lobe lobectomy with out untwisting the lung lobe, to prevent the liberation of inflammatory mediators. Stapling equipment is the preferred method. If stapling equipment is not available the pedicle is clamped with non crushing forceps and then untwisted. After the lung as been untwisted, the vessels and bronchus are exposed and ligated with sutures.

Prognosis:
The prognosis in one study was reported as fair to guarded after lobectomy with a survival rate of 50%. In another study survival rate was around 61% with a favorable outcome in pugs.



Pulmonary Neoplasia

Primary lung neoplasia represents 1% of all tumours in dogs, and its much less common than metastatic neoplasia. Most primary lung tumours are malignant with carcinomas of bronchial and alveolar origins predominating. Other tumor include squamous cell carcinoma, sarcoma and anaplastic tumours. Animals with primary or metastatic lung tumour or other thoracic masses may results in extensive develop hyperthrofic osteopathy, a paraneoplastic syndrome.

Diagnosis

Three view thoracic radiographs. The most common radiographs sign is a solitary mass in a caudal lung lobe. The mass may appear cavitated if there is necrotic tissue. The hilar lymph nodes should be assessed on CT scans as the presence of lymph node metastasis affect prognosis. CT can also improve the detection of small tumours. Definitive diagnosis is by demonstration of neoplastic cells on histological or cytological evaluation. To reduce complications this test should be performed guided by ultrasound.

Treatment:

Surgery is considered in animals with primary or metastatic neoplasia of the lung if the mass is a solitary nodule. A lung lobectomy is performed via thoracotomy or thoracoscopy.

Prognosis:

Survival rate are correlated with the histologic cell type, tumour size, presence of metastasis, presence of pleural effusion and clinical signs. Survival times of animals with out clinical signs or lymph node involvement at time of surgery where 545 days and 452 days respectively, compared with 240 days and 26 days when clinical signs or lymph node involvement were present. The prognosis is better for dogs that have a solitary well differentiated carcinoma smaller than 5 cm, no regional lymph node involvement and no malignant pleural effusion.50% of dogs can survive for 1 year.

In cats the degree of differentiation is predictive of survival. Survival times of cats with moderately differentiated tumor is 698 days compared to 75 days for poorly differentiated tumours.

Surgical Techniques

Partial lobectomy

Partial lobectomy of the distal two thirds or less of lung lobe can be performed for diagnostic biopsy or removal of isolated disease, such as abscess, cysts or bullae, small tumors and severe lacerations. The surgical approach can be made through an intercostal thoracotomy, sternotomy or thoracoscopy.

Partial lobectomy can be performed with the use of crushing forceps and continuous overlapping hemostatic-pneumostatic sutures. Once the area of interest is resected the edge of the lung incision will be over sewn with a very closely spaced simple continuous pattern of absorbable suture. The second technique which is quicker, safer and easier would be performing the partial lung lobectomy with the use of mechanical stapling equipment. The staples are positioned across the lobe proximal to the lesion, and a double row of fine staples are placed. The lobe distal to the staples is cross clamped to prevent leakage and excised between the clamp and staples. Small air leaks and hemorrhages are occasionally found along the stapled surface due to the B configuration of the staples. These leaks are controlled by a few interrupted sutures. Stapling is very rapid and is warranted in patients in critical condition.

Total lung lobectomy

The preferred open surgical approach for total lung lobectomy is through a lateral intercostal thoracotomy. Lung lobectomy is more complicated through a median sternotomy, however this approach is more appropriate if lung lobes must be removed from both sides of the thorax or exploration of the pleural space is required. During caudal lung lobectomy, the pulmonary ligament, an avascular pleural fold that extends from the caudal edge of the hilus to the mediastinal pleura, must be transected to mobilize the lobe.

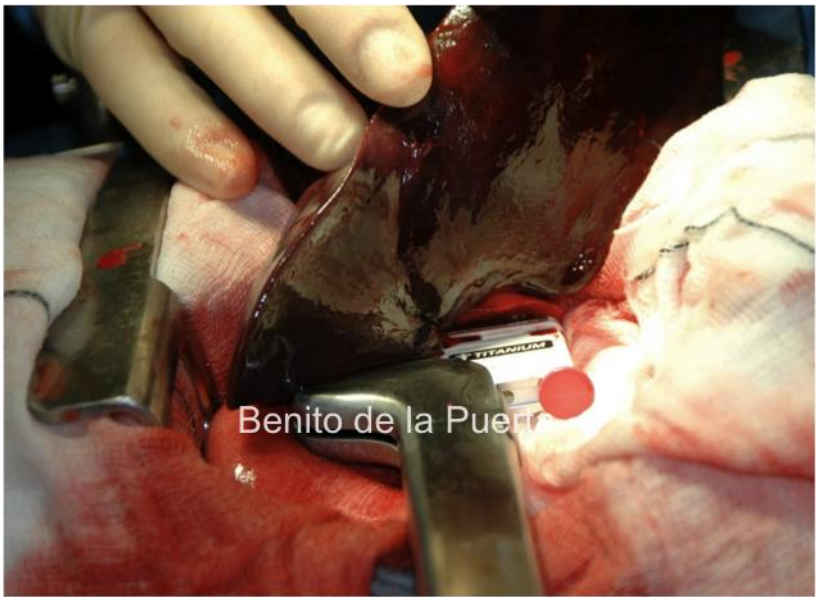
<u>Suture ligation</u>

Unaffected lung lobes are packed out of the way with moist laparotomy sponges. The pulmonary vessels and the lobar bronchus are identified. The arterial supply to the lobe is approached first to control blood flow to the lobe. The pulmonary artery is exposed by sharp and blunt dissection until its circumference is clear of pleural and perivascular tissue. The artery is triple ligated, using 2-0/3-0 absorbable or non absorb able sutures, taking care not to encroach on the lumen of the parent vessel.
The lobe is retraced dorsally, and the pulmonary vein is approached on the ventral side of the bronchus. Care is taken as this structure is more delicate than the artery. Three ligation sutures are placed, again being careful not to incorporate the venous drainage from the other lung lobes. and the vein transected.
The main bronchus supplying the lobe is dissected free of the remaining tissue. The bronchus is cross-clamped with two pairs of noncrushing type forceps. The bronchus is transected between the forceps and the lung is removed. Near its origin and proximal to the remaining clamp, the bronchus is sutured with preplaced interrupted horizontal mattress sutures of 2-0/3-0 absorbable or non absorbable monofilament sutures. The mucosa and cartilage on the distal edge of the bronchus are over sewn with a simple continuous pattern. The bronchial sutures line is tested for air leakage by flooding the thorax with warm sterile saline. Additional sutures may be placed to close major leaks. Small suture hole leaks are closed by suturing surrounding pleural and subpleural tissue over the end of the bronchus and vessel stump.

<u>Stapling technique</u>

Total lung lobectomy using automatic stapling equipment can be performed more rapidly than suture ligation and with minimal complications. A premium thoracic anastomosis (TA) V3 or TA55 with 3.5 mm staples is usually used to occlude the vessels and bronchus. The TA stapler is placed across the hilus of the lung, being sure to exclude vessel sand tissue to the other lobes. The stapler is fired and the affected lobe is transected distal to the stapler. The

lobe should be clamped by to prevent intrathoracic contamination upon transection. The stapler is opened, and the lung lobe is released and checked for hemorrhage or leakage. TA staples may be difficult to position in a small animal. The bronchial sutures line is tested for air leakage by flooding the thorax with warm sterile saline. Leakage of air and blood through the B shaped staples usually seal spontaneously, sutures are used to stop minor leakage.



Pneumonectomy

Pneumonectomy is indicated for lesion that have extend to all lobes of one lung but have spared the contralateral lung. Lesions that may require pneumonectomy are the same as for lobectomy. Pneumonectomy can have far greater physiological consequences than removal of one or two lung lobes.

Acute restriction of more than 60% of pulmonary artery outflow is fatal in a dogs because it can induce acute pulmonary hypertension. Dogs can survive a 50% loss of total lung volume but will die after a 75 % loss. Excision of the entire left lung is tolerated as long as the right lung is healthy because it only represents 42% of the lung mass. Because the right lung is larger than the left, an acute right pneumonectomy removes more than 50% of the lung and is likely to be fatal. However if the disease disease process induces a slow progressive reduction of lung function, peneumonectomy of the right is possible in dogs.

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