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Thoracostomy tube placement, drainage and management in dogs and cats

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ABSTRACT: Thoracentesis and thoracostomy tubes, also referred to as chest tubes or thoracic drains, are used to withdraw air (pneumothorax) and/or fluid (effusion) from the pleural space in order to relieve pulmonary collapse and restore pleural subatmospheric pressure. Chest tubes may also be used in cases where it is predicted that fluid or air may accumulate in the pleural space to prevent dyspnoea and consequential respiratory compromise.

This article focuses on initial treatment for pleural cavity diseased patients, chest tube induction, drainage and management. In addition, this paper discusses patient care following chest drain placement. The first section considers the anatomy associated with pleural cavity disease and initial patient management. The second part explains the indications for thoracostomy tube induction, thoracic drain placement, management including drainage methods, nursing care and chest tube removal.

The pleural space

The pleura are serous membranes that cover the lungs and line the thoracic cavity, enclosing a potential space referred to as the pleural cavity. The inner pleura (visceral or pulmonary) encase the lungs and line their fissures, completely separating each lobe, whereas the outer pleura (parietal) is the section that lines the walls of the thoracic cavity.

The pleural space may become occupied by pneumothorax and or effusions (hydrothorax, haemothorax, chylothorax, pyothorax). This cavity requires drainage when it becomes occupied by air or fluid.

The pleural cavity contains a small volume of pleural fluid which prevents friction between the body wall and thoracic organs, thus allowing the pleura to move effortlessly against each other during respiration, aiding in optimal lung function. Also, surface tension attaches the lungs to the chest wall assisting with expansion as it moves outwards during inspiration.

Accumulation of fluid or air in the pleural space separates the lungs from the chest wall thereby applying pressure and creating difficultly for the lungs to expand and fill with air, consequently causing clinical signs of dyspnoea, tachypnoea and hypoxia. If fluid or a moderate amount of air accumulates in the pleural space, heart and lung sounds may sound suppressed on auscultation. In cases of severe pneumothorax, cardiac sounds may amplify and resonate.

Thoracentesis/initial management

Thoracentesis is an invasive surgical puncture of the thoracic wall to remove pneumothorax and/or effusion from the pleural space for diagnostic and therapeutic purposes.

Pneumothorax and pleural effusions are usually managed initially with oxygen supplementation and immediate thoracentesis. This allows re-expansion of the lungs, which have been compressed.

In most cases, thoracentesis rapidly and significantly improves ventilation, thus stabilising the patient allowing safe and effective diagnostic interpretation to be obtained.

This procedure should, therefore, always be carried out by the veterinary surgeon prior to chest tube placement, radiographs or any other further testing, especially in cases of severe dyspnoea. Fluid collected by this method should be submitted for diagnostic purposes.

The majority of dyspnoeic animals allow thoracentesis to be performed under local anaesthesia with minimal restraint. Sedation or general anaesthesia is rarely required and should be avoided wherever possible. However, patients with pleural disease are generally morbid and should the animal become distressed by the procedure, it may be safer to administer an appropriate sedation combination rather than struggle with a patient in respiratory distress.

Procedure

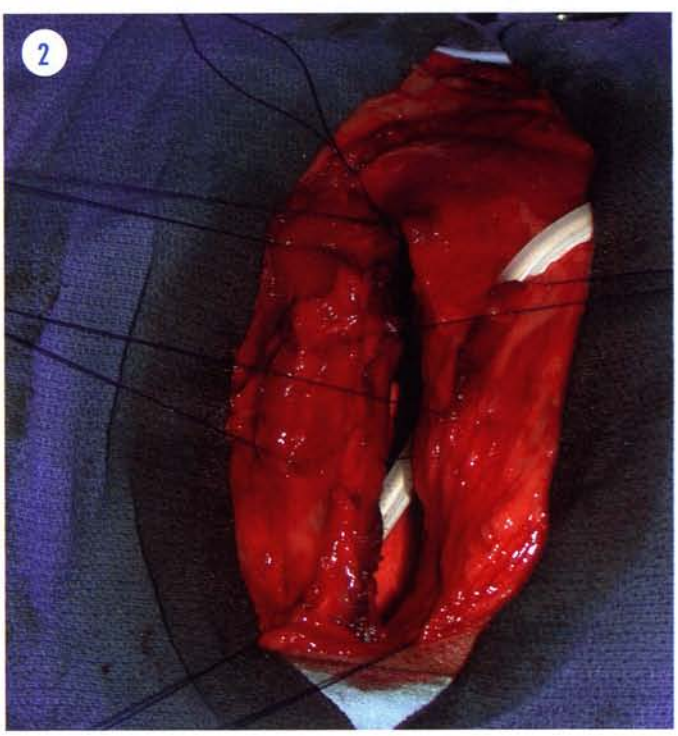
A wide area is clipped and prepared aseptically around the intended site. Local anaesthetic is then infiltrated into the skin directly over the proposed site – usually the sixth, seventh or eighth intercostal space – and into the intercostal muscles.

Thoracentesis is usually performed using a small gauge butterfly needle (19 to 23) with an incorporated extension line, attached to a three-way tap and syringe. The extension set allows manipulation of the syringe and some patient movement, without displacing the needle, whilst minimising the risk of lung laceration. The needle is inserted at a 45-degree angle to the chest wall with the bevel facing the lung to minimise trauma.

In cases of pneumothorax where the patient is positioned in standing or sternal recumbency, thoracentesis is performed in the dorsal one third of the chest cavity. However, if pleural effusion is to be retrieved, thoracentesis is more effectively carried out in the ventral third of the thorax.

If the animal is in lateral recumbency, the needle is introduced in the mid-third of the thorax. Nonetheless, wherever possible, the animal should be allowed to remain in sternal position to optimise lung capacity, thus minimising respiratory distress. Oxygen should be supplied via a face mask, flow-by or nasal insufflations, if tolerated by the patient.

Figures 1–4. Thoracostomy tube placement may be performed with the thorax closed or open, as at the end of thoracotomy



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Both sides of the thorax should be drained and post-procedural thoracic radiographs should be obtained to assess the efficiency of the procedure and attempt to identify a cause of the effusion and/or pneumothorax.

Further diagnostics to be obtained may include computerised tomography (CT), thoracic ultrasonography and electrocardiogram (ECG). These tests allow identification of the cause of pleural space disease such as intrathoracic masses, underlying cardiac disease or other pathologic processes.

Indications for thoracostomy tube placement

Indwelling thoracotomy tube placement should be considered in the following situations:

- if negative pressure is not achieved at the end of thoracentesis
- if the patient deteriorates and repeated thoracentesis is necessary for control of ongoing pneumothorax or pleural effusion
- if lavage as well as suction is planned, such as with pyothorax management
- following thoracic surgery.

Anaesthesia

Thoracostomy tube placement may be performed with the thorax closed or open, as at the end of thoracotomy **(Figures 1, 2, 3 & 4)**.

Closed chest insertion may be performed in the conscious, sedated animal, under local anaesthesia or under general anaesthesia following therapeutic thoracentesis.

Critical patients have a high risk of respiratory arrest, and in such cases chest tubes are occasionally placed without the use of general anaesthesia. A light sedative and local anaesthesia, such as anaesthetic infiltration or an intercostal nerve block, may be sufficient. However, efforts should made to avoid this protocol, as not only is placement of the tube under general anaesthesia simpler and less stressful for both patient and operator, animals with pleural cavity disease benefit from intermittent positive pressure ventilation (IPPV) and oxygen supplementation during chest tube placement.

Control of the animal's airway should, therefore, be achieved rapidly following general anaesthetic induction by means of endotracheal intubation and full ventilation control maintained during thoracostomy tube placement.

Materials

Commercial chest tubes are available in a various sizes ranging from 14 to 40 French Gauge. The diameter of the thoracostomy tube should be approximate to the main stem bronchus. Smaller tubes may be adequate for removing air, whereas large bore tubes may be necessary for viscous effusions.

Most commercial drains are made of PVC or silicone. These materials allow the drain to be flexible and comfortable, but do not collapse when negative pressure is applied during drainage. They usually have between three and six side holes. Additional ones can be created if considered necessary for adequate drainage, such as with pyothorax **(Figure 5)**.

Care must be taken, however, to ensure that the holes are less than a third of the tube diameter in order to prevent kinking or breaking of the tube **(Figure 6)**.

The two main types of thoracostomy tubes used in practice are:

- **The Mila chest tube**

This is placed using the Seldinger technique. It is a small-bore drain that causes minimal trauma when placed and is usually well tolerated.

- **The trochar thoracic drain**

This is a large bore chest drain that can be traumatic to place. Nevertheless, owing to its size it rarely obstructs, and allows large volumes of fluid and air to be removed easily.

(Note: An unnecessarily large chest tube is likely to be associated with increased pain and discomfort and should, therefore, be chosen with consideration of the description of the pleural disease and the width of the patient's intercostal space).

Patient preparation for chest drain placement

The skin is clipped and aseptically prepared. Local anaesthetic is infiltrated into the intercostal muscles at the proposed site of entry into the chest wall and into the skin at a point two intercostal spaces further caudally.

Thoracic drain placement

The decision as to which side the chest tube is placed is determined by evaluating thoracic radiographs. Occasionally bilateral chest tubes are necessary; however, in the majority of canine and feline patients, the mediastinum is permeable to fluid and air, thus allowing drainage of both hemi-thoraxes through a single tube. The exception to this may be in cases of chylothorax or pyothorax.

When placing a drain using a central trochar a small skin incision is made in the dorsal one third of the lateral thoracic wall over the tenth or eleventh intercostal space. The trochar is then introduced into the incision and tunnelled subcutaneously in a cranioventral direction for three to four intercostal spaces, until the tip of the trochar lies over the seventh intercostal space.

The aim of the subcutaneous tunnel between the skin incision and the point of entry is to create an airtight seal around the tube, preventing atmospheric air tracking to the chest cavity and causing pneumothorax.

The trochar is then elevated so that it is perpendicular to the chest wall. The operator should then firmly grasp the tube one to two centimetres from the body wall with one hand, while using the other to firmly push or 'pop' the tube through the intercostal musculature and pleura. This technique prevents the trochar from being advanced further than

Figure 5. Additional drains can be created if considered necessary for adequate drainage, such as with pyothorax

anticipated into the thoracic cavity and penetrating the heart or lungs.

Once in the chest the trochar is withdrawn slightly so the tip does not damage any thoracic structures. The handle is lowered again and the tube is advanced off the trochar in a cranioventral direction to a predetermined point. Before completely removing the trochar, the tube must be fastened using a tube clamp to prevent pneumothorax.

If placing a drain without a trochar, the procedure is the same, except the tip of the tube is gripped using long, curved artery forceps and forced through a bluntly dissected hole in the intercostal muscles into the thoracic cavity.

If a drain is placed during thoracic surgery, the tube can be placed without a trochar. Artery forceps are used as explained above and passed into the thorax.

The tube is secured to the skin using a Chinese Finger Trap suture and a purse-string suture is placed loosely in the skin around the tube entry point and the ends tied in a loose knot. The suture will be tightened on removal of the tube.

The chest tube should be connected to a three-way tap with closed cap bungs. Two points of closure should always be present on the drain to minimise the risk of pneumothorax. A gate clamp and three-way tap are normally used.

Appropriate placement of a chest drain should be confirmed by gaining a post-procedural thoracic radiograph. In addition, it is often useful to reassess the patient for any thoracic disease that was not apparent prior to complete removal of pleural effusion and/or pneumothorax.

There are no absolute contraindications to thoracostomy tube placement in the critically ill patient with ongoing pneumothorax or pleural effusion. However, in stable patients, relative contraindications are coagulopathies or pleural adhesions.

Pleural drainage

Once the tube is *in situ*, drainage can be achieved by continuous or intermittent suction. Intermittent thoracic drainage is most commonly used. However, when fluid and/or air accumulate so quickly that this method is not practical, then continuous suction may be required.

Figure 6. Care must be taken to ensure that the holes are less than a third of the tube diameter in order to prevent kinking or breaking of the tube

Equipment required for intermittent suction

- sterile gloves
- bowl
- three-way tap
- alcohol sterets
- sterile Luer lock syringe
- sterile closed cap bungs.

Intermittent thoracic drainage is performed by aspirating the pleural space using a syringe attached to the three-way tap connected to the chest tube end. This method of pleural drainage is generally adequate when the accumulation of pleural fluid or air is not life threatening, and allows measurement of the fluid or air evacuated.

Any volumes of air should be recorded and any fluid removed should have its volume, colour and consistency noted. How often this drainage is performed depends on how rapidly air or fluid accumulates, although one- to four-hourly is usually adequate.

Drainage should be carried out using a sterile technique to prevent the introduction of infection into the thorax, and care must be taken to ensure that valves are opened and closed correctly to reduce the risk of iatrogenic pneumothorax.

A maximum 3 - 5ml of negative pressure should be applied to the drain to avoid trauma to the pleura and occlusion of the tube by mediastinal or pleural tissue. Drainage should be stopped once negative resistance is felt.

Thoracic drain management

Incorrectly placed – or inappropriately managed – chest tubes are extremely detrimental to patient welfare and can result in significant morbidity and mortality. Thoracic drains in veterinary patients, therefore, require continual monitoring, and precautions must be taken to ensure that the animal cannot remove the tube prematurely or damage the tube by chewing.

The drain should be bandaged appropriately to the body wall, not only to reduce the likelihood of patient interference, but also for patient comfort and to decrease the risks of infection. The drain site dressing must be removed and replaced twice daily using a sterile manner in order for the exit site to be observed for signs of infection.

The patient's respiratory rate, effort and pattern must be recorded. Any change in this may indicate that the thorax requires further drainage or that the position of the drain is incorrect, causing fluid and/or air retention and discomfort.

Mucous membrane colour and pulse oximetry should be used as indicators of tissue perfusion (Note: < 90% is highly significant) and ECG monitoring of heart rate and rhythm to demonstrate cardiac impact. Pulse rates should also be recorded as an increase may indicate pain or hypotension. Blood pressure monitoring can be performed to allow adequate assessment of pain relief and circulatory volume.

In addition, temperature readings should be carried out to identify pyrexia and hypothermia (Note: hypothermia and shivering increases oxygen consumption and, therefore, decreases ventilatory capacity) and analgesia requirements (Note: pyrexia may be associated with pain).

Management of pain

Having a chest drain in place is recognised as being significantly painful. In addition, often these are postoperative cases where patients have undergone invasive thoracic surgery and sternotomies.

Chest wall pain exacerbates respiratory distress and causes patients to become reluctant to ventilate efficiently, resulting in atelectasis. Appropriate pain management is, therefore, paramount following thoracotomy tube placement, especially if the animal has undergone surgery.

The use of multi-modal analgesia is preferable in such cases. Opioids and non-steroidal anti-inflammatory drugs (NSAIDs) can be administered systemically. Intercostal nerve blocks assist with pain associated with intercostal thoracostomy incisions; and local anaesthetics applied by interpleural infusion, instilled by the chest drain, provide useful analgesia following sternotomy and reduce discomfort caused by the presence of the drain itself.

Bupivicaine (Marcain, Hospira) is the local anaesthetic of choice for these methods. It can be administered every six to eight hours. (Note: Bupivicaine is an acidic solution which may elicit discomfort during initial administration and should, therefore, be diluted with an equal amount of saline).

Following thoracostomy tube placement, the patient should be positioned in sternal recumbency to optimise lung capacity because hypoventilation causes hypoxemia, hypercapnia and respiratory acidosis. If a sternotomy has been performed, such positioning will not be possible, in which case the patient should be placed in lateral recumbency and carefully turned every two to four hours.

After intercostal thoracotomy, patients should be positioned so that the lung concerned is placed uppermost. This reduces pain, allows management of the chest drain and encourages re-expansion of the affected lung. Intercostal thoracotomy patients should still be repositioned periodically to allow any pockets of gas or fluid to be removed by the tube and to allow the other lung to expand.

Bedding materials and bladder management

Patient bedding should consist of a waterproof mattress and vet bed for comfort, to reduce the risk of decubitus ulcers and prevent urine scalding. If it is not possible sufficiently to manage an animal's bladder, an indwelling Foley urinary catheter and closed collection system should be placed and managed aseptically to prevent urinary tract infection.

Nutrition

As with all clinical and postoperative cases, nutrition should be considered carefully. Chyle consists of lipid from the gastrointestinal tract, which is transported through the thoracic duct to the systemic circulation. Digested fat is consequently removed via the chest tube in cases of chylothorax. Also exudates contain copious amounts of protein which may increase the animal's nutritional requirements.

Complications

Patients with pneumothorax are demanding from a nursing perspective, either as a consequence of patient interference or difficulties with the drain – such as disconnection of connectors and subcutaneous leaks around the tube.

Cellulitis and subcutaneous oedema may occur at the drain placement site and along the subcutaneous tunnel. Ascending infection is also a risk which increases with the length of time the drain is *in situ*.

In addition, although rare, the drain can cause irritation leading to pleural effusion, cardiac dysrhythmias, phrenic nerve irritation and Horner's syndrome.

Chest tube removal

In patients with pneumothorax, the chest tube can be removed once negative pressure has been achieved for 12 - 24 hours.

In cases of pleural effusion, the tube is removed once the output of fluid accumulation diminishes to a volume consistent with that caused by the presence of the tube itself.

The placement of a thoracostomy tube in the pleural space elicits an inflammatory response associated with the production of an effusion rate of 2 - 4 ml/kg/day. Waiting until no fluid is being produced is, therefore, not an option.

Thoracic drain removal can be performed in the conscious animal, although particularly anxious patients may require sedation. The Chinese Finger Trap suture is removed and the drain is gently withdrawn whilst the pre-placed purse string suture is tightened to close the skin entry point before applying a primapore dressing over the site.

If the thoracic drain has been in place for several days or infection is suspected, the tube end should be cultured.

Conclusion

As veterinary nurses, we are responsible for assisting in providing initial care and treatment to pleural cavity diseased patients.

In addition, we are accountable for maintaining the appropriate management of thoracostomy tubes, identifying complications through vigilant observation, preventing the incidence of infection and delivering the highest standard of nursing care to our patients.

It is hoped that this article has provided the reader with a useful overview of how to carry out this vital role within veterinary practice. vnj

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