CONTINUING PROFESSIONAL DEVELOPMENT

Aims and intended learning outcomes

The aim of this article is to give the reader an overview of current developments, areas of debate and best practice recommendations for chest drain insertion and underwater seal drainage. After reading this article and completing the time out activities you should be able to:

- Outline the indications for chest drain insertion and underwater seal drainage.
- Discuss the advantages and disadvantages of different types of chest drain tubes.

Introduction

In a healthy individual the pleural membranes (visceral and parietal) are closely associated, with only a potential space separating them. The pressure within the pleural space is negative and has an important role in maintaining lung expansion. If air or other substances enter the pleural space, negative pressure is lost and the lung collapses. Chest drains are inserted into the pleural space to drain air, or other substances such as blood or pus, and allow lung re-expansion.

Classification of pneumothorax

Pneumothorax can be classified according to its aetiology. A spontaneous pneumothorax occurs without a discrete precipitating event, for example trauma, and can be categorised as either primary or secondary.

Primary spontaneous pneumothorax This occurs in individuals without any obvious underlying lung disease. It is most common in tall, young, male adults and is associated with lower body weight and smoking. Although there is no apparent underlying lung pathology, further investigation often reveals subpleural blebs (accumulation of fluid). Bullae (blisters) are also present in some individuals. The exact aetiology of these lesions is unclear, although smoking is thought to have a role in their development (Henry et al 2003).
Secondary spontaneous pneumothorax
This occurs in older individuals with underlying lung disease, most commonly chronic obstructive pulmonary disease or asthma.

Traumatic pneumothorax This follows trauma to the chest and is often accompanied by haemothorax (blood in the pleural cavity).

Iatrogenic pneumothorax Pneumothorax may complicate a number of procedures, most commonly central venous catheter insertion, lung biopsy and percutaneous liver biopsy. The National Institute for Health and Clinical Excellence (NICE) has published guidance on limiting the risk of pneumothorax during central catheter insertion (NICE 2002).

Tension pneumothorax This can occur with any of the above categories of pneumothorax, but it is more common in cases of traumatic pneumothorax. A valve-like mechanism becomes established through which air enters the pleural space with each inspiration, but cannot escape during expiration (Hess and Kacmarek 2002). The amount of air collecting in the pleural space increases with each breath. This can cause rapid expansion of the pneumothorax, and the pressure within the pleural space increases substantially. If the problem is not recognised and treated, mediastinal shift can occur, causing severe haemodynamic compromise and eventual cardiac arrest (usually pulse-less electrical activity).

Tension pneumothorax is a medical emergency and requires immediate recognition and treatment. The diagnosis is made clinically, and treatment should not be delayed for chest imaging. Emergency needle decompression may be indicated, particularly in an out-of-hospital ‘field’ setting. This involves the insertion of a needle into the chest in the mid-clavicular line in the second intercostal space. An immediate ‘hiss’ can be heard on needle insertion as the pressurised air escapes from the pleural space. A chest drain can then be inserted following this procedure (Ward et al 2006).

Time out 1
Look again at the information given above on the aetiology of pneumothorax. How does this apply to patients you have cared for with this condition? What is the most common reason chest drains are inserted in your clinical area?

If pneumothoraces or pleural effusions are small and/or minimally symptomatic, chest drains may not always be inserted. Small fluid and air collections can be managed with a ‘watch and wait’ approach. The British Thoracic Society (BTS) has issued guidance about the management of spontaneous pneumothorax. It recommends single needle aspiration as first-line treatment for all primary pneumothoraces requiring intervention and small secondary pneumothoraces when the patient is minimally breathless and under the age of 50 years (Henry et al 2003). New guidelines for the management of pleural disease are due to be issued by the British Thoracic Society during 2010.

The 2003 guidance from the BTS (Henry et al 2003) updates recommendations published by Miller and Harvey (1993). Henry et al (2003) reported that earlier guidance had not universally influenced practice. This view is supported by the work of Mendis et al (2002), who identified the under-use of simple aspiration for the management of spontaneous pneumothorax. This was attributed to a lack of familiarity with the guidelines.

The efficacy of single needle aspiration as the initial management choice for primary spontaneous pneumothorax has been the subject of a systematic review (Devanand et al 2004). Although good quality controlled randomised trials were few, the review suggested that using needle aspiration to treat primary spontaneous pneumothorax was a safe alternative to chest drain insertion, with little difference between the techniques (single needle aspiration versus chest drain insertion) in terms of safety and efficacy (Devanand et al 2004).

Single needle aspiration may not always be appropriate, and chest drain insertion is indicated in a number of situations (Box 1).

Chest drain tubes
A chest drain tube is inserted into the pleural space and attached to an underwater seal drainage bottle. These tubes can be small, medium or large bore.

The relative merits of large and small bore chest drain tubes continue to be debated in the literature. Advocates of smaller chest drain tubes argue they perform as well as larger devices, are less painful and are better tolerated (Parulekar et al 2001, Argall and Desmond 2003, Horsley et al 2006). A small calibre drain may be insufficient to deal with a large air leak, and some suggest that larger chest drain tubes are better for viscous drainage, for example, in the case of empyema or haemothorax.

Horsley et al (2006) assessed the efficacy and complications of small bore, wire-guided chest drain tubes. They found that these performed well when draining pneumothoraces and uncomplicated effusion, but were more likely to block when used to drain empyemas.
Imaging

A diagnosis of pneumothorax, haemothorax or pleural effusion is usually made by assessing the clinical signs and symptoms of respiratory distress, altered breath sounds on chest auscultation and chest percussion. Diagnosis is usually confirmed by a plain chest X-ray. An exception is tension pneumothorax, which is a medical emergency. When this occurs, treatment must not be delayed for chest imaging (Laws et al. 2003).

Chest drains have been the subject of a rapid response report from the National Patient Safety Agency (NPSA) (2008), which advocates the use of ultrasound imaging during chest drain insertion, particularly for fluid drainage.

Chest drain tube insertion

Chest drain insertion is an aseptic technique. Special insertion packs are available from the Central Sterile Services Department or the Hospital Sterile Services Department. These contain scalpel handles, dissecting forceps, artery forceps, needle holders and scissors. Other equipment required for the procedure is listed in Box 2.

Detailed and up-to-date procedure guidelines for chest drain insertion are available in the Royal Marsden Hospital Manual of Clinical Nursing Procedures (Dougherty and Lister 2008).

Inserting a chest drain is not a risk-free procedure (NPSA 2008). Wherever possible and practical, a comprehensive discussion of the risks and benefits of the procedure should be held with the patient and formal written consent obtained. Chest drain tube insertion is a painful procedure and the patient should receive systemic analgesia beforehand. The insertion site should also be infiltrated with a local anaesthetic.

NURSING STANDARD
The most common insertion site is the mid-axillary line within the ‘safe triangle’, although other sites are used in complex cases (Laws et al 2003). This triangle is bordered by the anterior border of latissimus dorsi, the lateral border of pectoralis major, a line superior to the horizontal level of the nipple and an apex below the axilla’ (Laws et al 2003). Selecting a site within the safe triangle minimises the risk of trauma to underlying structures. Drains are inserted with the patient in an upright position, although the precise patient position adopted may vary. Laws et al (2003) stated that the preferred position is ‘on the bed, slightly rotated, with the arm on the side of the lesion behind the head to expose the axillary area’. This allows good access to the safe triangle. Other common positions may include sitting upright, leaning over the back of a chair or bedside table.

To prevent displacement, the chest drain tube is anchored in place with a ‘stay’ suture. A ‘closing’ suture is also inserted into the skin during drain placement. This closing suture allows closure of the insertion hole when the chest drain tube is eventually removed. It is often mistakenly referred to as a ‘purse string suture’. However, purse string sutures must no longer be used, because they cause pain and produce a poor cosmetic finish (Laws et al 2003). The closing suture must instead be of a type that is appropriate for closing a linear incision, as recommended by Laws et al (2003). A closing suture might not be required if a small calibre drain is used as the small insertion hole will not need suturing.

Blunt dissection through the subcutaneous tissues and muscle into the pleural cavity is recommended for medium to large chest drains (Laws et al 2003). This involves using a surgical instrument such as a clamp or artery forceps to separate muscle fibres and create a pathway through the chest wall. The use of trocars for insertion and perforation of the pleura has been linked with an increased risk of perforation complications and is universally discouraged within the published literature (Laws et al 2003, Bowyer 2007). When inserting larger drains, probing of the pleural cavity with a digit is recommended to ensure there are no underlying structures that may be damaged during insertion of the tube (Laws et al 2003, Bowyer 2007).

Because of concerns about trocars, percutaneous insertion of chest drain tubes using a Seldinger insertion (over the wire) technique has become increasingly popular in recent years. This technique has traditionally been used with smaller calibre chest drain tubes, but dilators can be used to allow insertion of bigger chest drain tubes. The best method is open to debate and will depend on local preference, since good comparative studies are lacking. Argall and Desmond (2003) concluded that ‘there is no evidence to show that a Seldinger over the wire insertion technique is superior to traditional methods’.

In a recent NPSA (2008) report, the majority of adverse incidents (including some patient deaths) occurred almost exclusively with Seldinger chest drains. Adverse incidents were attributed to failure to follow manufacturer’s instructions, lack of familiarity with the Seldinger technique and excessive insertion of the dilator. This, along with the lack of primary studies in the area, suggests that the skill and experience of the clinician inserting the drain is the most important factor in minimising the risks associated with the procedure, rather than type of chest drain. Recommendations for improving the safety of chest drain insertion have recently been issued by the BTS (2008). Full updated guidance about the management of pleural disease is expected from the BTS in 2010.

Once inserted into the pleural space, the chest drain tube is attached to a one-way drainage device, usually an underwater seal drainage bottle. A chest X-ray is required following insertion to check the position of the chest drain tube. Over time the effusion resolves and/or the air leak stops and the lung re-expands.

There should be no audible air leak after insertion. When this occurs it suggests additional sutures are required in the skin, or that the drainage holes in the chest drain tube are positioned at skin level. If this occurs, the tube will need to be repositioned.

The drainage device will usually be an underwater seal drainage bottle, although drainage valves (Heimlich or flutter valves) (Figure 2) attached to a sterile drainage bag are used in some patients. Heimlich valves are useful for out-of-hospital pneumothorax management and for recovering patients who are mobile. Valves are not usually recommended for fluid drainage because they have a tendency to block (Laws et al 2003). Both Heimlich and chest drain devices work in a similar way: the underwater seal drainage device or valve acts as a one-way drainage device allowing drainage out of the...
pleural space, but preventing air from entering or re-entering the pleural space when the patient breathes in.

An underwater seal drainage bottle can give some visual clues about the progress of a pneumothorax (as the air leak resolves and the lung re-expands, bubbling and swinging in the underwater seal drainage bottle decreases).

Figure 3 shows an underwater seal drainage bottle. The bottle is filled with sterile water to the water seal level indicated on the graduations. The tube in the bottle must be below the surface of the water. If the tube is not below the surface of the water, the device will not work and air will enter the pleural space. Before the device is attached to the patient’s chest drain tube, it is vital to check the tube is below the surface of the water. However, the submersion level should be no more than a few centimetres. Excessive submersion increases the hydrostatic pressure that the intrapleural air must exceed before it can escape from the chest, making it more difficult for the air to escape from the pleural space (Tang et al 2002). For this reason, it is important to adhere to the recommended water seal level indicated on the underwater seal drainage bottle.

With a single chamber underwater seal drainage bottle, any drainage from the pleural space mixes with the water seal liquid and the total volume of fluid in the underwater seal bottle increases. As the total volume increases, hydrostatic pressure rises and drainage becomes less efficient. This problem is avoided with multi-chamber underwater seal drain devices, which provide separate chambers for drainage, water seal and suction. Allibone (2003) gives a full explanation of multi-chamber drainage devices.

If the patient has a pneumothorax, air bubbles will be visible in the underwater seal bottle, as air is drained from the pleural space and the lung re-expands. The bubbling occurs intermittently as the patient breathes out or coughs, and reduces in frequency as the pneumothorax resolves (the pattern of bubbling is reversed if the patient is receiving positive pressure ventilation).

A respiratory swing is also seen in the underwater drainage bottle tubing – fluid in the tubing oscillates as the patient breathes. This confirms correct placement in the pleural space and tube patency. This swing can easily be seen if there is drainage in the tubing because the drainage will move as the patient breathes. If no drainage is present, the swing can be found at the fluid meniscus (the water level in the tube in the drainage bottle under the surface of the water). In the United States this respiratory oscillation is often described as ‘tidaling’ (Reid 2006).

When air is present in the pleural space, as mentioned previously, bubbling is usually intermittent during expiration. If the air leak is severe then bubbling occurs over a longer duration as the patient breathes out, and the bubbling may eventually extend into inspiration and become continuous (Tang et al 2002). Although continuous bubbling (during inspiration and expiration) can indicate a severe and worsening air leak, it may be an artefact caused by air leaking from outside into the drainage system, usually because of a breach in the system.

Reid (2006) described a system of brief sequential chest drain clamping to detect the location of a system leak. If the cause of continuous bubbling cannot be quickly identified and attributed to artefact it is most likely the result of deterioration in the patient’s underlying lung pathology. Immediate review by the medical team is indicated.

The chest drain will gradually stop swinging and bubbling as the lung re-expands and the air leak resolves. However, a chest drain that stops swinging and bubbling suddenly is a cause for concern. It may indicate the chest drain tube has become blocked or displaced, and this can result in acute re-accumulation of the pneumothorax and extreme respiratory distress. Monitoring the chest drain for swinging and bubbling is therefore an essential nursing observation.
extensive blood loss (Tang et al. 2002). Patients in this situation require urgent cardiothoracic surgical referral.

Figure 4 shows two chest drain clamps in use. These clamps are made specifically with flat surfaces that do not bite into the surface of the tubing. Some units do not have access to these and make do with large artery forceps or clamps. If these artery forceps or ‘make-do’ clamps are used, the tips must be covered to prevent them cutting into the chest drain tubing – green oxygen tubing is often applied. Clamps should always be immediately available and kept at the patient’s bedside.

### Milking or Stripping

Milking or stripping chest drain tubes is used when drainage is bloody to prevent occlusion by clots and involves special roller clamps. The routine use of this procedure is now discouraged (Reid 2006, Bowyer 2007). It has been suggested that the practice is not safe because it generates extreme negative pressure in the pleural space and may cause lung tissue entrapment (Duncan et al. 1987), and therefore should be avoided.

Few primary studies have been conducted in the area of milking or stripping. A systematic review by Wallen et al. (2002) concluded that the need to manipulate chest drains could not be either supported or refuted by the results of randomised controlled trials. Studies in this area are usually conducted in post-operative cardiac surgical settings and several such trials were the subject of a recent literature review by Halm (2007), who also questioned the value of milking or stripping. It seems reasonable to question the value of routinely milking or stripping chest drains, but more research is required in this area.

As an alternative to stripping or milking, positioning chest drain tubing so that drainage flows freely as well as avoiding dependent loops of tubing has been emphasised (Tang et al. 2002, Allibone 2003, Halm 2007).

### Underwater Seal Drainage

Routine clamping of chest drain tubes, for example when the patient is being moved in bed, is discouraged (Laws et al. 2003). Clamping is particularly contraindicated for a bubbling chest drain because this prevents the escape of air and can result in a build-up of pressure (tension pneumothorax) (Laws et al. 2003). However, there are times when it is necessary to clamp chest drain tubes, for example when accidental disconnection or damage to the drainage system occurs, or when bottles and/or tubing are changed. In these circumstances the chest drain must be clamped with non-traumatic clamps to prevent air entry while new tubing and/or an underwater seal drainage bottle are being attached. Even under these conditions, the clamps must be in place for as brief a time as possible.

Re-expansion pulmonary oedema is thought to be related to the length of time the lung has been collapsed. It is associated, in particular, with rapid drainage of large quantities of fluid from the pleural space (Henry et al. 2003, Laws et al. 2003; Tang et al. 2002) and Laws et al. (2003) recommended that no more than 1,500mL of fluid should be drained at any one time or drainage should be slowed to about 500mL per hour. Drainage is slowed by applying non-traumatic clamps to the drain to reduce, but not completely stop, drainage. A gate clip can also be applied to the tubing. Some underwater seal tubing is provided with gate clips to slow drainage.

Although controversial, some physicians clamp chest tubes after re-expansion of the lung, before removal of the chest drain tube, as a method for detecting small air leaks. The literature generally discourages this practice, although Baumann et al. (2001) found in a survey of American practitioners that clamping chest tubes before removal was still recommended by a substantial number of respondents. If this practice is carried out in the clinical area the patient should be observed carefully for signs of respiratory distress, and if adverse respiratory symptoms do occur the drain must be unclamped immediately (Henry et al. 2003).

If catastrophic haemorrhage occurs it will be necessary to clamp chest drain tubes, to prevent
acutely occluded and the patient shows adverse signs and symptoms. However, this should be performed with care, ideally by specialist staff. Such patients need specialist referral and access to critical care support.

**Drainage**

It is important to measure the amount and nature of drainage as this, in addition to the presence or absence of swinging and bubbling, can help medical staff decide when it is appropriate to remove the chest drain tube. Underwater seal drainage bottles usually have a measuring scale, where zero is the water seal level (the level to which sterile water is poured into the bottle before it is attached to the chest drain tube) and anything in excess of this represents drainage. How frequently drainage should be measured is dictated by the patient’s condition and the amount and nature of the drainage. If the drain has been inserted recently and the drainage volume is large, it is not unusual for it to be measured frequently, for example every 15-30 minutes.

If the drainage becomes cloudy or the patient develops a high temperature, a sample should be sent for culture and sensitivity. Underwater seal drainage bottles should be changed at regular intervals for infection control purposes; local infection control practice will dictate the frequency of change. Drainage bottles should also be changed to avoid over-filling, as discussed earlier, because this reduces the efficiency of the drain. The drainage fluid should be treated as potentially contaminated, and standard precautions observed when dealing with it.

Some underwater seal chest drain bottles come with stoppers to close and seal the bottle when it is removed. These stoppers prevent the leakage of fluid from the bottle and are important for infection control and safe disposal of the underwater seal drainage bottle. However, they should not be applied when the chest drain tube is still attached to the patient. The Medicines and Healthcare products Regulatory Agency (2006) reported instances where stoppers have been applied to the air or suction port of underwater seal drainage bottles attached to patients. This action seals the bottle. In one case this resulted in a tension pneumothorax. It is vital that the air or suction port on the underwater seal drainage bottle is not occluded while the bottle is still attached to the patient.

**Surgical emphysema**

Surgical emphysema presents as swelling in the tissues – when the affected area is compressed, a distinct ‘crackling’ can be felt. Figure 5 shows a patient with extensive surgical emphysema.

Patients with a chest drain tube in place can already have or may develop surgical emphysema. The extent of this must be monitored and reported. If severe, it can compromise the airway. If it develops suddenly in a patient, it indicates the drain is not functioning properly and urgent medical review is necessary. Possible causes include a worsening pneumothorax overwhelming the size of the drain, a side hole in the chest drain tube lying outside the pleural space that allows air to enter the tissues, and blockage of the chest tube drain (Tang et al 2002).

**Suction**

If there is a persistent air leak or failure of the lung to re-expand, suction is sometimes attached to the chest drain system. The value and timing of this has been debated (Henry et al 2003, Laws et al 2003). Henry et al (2003) recommend considering suction 48 hours after tube insertion. If suction is indicated, special low-pressure high-volume suction devices must be used.

Use of suction is not recommended for patients with chest drains that are being managed outside specialist units (Henry et al 2003, Laws et al 2003). The amount of suction applied ranges from 10–20cmH₂O, although levels of 40cmH₂O have been applied.
(Reid 2006, Bowyer 2007). Failure of the lung to re-expand or a persistent air leak is an indication for specialist cardiothoracic surgical referral. Suction is better used with multi-chamber than single-chamber underwater seal drainage devices.

Removal should be performed by two people. Nurses who have the required skills and expertise may remove chest drains. Such individuals are usually respiratory nurse practitioners, critical care outreach nurses or specialists in cardiothoracic care. The patient should be given analgesia before the removal because the procedure is painful. If the patient breathes in as the chest drain is being removed, air will be drawn back into the pleural cavity. There are two commonly reported respiratory manoeuvres a patient can be asked to (Reid 2006, Bowyer 2007). Failure of the lung to re-expand or a persistent air leak is an indication for specialist cardiothoracic surgical referral. Suction is better used with multi-chamber than single-chamber underwater seal drainage devices.

Removal of the chest drain tube

The patient should be observed continuously and, when there are clinical signs that the air leak has resolved and lung re-expansion is confirmed by chest X-ray, the drain can be removed. Bowyer (2007) stated that most physicians will consider removing a chest drain tube if a patient’s chest X-ray confirms satisfactory lung expansion, there has been no air leak for 24 hours and/or if drainage is below 100mL in 24 hours. Before removal some physicians clamp the chest drain tube for a period of time to assess patient tolerance, as discussed earlier. Although this practice has been questioned, it continues (Henry et al 2003, Laws et al 2003, Ward et al 2006).

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References


Learning Zone Respiratory Nursing

Patients with a chest drain require close observation to reduce complications. Does your ward or department have a written protocol for the care of such patients? Are there or should there be specific observation charts for monitoring such patients?

Time out 8

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