Chapter

Chest Tubes

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Abstract

Insertion of intercostal drainage (ICD) tube is one of the commonest surgical procedure that is life saving in certain circumstances. Although the procedure is being used for long, yet there is no consensus in its management. The procedure is simple to perform but the incidence of the complications, which primarily occur due to improper positioning of the tube and poor post-procedural care, is as high as 40%. It is therefore essential that all clinicians should be familiar with this simple, common and lifesaving procedure. This chapter provides a comprehensive overview of various aspects of intercostal drainage including the prerequisites, technique of insertion, post-procedural care, complications and common pitfalls in the management of chest tubes in the light of the recent advances and updates.

Keywords: Chest tube, Tube thoracostomy, intercostal drainage tube, ICD tube, Thoracentesis, Thoracostomy drainage

1. Introduction

Insertion of intercostal drainage (ICD) tube is a common procedure that is required to drain the abnormal intrapleural collection. As the name implies, it is insertion of a tube through the intercostal space to facilitate the drainage of abnormal collection in the pleural cavity. The procedure is also known as tube thoracostomy and thoracostomy drainage. The earliest reports of thoracic drainage dates back to 5th century BC [1, 2].

The aim of thoracostomy drainage is to:

i. Remove fluid and air from pleural cavity as promptly as possible.

ii. Prevent drained air and fluid from returning to pleural cavity.

iii. Restore negative pressure in pleural cavity to help re-expand the lung.

Although, the procedure has been in practice since long, there is still no consensus in the management of chest tubes and there remains great variability in practice. The procedure of inserting a chest tube is simple, definitive in treating a majority of thoracic pathologies and may be life-saving in certain situations. However, improperly placed chest tubes and poor post-procedural care may increase the morbidity and is associated with complications in up to 40% of patients [3, 4]. It is therefore imperative that all clinicians should be well versed with this simple yet life-saving procedure.

In this chapter, we will discuss various aspects of intercostal drainage including the prerequisites, technique of insertion, post-procedural care, complications and common pitfalls in the management of chest tubes in the light of the recent advances and updates.

2. Characteristics of an ideal thoracostomy tube

An ideal thoracostomy tube should:

i. Allow collected air and fluid to drain out from the chest.

ii. Contain a one-way valve to prevent air and fluid from returning back into the chest.

iii. Allow maintenance of negative intra-pleural pressure (the normal intrapleural pressure is −3 mmHg that decreases further on inspiration).

iv. Have provision for applying higher negative pressure to help in expanding the lung.

v. Allow accurate measurement of drained fluid and air.

3. Indications for inserting chest tube

Tube thoracostomy is required to drain any abnormal collection in the pleural cavity, that includes:

i. Air: Pneumothorax

ii. Fluid: Pleural effusion

iii. Blood: Hemothorax

iv. Pus: Empyema

v. Chyle: Chylothorax

vi. Prophylactically following cardio-thoracic surgery to drain post-operative collection of air, fluid or blood

4. Commercially available chest tubes

The modern, commercially available chest tubes are soft and pliable that are either made up of Polyvinyl chloride (PVC) or silicone (**Figure 1**).

The red rubber or malecot tube drains (**Figure 2**) are sometimes used as thoracostomy tubes mostly in resource constraint settings because of their low-cost, however their use is not advisable as they are difficult to retain, get kinked easily, wither rapidly and at times may break.

Chest tubes come in various sizes from 6 French gauge (F) to 40 F. Larger the size of the tube, greater is its diameter. One F is equal to 0.033 cm. To know the diameter of the tube from the F size, one need to multiply F size by a factor of 0.033, so a chest tube of size 24 F will have an internal diameter of approximately 0.8 cm.

Some chest tubes are available with metallic trocar that has a pointed end (**Figure 3**).

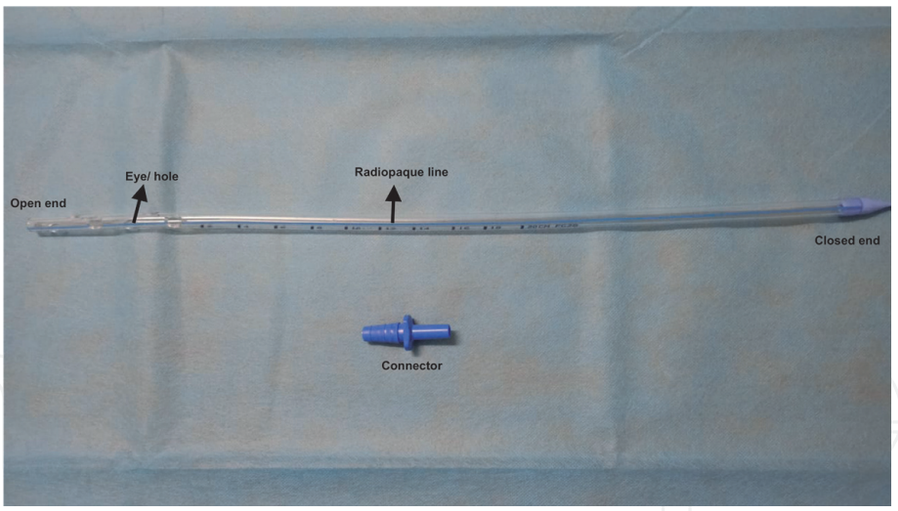

Figure 1.
Intercostal drainage tube (chest tube).

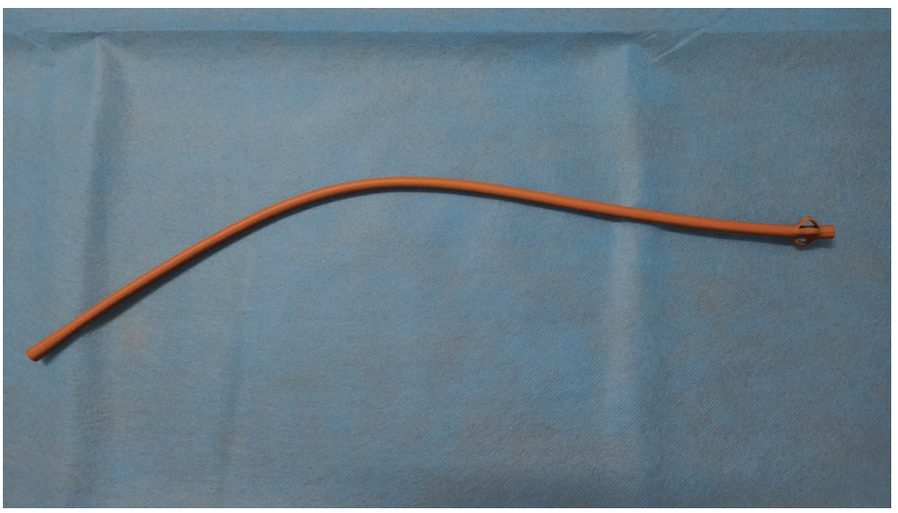

Figure 2.
Malecot (red rubber) tube drain.

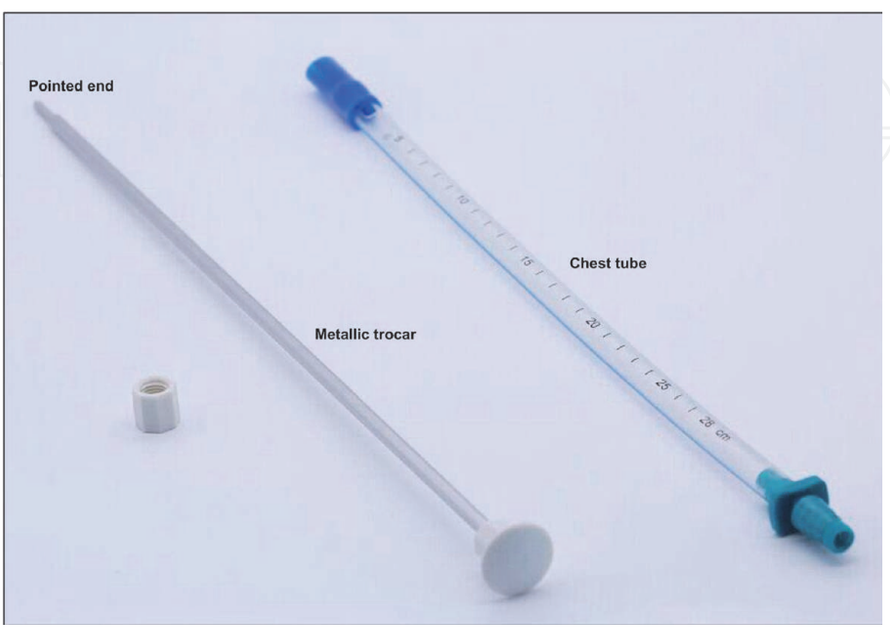

Figure 3.
Chest tube with metallic trocar.

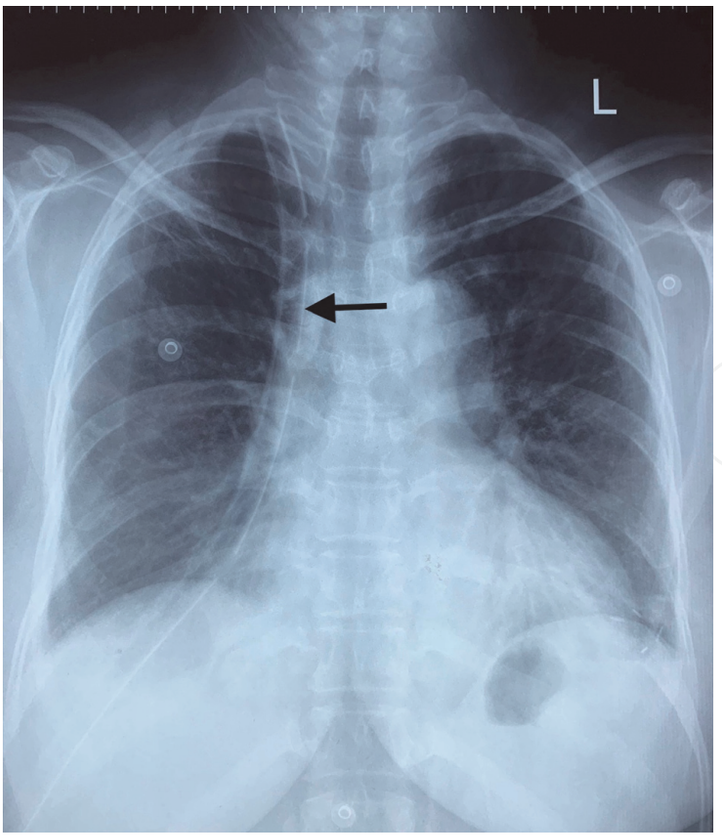

Figure 4.
Radiopaque line in the chest tube visible on x-ray (arrow).

These are meant to insert in intercostal space after making a small skin incision, without dissecting the intercostal muscles. Although, this makes the procedure fast, there is a higher risk of injury to the intrathoracic organs and as such use of chest tubes with trocars should be discouraged [3, 5, 6]. Most of the chest tubes are open from one end while the other end is sealed. There are side holes or eyes on the tube and the markings are printed on it. There also is a radiopaque line all along the length of the tube that helps in identifying the position of the chest tube on X-ray (**Figures 1** and **4**).

5. Before inserting the chest tube- the preparation

5.1 Consent

Insertion of ICD tube is a surgical procedure and like any other surgery, a written informed consent is required prior to the procedure. Consent may not be possible in cases where the patient requires urgent tube thoracostomy as a lifesaving measure and when he/ she is unconscious, unattended or is in extremis.

5.2 Preparing the trolley: Equipment required

Following instruments and equipment are required for inserting the chest tube. One must ensure the availability of all necessary equipment beforehand to avoid any difficulty during the procedure.

1. 5 ml syringe with a suitable local anesthetic. Preferably 2% lidocaine with adrenaline.

2. Sponge holding forceps
3. Bowl with solution for painting
4. Number 11 surgical blade with handle
5. Sheets for draping
6. A pair of medium sized curved artery forceps
7. An appropriately sized chest tube: See the section on 'selecting the size of chest tube.
8. Silk No.1 suture on cutting needle
9. Needle holder
10. A pair of tooth forceps
11. Prepared underwater seal bottle or bag.
12. Gauze pieces
13. Adhesive tape for dressing

5.3 Selecting the size of chest tube

The chest tubes are available in various sizes ranging from 6 F to 40 F. There is a general understanding that large-bore tubes are required to drain fluid and small-bore tubes are sufficient to drain air. There have been numerous studies on this issue, however there is no conclusive scientific data to support this idea. Large-bore tubes have been related to higher incidence of pain and patient discomfort without any significant advantage in draining the intra-pleural fluid. In various studies, small-bore tubes have been found to be equally effective to drain pleural effusion and hemothorax [7–11]. This has generated wider interest in use of small-bore tubes for thoracostomy. Conventionally, for most of the clinical conditions requiring tube thoracostomy a 24–32 F chest tube is inserted, depending on the expected underlying pathology, however tubes smaller than 24 F may be sufficient to drain pneumothorax.

5.4 Preparing the under-water seal

The reservoirs for collecting the pleural drainage are available either in the form of bags or single or multiple chambered plastic bottles (**Figure 5A** and **B**).

In both of these reservoirs, there are markings for calculation of effluent. In addition, there is also a marking for 'initial fluid level'. Before connecting the reservoir to the chest tube, a sterile fluid like normal saline should be filled till this mark. As the chest tube is connected with the tube in the reservoir that remains below the 'initial fluid level', the air from the environment cannot gain access to the pleural cavity, however the intrapleural collection may egress easily into the reservoir, thus it functions as a one-way valve or 'under water seal'.

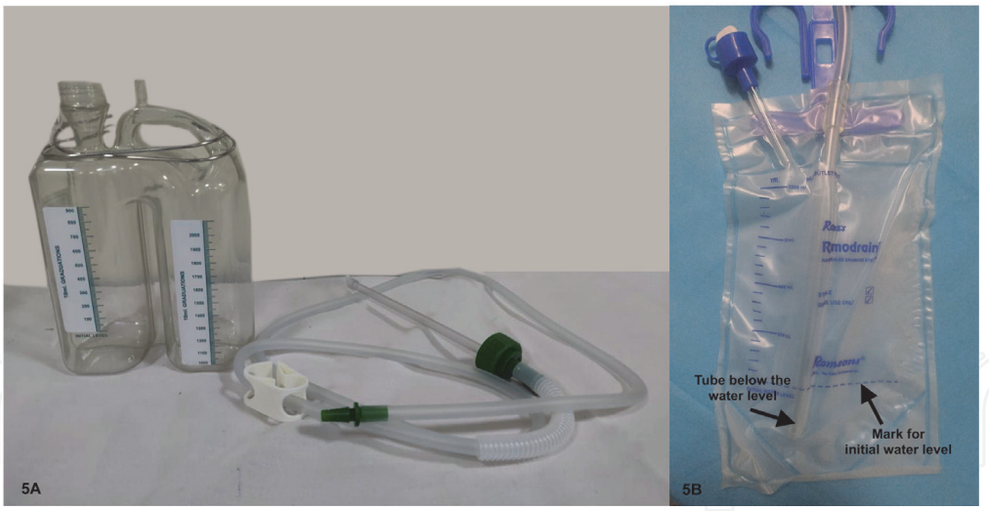

Figure 5.
A: Two chambered plastic bottle and B: ICD bag.

5.5 Local anesthesia: type, amount and technique

Any suitable local anesthetic is appropriate for the procedure. Plain Lidocaine 2% solution and Lidocaine 2% with adrenaline are commonly used drugs for ICD insertion. A volume of nearly 5 ml is sufficient to anesthetize the local site. Local anesthesia may not be required where the patient is obtunded or unconscious and ICD insertion is required urgently.

6. Inserting the chest tube

The step by step procedure is demonstrated in the video supplemented with this article.

Inserting Intercostal drainage tube: step by step.

6.1 Position of the patient

Although the ICD can be inserted while the patient is sitting, leaning forward with the forearms resting over a stool, the supine position is less cumbersome and more comfortable for both patient and the doctor. In addition, the patient may not be able to sit for the procedure due to the underlying clinical condition. We prefer to insert ICD tube in supine position. The patient lies on the table close to the edge with arm abducted over the head if possible.

6.2 Identifying landmarks

The ideal site of inserting ICD is 4th or 5th intercostal space just anterior to the mid axillary line. One may calculate the desired intercostal space by considering sternal angle as landmark. The rib attached to the level of sternal angle is the second rib, subsequent ribs can be counted while palpating the chest wall distally and laterally. There is an alternative way of counting the ribs and the intercostal

spaces which is quick and is particularly helpful in obese patients and in presence of subcutaneous emphysema. The level of the nipple in males and inframammary crease in females can be taken as a reference point- a line drawn from this point laterally to a point where it intersects the mid-axillary line is marked and the site for insertion of the chest tube is just anterior to this.

In case, the chest tube is being inserted prophylactically during thoracic surgery, the site of insertion is selected under vision in appropriate intercostal space.

6.3 Steps of the procedure

A wide area around the predetermined site of ICD insertion is painted with a suitable antimicrobial solution (Chlorhexidine or Povidone-iodine) and is draped. If the patient is awake and conscious, 5 ml of local anesthetic solution (preferably 2% lidocaine with adrenaline) is infiltrated in the overlying skin, intercostal muscles and pleura at the site of ICD insertion. Before injecting the local anesthetic, one should ensure that the needle is not in a blood vessel by pulling the plunger of the syringe back. For the adequate effect of local anesthesia, it is prudent to wait for at least 2 minutes before making the incision.

An incision measuring nearly 1.5–2 cms is made by a number 11 surgical blade at the predetermined site of ICD insertion along the long axis of the rib in the inter-costal space just over the upper border of the lower rib. This is done to prevent injury to the neurovascular bundle that runs along the lower border of the ribs.

Using a medium sized curved hemostatic clamp, the subcutaneous tissues and inter-costal muscles are dissected bluntly till the parietal pleura is reached. By the tip of the closed hemostatic clamp, gentle pressure is then applied till there is a feeling of 'give way' which marks the entry into the pleural cavity. The entry into the pleural cavity is also confirmed by the escape of intra-pleural collection like air, fluid or blood (as the case may be). One should be careful enough not to apply undue force while puncturing the pleura as this may cause injury to lungs or mediastinal structures. The jaws of the hemostatic clamp are then opened while withdrawing the instrument to increase the size of the thoracostomy wide enough to allow the entry of index finger. This should be followed by 'finger thoracostomy'. The index finger is inserted through the thoracostomy site to explore the pleural cavity for presence of any pleuro-pulmonary adhesions. In case they are present, adhesiolysis is performed to create space inside the pleural cavity for the chest tube. This step is important as attempts to insert a chest tube without ensuring space between the lung and the chest wall may injure the lung, cause air leak from the damaged lung parenchyma and such improperly placed tube may fail to drain the intra-pleural collection.

Following finger thoracostomy and ensuring safe space inside the pleural cavity to accommodate the chest tube, an adequately sized chest tube is then taken. The tip of the tube from the open end (the end that should lie inside the thoracic cavity) is held with the tip of the hemostatic clamp and the rest of the tube is held parallel to the instrument. The tube is introduced inside the pleural cavity, the instrument is then released and the tube is inserted gradually by guiding it to lie posteriorly and superiorly by using the same instrument aided by the index finger of the opposite hand to the point till the last eye (hole) on the chest tube is at least 5 cms inside the pleural cavity (this can be confirmed by looking at the markings over the chest tube). The limit to which the ICD tube needs to be put in depends on the build of the patient. In a patient with an average built a length till 8–12 cms inside the chest is sufficient.

The tube is then clamped by using an artery forceps (hemostatic clamp) close to its distal (closed) end. The end of the chest tube is now cut and is connected with

the tubing of the underwater seal using the connector provided with the chest tube. The length of the tube of under-water seal apparatus should not be unduly long as the fluid column in the tube will provide resistance to the egress of intrapleural collection compromising the drainage. A good rule is not to allow any loop in the draining tube between the connector and the tubing of the reservoir.

The chest tube is then fixed by silk suture no.1. For better fixity, it should be anchored on either side. While fixing, one must ensure to take deep bites through the soft tissues close to the tube. Fixing the tube by taking superficial bites (including skin only) may leave potential space around the tube at the site of entry in the intercostal space which may lead to subcutaneous emphysema in cases of pneumothorax and may increase morbidity. Some clinicians prefer purse string suture for fixation of the tube but that leaves an ugly scar following removal of the chest tube and as such is not necessary. A dressing is now applied at the ICD site and the tube may then firmly be reinforced at the site by using adhesive tapes. This completes the procedure.

The free drainage of the collected material from the pleural cavity and the movement of the column of the fluid in the tube confirms the adequate position of the chest tube. The chest should now be auscultated, improvement in the breath sounds suggests success of the procedure. A chest X-ray is then performed for confirmation of proper positioning of the tube radiologically.

Some authors advocate creation of an oblique passage or 'tunnel' in the chest wall to insert the tube, primarily to decrease the incidence of recurrent pneumothorax following removal of the chest tube [12]. In this technique incision is made one intercostal space below the pre-determined site of thoracostomy, the skin and soft tissues of the chest wall are then bluntly dissected to reach the site of thoracostomy thereby creating a curved passage through the chest wall for introduction of the chest tube. This requires additional time at the expense of no added advantage and therefore is not required.

7. Post-procedural care

7.1 Nursing the patient with chest tube

Utmost care should be exercised while nursing a patient with chest tube. The reservoir should remain below the level of the chest at all times. Raising the reservoir above the chest level may result in passage of the fluid from the reservoir back into the pleural cavity. While turning or shifting the patient, one must ensure that the tube is not held or entangled in the patient's bed. This may result in accidental displacement or dismantling of the tube. The outlet of the reservoir should remain open at all times especially in patients with pneumothorax or air leak. The closed outlet of the reservoir may lead to failure of decompression of pneumothorax leading to development of life-threatening tension pneumothorax. For the same reason, the tube should not be clamped at any time except while changing the fluid in the reservoir, collecting a sample of effluent or while planning to remove the chest tube. The patient should be closely monitored during this period.

The patient should be motivated for active physiotherapy and incentive spirometry (**Figure 6**).

This aids in faster resolution of pleural collection and thereby early removal of the ICD tube. In case, the patient is unable to do active physiotherapy, passive physiotherapy should be performed. All efforts must be made to ambulate the patient early. The chest tube must be secured carefully while patient mobilizes and the drainage bag (reservoir) should be kept well below the thoracostomy site.

Figure 6.
Patient performing incentive spirometry.

The ICD site should be carefully examined every day for signs of local infection like peri-tubal inflammation or tenderness. The dressing needs to be changed in case it is soaked. Extreme care must be taken while dressing the ICD site lest the tube is displaced or dismantled. The patient should be clinically monitored every day and the volume of drained fluid should be charted carefully in the patient's record. The reservoir should be emptied once it is full up to 3/4 of its capacity. A new reservoir with prepared under water seal or disposable reservoir (in case of digital chest tube drainage systems) is kept ready while changing the reservoir. In resource constraint settings the same reservoir may be reused. It is important to follow universal precautions while changing the reservoir. The chest tube is clamped and the filled reservoir is disconnected from the tube, the new reservoir is then connected or fluid is filled up to the 'initial water level' mark (or till the outlet tube is at least 2 cms below the water level) in case one contemplates to use the same reservoir. Once the reservoir is reattached, the tube is unclamped. It is important to prepare the equipment beforehand while changing the reservoir to keep the time of occlusion of the chest tube to minimum possible.

The practice of performing daily x-ray has been questioned by many authors and it is suggested that this may not be required if there is pleura to pleura apposition in the post-procedure x-ray and the patient is improving clinically [13].

7.2 Use of analgesics and antibiotics

Appropriate oral or parenteral analgesics are administered depending on the underlying condition for which tube thoracostomy was necessitated. There has been much debate on the use of antibiotics following tube thoracostomy. There is no evidence to support the routine use of prophylactic antibiotic therapy following the procedure [14, 15]. However, the antibiotics may be needed for other associated causes for which tube thoracostomy was performed like in empyema thoracis or in a patient of trauma with soft tissue injuries.

7.3 Use of suction

The use of controlled suction (−10 to −15 cm saline) to the outlet of the reservoir may help in faster resolution of intrapleural collection and promote early pleura to pleura approximation. This is most useful following pulmonary resections

and may decrease the incidence of persistent post-operative space problems. In our practice, we apply overnight suction in patients undergoing pulmonary resection surgery (except following pneumonectomy). At times, the application of suction may result in pleural pain, the amount of suction should be decreased in such situations. In case of increased air leak on application of suction, the suction may be decreased or avoided altogether.

7.4 What to do in case the tube is blocked?

Blockage of thoracostomy tube is not uncommon and occur frequently in hemothorax. Careful observation of the ICD tube and the ensuring drainage of the fluid are paramount to detect this complication early. If appropriate measures are taken in time, the possibility of maintaining the tube patency are high.

Various manipulations can be performed to restore the patency of blocked ICD tube. These include tapping, milking and stripping of the tube. These measures are successful only with partial blockage of the tube and should not be performed routinely to prevent blockage. There is theoretical possibility of generation of high intrapleural pressures with stripping and milking. Some authors have raised concern that this may cause pulmonary injury, however we have not observed any clinically significant adverse effects of these procedures. The practice of flushing the blocked tube by instilling sterile solutions should be discouraged as this may increase the chances of introducing infection from outside with resultant increase in the incidence of empyema. Some clinicians have used novel methods like using a fogarty balloon catheter to unblock the chest tube [16] or use of advanced systems to either prevent clot formation inside the tube [17] or wipe the inside of tube to unblock it [18].

7.5 How to collect a sample from the chest tube

A loop is formed in the ICD tube and the intrapleural fluid is allowed to accumulate in this loop. The tube is then clamped proximal to this collected fluid. With all aseptic measures the external surface of the ICD tube near its connection with the tubing of the reservoir is cleaned with alcohol based antiseptic solution. The tube is then disconnected from this end and the sample is collected in a sterile container. The ICD tube is then reconnected with the reservoir tube and is unclamped.

8. Removing the chest tube: when and how?

There are no fixed or universally agreed criteria that applies to all patients for guiding removal of the thoracostomy tube. There is great heterogeneity in practice, however the rule of thumb is that the chest tube should be removed once it has served its purpose. If the patient is clinically well, there is no more air leak than on forced expiration, no expanding subcutaneous emphysema, no blood, pus or chyle in the effluent and the volume of the fluid being drained is less than 250 ml, the tube can be safely removed. In case of residual space following pulmonary resection with persistent low volume air leak (no more than on forced expiration) beyond day 5, the chest tube may be clamped for up to 24 hours and a repeat x-ray is performed. The patient should be closely monitored during this period for tachypnoea or dyspnea. In case the patient remains asymptomatic and the pneumothorax does not worsen, the chest tube may be removed. The same may be done in case of persistent non-expanding effusion. This practice however, carries the risk of serious side effects if the patient monitoring following clamping of the tube is not diligent. The use of digital chest tube drainage devices might obviate this risk. The chest tube

may be safely removed if the air leak is <40 ml/ min over 24 hours [19]. Alternatively, in patients with prolonged air leak (beyond day 5), a Heimlich valve may be applied to the chest tube and the patient may be followed on outpatient basis with a plan to remove the tube later allowing more opportunity for the residual lung to expand. We have recently proposed a protocol for removal of chest tubes following thoracic surgery that have enabled us to decrease the chest tube indwelling time [20].

In some specialties like Colorectal and Gynecological Surgery, the Enhanced Recovery After Surgery (ERAS) protocol has been well established. This has recently been proposed for patients undergoing oncological major lung resection surgery too. The guidelines suggest that chest tubes may safely be removed with a non-chylous fluid output of up to 450 ml/ day in absence of air leak or minimal air leak detected by the digital chest tube drainage systems [21].

The view is equally divided regarding removal of the chest tube during end-inspiration or end-expiration [22, 23]. In a Randomized Controlled Trial by Bell RL et al., there was no significant difference between the complications following removal of the chest tube at either the height of inspiration or expiration and both methods were considered safe [23]. The incidence of recurrent pneumothorax is likely to be multifactorial and correlates poorly to the method of chest tube removal alone [23, 24]. We prefer to remove the chest tube by a swift motion followed immediately by sealing of the thoracostomy wound by appropriate dressing material irrespective of the phase of respiration.

9. Complications

The complications of tube thoracostomy may be divided into 3 phases:

1. During insertion of the tube:
    i. Hemorrhage from the ICD site
    ii. Injury to the lung and the mediastinal structures
    iii. Misplacement of the tube
2. During the indwelling time of the chest tube:
    i. Displacement or dislodgement of the tube
    ii. Subcutaneous emphysema
    iii. Kinking
    iv. Blockage
    v. Fracture of the tube
    vi. Empyema thoracis
    vii. Wound infection
    viii. Re-expansion pulmonary edema

3. Following removal of the tube

    i. Recurrent pneumothorax or pleural effusion

    ii. Thoracostomy site pain

Hemorrhage from the ICD site may be avoided by carefully siting the thoracostomy incision on the upper border of the lower rib in the desired intercostal space. This avoids the damage to the neurovascular bundle that runs along the lower border of the rib. All aseptic measures should be taken while inserting the chest tube and later while handling the tube during the post procedural care to prevent wound infection and empyema. Care should be exercised while nursing and mobilizing the patient with chest tube to prevent accidental displacement or dislodgement of the tube.

To prevent re-expansion pulmonary edema, the pleural cavity should be gradually decompressed. Sudden evacuation of more than one liter of fluid from the thoracic cavity should be avoided. It is desirable to monitor the intrapleural pressure while draining large amount of fluid from the pleural cavity. The intrapleural pressure should not be allowed to fall below −20 cm saline at any point of time.

10. Common pitfalls in chest tube management

A pitfall is different from complication and is defined as a hidden or unsuspected danger or difficulty that may lead to adverse events. The awareness of a pitfall and preparation to act swiftly in such eventuality may help in averting the complication arising from it. Following are the common pitfalls in ICD tube management:

i. Missed diagnosis: ICD tube placed in a patient with large diaphragmatic hernia suspecting it to be a loculated pneumothorax. A careful history and diligent look at the x-ray will avoid this pitfall (**Figure 7A** and **B**).

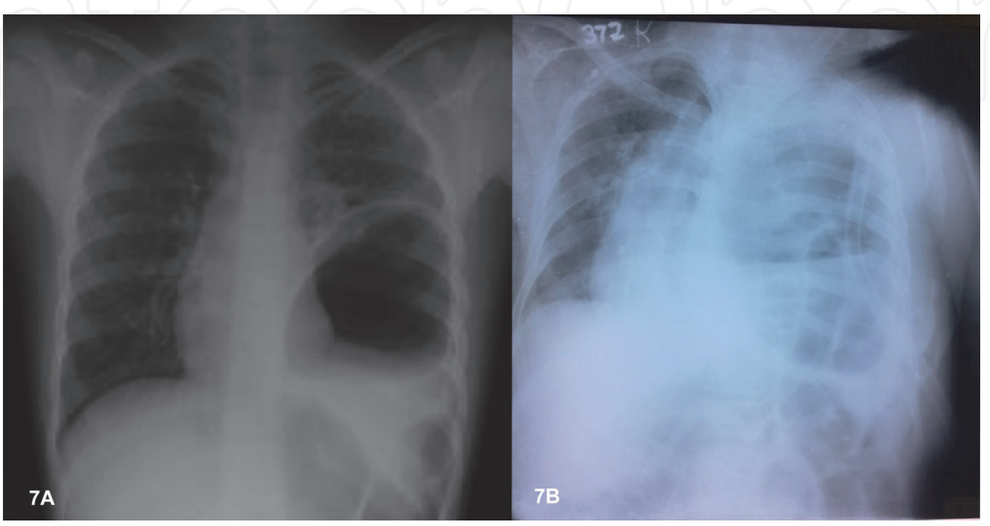

Figure 7.
A: Left sided diaphragmatic hernia with large gastric shadow. B: Chest tube inserted in a patient of diaphragmatic hernia misdiagnosed as hydropneumothorax.

ii. Placement of ICD on wrong side: One should confirm the side with pathology before putting the chest tube. The history of the patient, clinical notes and the radiological findings should be correlated to correctly identify the side of pathology.

iii. A large thoracostomy incision may result in potential space around the chest tube. This coupled with fixation of the tube by superficial skin suturing results in development of a closed plane in the subcutaneous tissues. Peri-tubal air leak in this situation may lead to massive surgical emphysema with attended morbidity and mortality.

iv. Avoiding digital exploration of the pleural cavity may result in injury to pulmonary parenchyma in addition to improper positioning and kinking of the tube (**Figure 8**).

v. One must perform 'finger thoracostomy' before inserting the chest tube to avoid this from happening.

vi. Use of tubes with trocar and applying undue force while gaining entry to the pleural cavity may result in injury to various thoracic, mediastinal or intra-abdominal organs.

vii. Poor placement result in a tube that may be:

a. Too in: may impinge on to the mediastinal structures (**Figure 9A** and **B**).

b. Too out: the eye (hole) of the tube may lie in the subcutaneous tissues with resultant subcutaneous emphysema (**Figure 10**).

c. Mispositioned or kinked resulting in poor drainage (**Figures 11–14**).

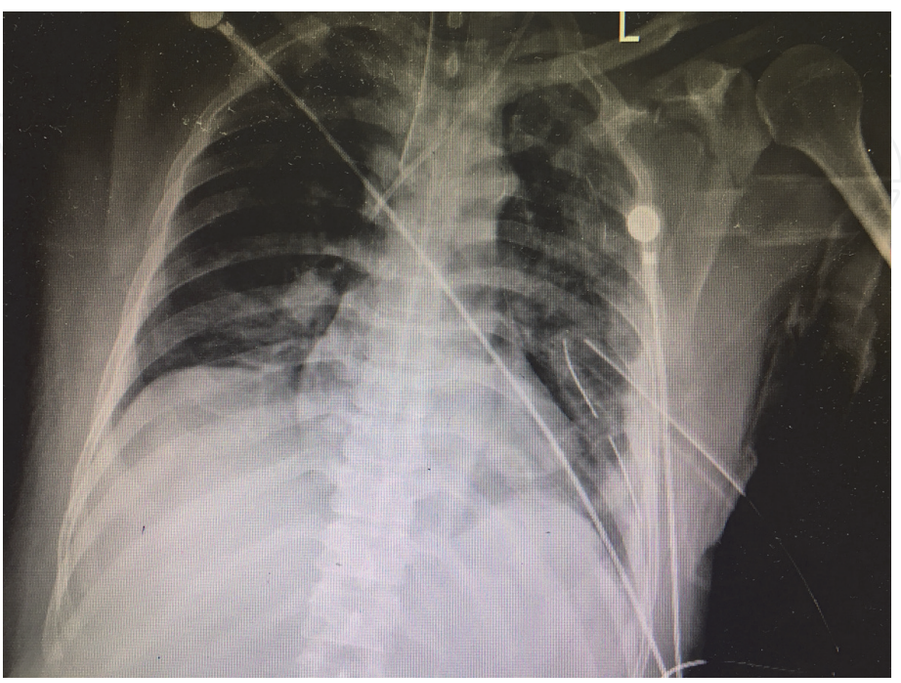

Figure 8.
A kinked chest tube.

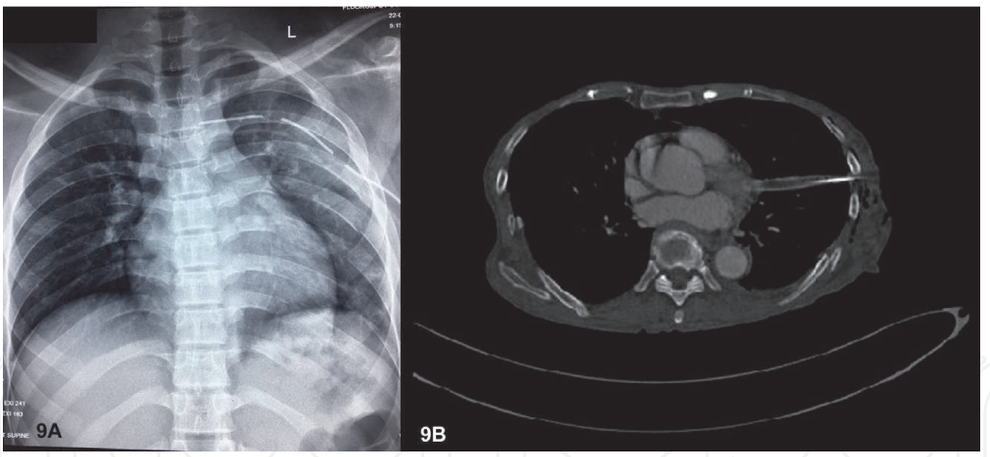

Figure 9.
A & B: Chest tube impinging on mediastinal structures.

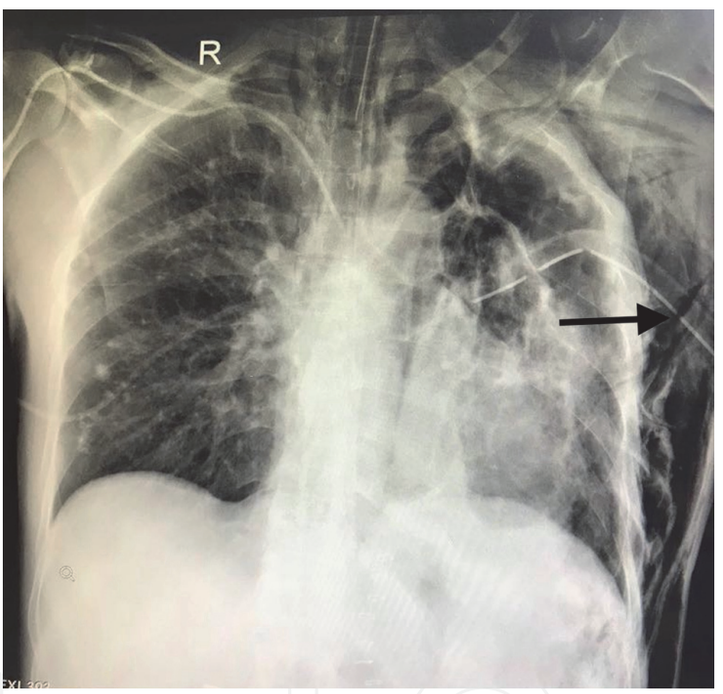

Figure 10.
Eye of chest tube in subcutaneous tissues with subcutaneous emphysema.

d. Poor fixation of the chest tube may result in accidental displacement or dislodgement (**Figure 11**). The chest tube should be anchored properly with number 1 silk suture. An additional suture from the opposite side improves the fixation and decreases the chances of this mishap.

e. Improper filling of the reservoir (under water seal) with sterile solution so that the outlet tube is not beneath the water column may result in pneumothorax.

f. Raising the reservoir above the level of the chest may result in drainage of the collected material back into the thoracic cavity. The reservoir should remain below the chest level of the patient at all times.

g. Clamping the tube while shifting or mobilizing the patient may result in tension pneumothorax. The outlet of the reservoir should be kept open at all times to prevent this.

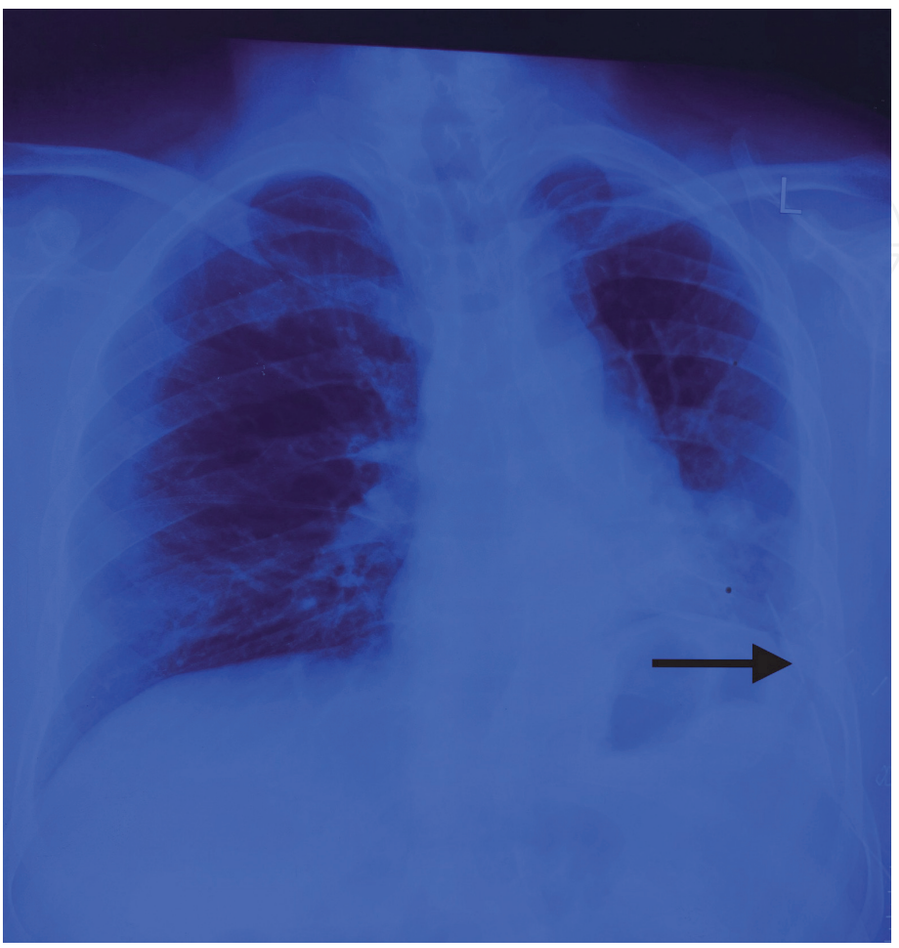

Figure 11.
Chest tube (arrow) about to come out.

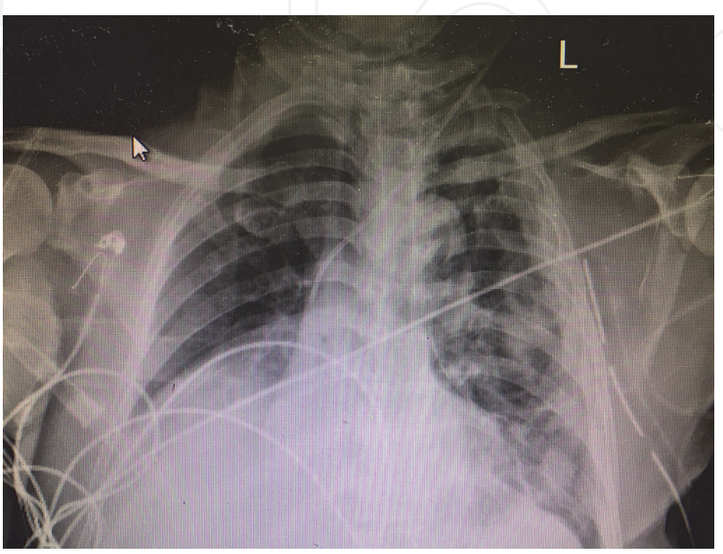

Figure 12.
Chest tube lying outside the chest wall.

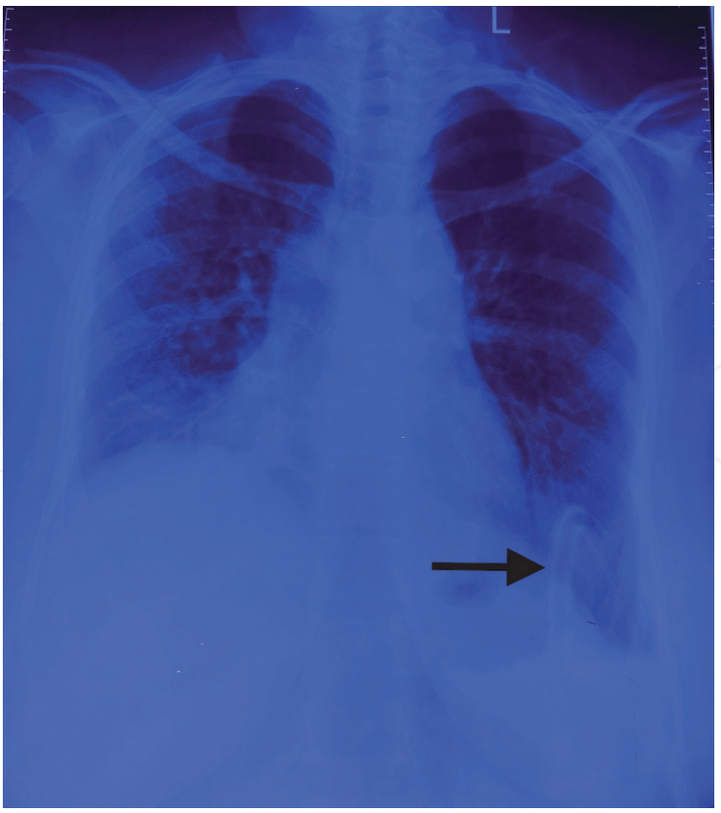

Figure 13.
Mispositioned tube over the diaphragm (arrow).

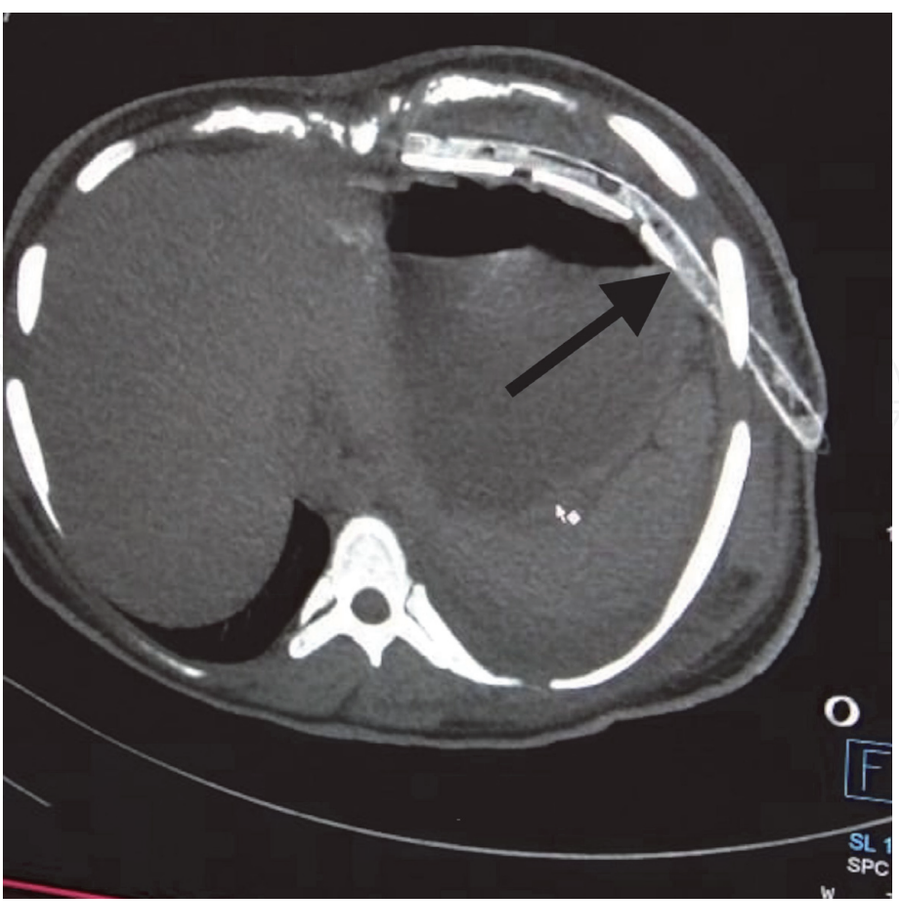

Figure 14.
Mispositioned tube lying in abdomen (arrow).

11. Advances in chest tube drainage systems

With the advancement in technology, newer equipment has become available that may help in decreasing some of the complications associated with the tube thoracostomy, make the assessment of drainage more objective and accurate thus helping in better management of ICD tubes. Some of the advancement in the recent times are:

i. Devices for better fixation of the chest tubes: Some devices are available that claim better fixation of the chest tubes [25], others have been tested on animal models and may soon become available [26].

ii. Digital chest tube drainage systems: This has been perhaps the most significant advancement that is now the part of most modern thoracic surgery units (**Figure 15**).

The use of these drainage systems has been associated with improved decision-making regarding chest tube management, decrease complications, improved quality of life and reduce the hospital stay [27–29] These are light weight, portable system with a disposable reservoir that may be replaced once full. The main advantages of this system are:

- It does not require an 'underwater seal' thus eliminating the risk of accidental pneumothorax and passage of drained material from the reservoir back to the chest.

Figure 15.
A patient being managed on digital chest tube drainage system following thoracotomy.

- It allows accurate measurement of drained fluid and air over time and thus helps in assessment of the trend of drainage (**Figure 16A** & **B**).

This may help the clinician in making decision for removal of chest tube more objective and accurately.

- Continuous controlled suction may be applied to the chest tube that remains constant irrespective of the position of the drainage system.

- The patient may easily carry the device while ambulation without the risk of changes in pressure effecting drainage or accidental drainage of the collected material back in chest.

    i. Chest tube systems with inbuilt mechanism to keep the inside of the tube clean to prevent clogging [16, 18].

    ii. Motion activated systems for prevention of clot formation inside the chest tube: This system uses motion-activated energy (vibration) primarily to prevent early adhesion of clots within the internal chest tube surface and thus maintains the patency of the chest tube [17].

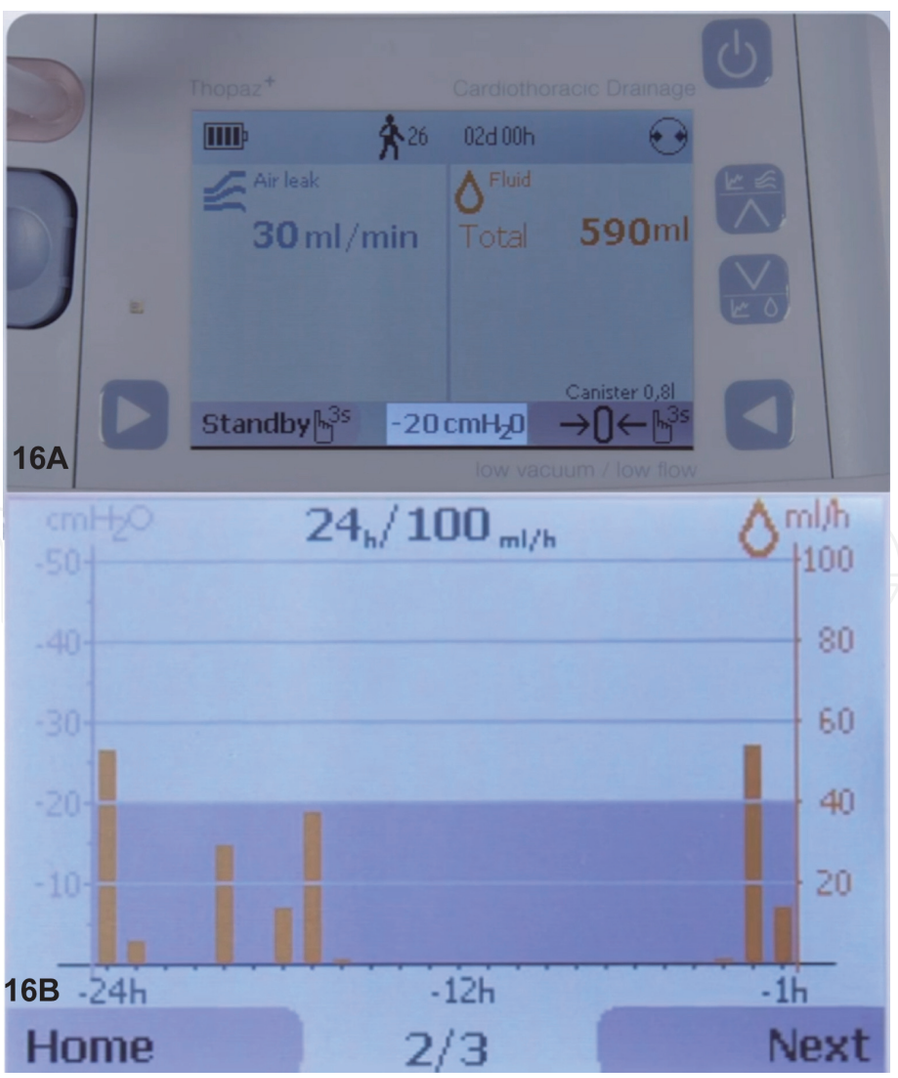

Figure 16.
A & B: Objective depiction of air and fluid drainage and trend of drainage in digital chest tube drainage system.

12. Conclusion

Insertion of ICD is a common, simple yet lifesaving procedure. All clinicians should be well versed with the appropriate technique of inserting the thoracostomy tube and various aspects of its management. Although simple, it is associated with high rate of complications that primarily occur due to improper technique of insertion or poor post-procedural care. Awareness of these factors will make the procedure safer with improved outcome.

Conflict of interest

There are no conflicts of interest.

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