CHEST DRAINS

PRACTICE GUIDELINE ©

DOCUMENT SUMMARY/KEY POINTS

All staff caring for a patient with a chest drain should read this practice guideline.

- Chest drains are inserted to facilitate the drainage of air and / or fluid from the thoracic cavity, preventing either from accumulating within the pleural or pericardial cavities.
- The indications for insertion of a chest drain include pneumothorax, haemothorax, chylothorax, pleural effusion and empyema.
- Do not clamp chest drains unless there is a clinical purpose to it or unless instructed by a medical officer.
- Hourly observations should include fluid amount, drainage type, site appearance, the suction setting and assessing the presence of oscillation and/or air bubbling.
- Chest drains should be secured to the patient to avoid disconnection while maintaining visibility.
- When mobilising a pair of spencer wells forceps or a tubing clamp must carried in the event of accidental disconnection.
- Only nursing staff accredited to administer Urokinase for empyema can flush chest drains and only as part of the documented treatment plan
- Aseptic Non-Touch Technique (ANTT) must be used in the clinical management of chest drains

CHANGE SUMMARY

- Removed equipment related information and created local work procedures that are linked to this Guideline.
- Atrium Express Mini drain now single use only

Approved by:	SCHN Policy, Procedure and Guideline Committee	
Date Effective:	1st July 2023	**Review Period**: 3 years
Team Leader:	Nurse Educator	**Area/Dept**: Cardiac Services

Date of Publishing: 28 June 2023 3:46 PM Date of Printing: 28 June 2023

K:\CHW P&P\ePolicy\Jun 23\Chest Drain.docx

READ ACKNOWLEDGEMENT

- Medical and nursing staff who are involved in caring for patients with chest drains should read and acknowledge this document.

TABLE OF CONTENTS

1 Scope and Purpose

Chest drains are inserted into the thorax and are used for draining air or fluid from the pleural, mediastinal, or pericardial cavities. This guideline covers the set-up and maintenance of chest drains in all areas of the hospital. Various types of drains and underwater systems are available, and this guideline is intended to cover the principles in the care of infants and children with a chest drain and drainage system.

2 Background and Definitions ([1, 2, 3, 4, 5])

1. **Thoracic cavity incorporates**:
   - Right lung and pleural cavity
   - Left lung and pleural cavity
   - Mediastinum (central area of the chest incorporating heart-aorta and great vessels, oesophagus, trachea, thymus, thoracic duct and other lymphatics)
2. **Pleural anatomy:**

   Lungs are surrounded by thin tissue called the pleura, a continuous membrane that folds over itself. The area between the pleura on the chest wall and that on the surface of the lung is called the pleural space.
   - Parietal pleura lines the chest wall
   - Visceral pleura covers the lung
3. **Chest drain:**

   Any drain inserted into the thoracic cavity, commonly into the pleural space.
4. **Mediastinal chest drain**:
   - Sits in the mediastinum
   - Placed in the chest following cardiac surgery to drain blood and fluid from the mediastinum.
5. **Pleural drain:**

   A tube inserted into the pleural space and is attached to a drainage system. It allows continual removal of air and/or fluid from the pleural space.
6. **Pericardial drain**:
   - A tube inserted into the pericardial sac
   - Potential for cardiac tamponade post cardiac surgery if the drain becomes blocked or dislodged
7. **Under water seal drain**:

   The underwater seal prevents back flow of fluid and air into the pleural space due to negative pressure.

8. **Conditions which may require the insertion of a chest drain**:
    - **Pneumothorax** – Occurs when there is an opening on the surface of the lung or in the airways, or the chest wall, or both which allows air to enter and accumulate in the pleural space.
    - **Haemothorax** – Blood in the pleural space may occur after thoracic surgery and traumatic injuries.
    - **Pleural Effusion** – Fluid in the pleural space (see below for fluids definitions).
    - **Chylothorax** – Chyle in the pleural space.
    - **Transudate** – a clear fluid that collects in the pleural space when there are fluid shifts in the body from conditions such as congestive heart failure, malnutrition, renal and liver failure.
    - **Exudate** – a cloudy fluid with cells and proteins that collects when the pleura is affected by malignancy or inflammatory conditions such as pneumonia.
    - **Empyema** – a collection of pus in the pleural space. Most commonly occurs as a complication in pneumonia due to *Staphylococcus aureus* or *Streptococcus spp*.
    - **Pericardial effusion** – accumulation of fluid in the pericardial cavity
9. **Chest drain unit components**:
    - **A:** Dry suction control regulator – controls the amount of negative pressure that can be transmitted to the pleural or mediastinal space.
    - **B:** Water seal chamber
    - **C:** Air leak monitor
    - **D:** Collection chamber – Fluids drains directly into the chamber and is measured in mL.
    - **E:** Suction bellow

3 Types of Chest Drain Units[1]

3.1 Atrium dry suction chest drain unit (underwater sealed drain)

1. Infant/paediatric size (200mL) (CHW only)

2. Single collection (2000mL)

3.2 Atrium Express Mini (500mL)

(CHW only)

4 Insertion of a Chest Drain

Ideally this procedure should be performed in the Operating Theatre (OT), Interventional Radiology (IR), anaesthetic bay or intensive care areas, as there are trained staff and equipment in these areas. Chest drains may also be inserted in the emergency department and ward as necessary.

Consent and clinical procedure safety list should be completed prior to procedure.

Provide appropriate analgesia and sedation as per local guidelines. CHW refer to Pain Management Practice Guideline (section 12.9) and the SCHN Procedural sedation (Paediatric ward, clinic and imaging areas) Practice guideline. In patients with pneumothorax, nitrous oxide is contraindicated during this procedure as it can cause a rapid increase in the volume of pneumothorax. [6]

Refer to Chest drain insertion Local Work Procedure

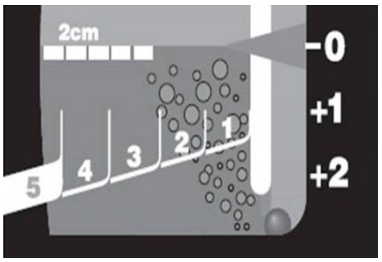
4.1 Complications[5,9,10]

- Life threatening bleeding
- Infection
- Subcutaneous emphysema
- Pneumothorax
- Damage to internal structures such as heart, diaphragm, liver, spleen, kidney, aorta and lung itself (malposition of tube)
- Intercostal nerve injury

5 Observations

1. Auscultate the patient's lung fields to assess the quality of air entry. Observe the child's chest expansion to ensure it is equal[11].
2. Assess for the presence of an air leak. Bubbling in the unit can indicate an air leak, however in the presence of a pneumothorax this is a normal finding[7,9].

   Atrium chest drain unit: Bubbling in chamber 'C' will indicate an air leak. The numbering system will demonstrate the severity of the air leak i.e., 1=small leak, 5=large leak[3,4].



   Mini chest drain unit (CHW only): If there is a concern of an air leak and there is nil drainage present in the unit, using a Luer lock syringe insert 20mL of sterile normal saline or water into the unit via the sample collection port at the base of the unit. While keeping the unit below the level of insertion at the chest, tilt the unit until the fluid is visible in the 'A' chamber. Bubbling will be visible in chamber 'A' if an air leak is present. If there is already drainage in the unit, then bubbling will be visible if there is an air leak. [2]
3. Assess the presence of oscillation or "swing". This indicates that the tube is in the right position because of normal lung movement during respiration (normal thoracic pressure). If there is no oscillation or "swing", this could mean there is an obstruction in the tubing (see Trouble shooting). There will usually be no oscillation or swing if suction is used[7, 11].
4. Hourly fluid drainage observations for[5,9]
   - Amount – This is read at an eye level while the chest drain in on the floor to ensure accuracy.
   - Drainage type
   - Suction setting
   - Oscillation/Swing
   - Air (bubbling)
5. Vital signs as indicated by patient's condition at least every four hours or as required.
6. Assess and document drain site appearance.
7. Assess patient's pain levels hourly and administer analgesia as required as per local guidelines. **CHW** refer to Pain Management Practice Guideline (section 12.9).

6 Patient Care

1. **Secure tubing to patient**

   Ensure that the tubing is taped securely to the patient so that drainage tube will not kink or pull when patient moves (see below for **site specific practice)**[5]. IN THE CONSCIOUS PATIENT – DO NOT PIN THE DRAIN TO THE PATIENT'S BED as the patient may move suddenly and dislodge the drain. Ensure the drain is visible at all times[9].

   Two pairs of Spencer Wells forceps should always be kept at the bedside for each drain and in sight so that they are readily available if there is a sudden disconnection or air leak. A clamp is also available on the Single collection Atrium dry suction chest drain unit and the Express Mini chest drain unit.

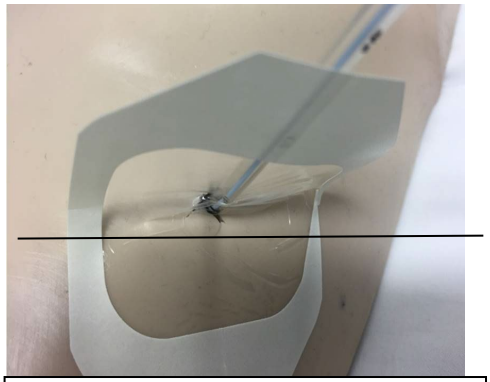
   A clear occlusive dressing is used to secure drain to patient. Change dressing if visible ooze from the chest drain site or concerns about skin breakdown. In the case of skin breakdown an absorbent dressing may be applied (Figure A and Figure B).

Dressing at CHW

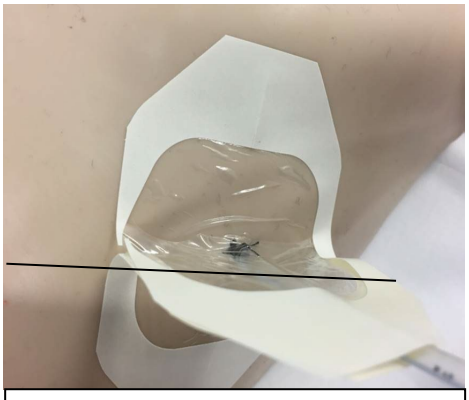
Figure A

Figure B

Dressing for Intercostal Catheters (ICCs) at SCH



1. Apply clear adhesive dressing with the midpoint of the dressing at the insertion site (shown with black line)



2. Repeat on opposite side

3. Remove outer paper, ensure dressing is airtight. Anchor tube with tape to patient's body lower down to prevent traction.

2. Pressure area care

Ensure the patient is not lying or resting on the tubing. Assess skin integrity under the dressing and drain tubing each shift and with every dressing change.

3. Maintain patency of the system

Ensure that the patency of the system is maintained at all times by gently tapping the tube hourly to remove thick drainage or clots. Aggressive milking or stripping is not recommended as this creates an increase in negative pressure in the tube and may cause a pneumothorax[5,7,9]. However stripping may be required if drainage has stopped and there is concern that the tube is blocked. **Outside of Intensive Care, stripping of chest drains should only be performed by a cardiac nurse practitioner or clinical nurse consultant.** Ensure tubing is not kinked or blocked and prevent fluid-filled loops that can interfere with drainage. Ensure any tapes applied to the drain connections do not impair the ability to view and observe the drainage contents. Drain connections should be checked at least twice daily and after patient mobilisation to limit the risk of inadvertent disconnections.

4. Maintain the underwater seal

Ensure that the underwater seal is maintained in the Atrium dry suction chest drain unit at all times by keeping the drain unit upright and the water level is adequate[7].

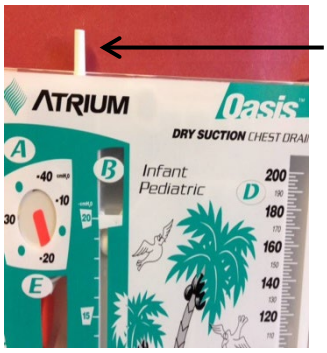
DO NOT raise drainage unit above level of patient's chest. This will cause a back flow of drainage into the pleural space[9]. Refer to Clamping of drains. The positioning of the drainage unit below the patient promotes drainage by gravity[5,7].

5. Suction settings[4,7]

The **standard suction setting** is -20cmH20, although there may be instances in which the physicians may deviate from this. Suction settings will be documented in the operation report or verbally handed over at time of admission from OT or IR.

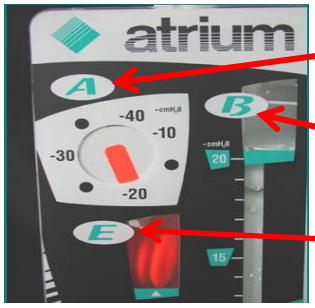
The suction is regulated by the dry valve on the underwater seal drain. This can be attached to either high or low wall suction – the dry valve on the drainage chamber will regulate the suction applied to the patient. Once the suction tubing is detached from the wall suction, the suction will be turned off. The suction can be disconnected and the drainage unit placed on free-drainage for transfers or short walks. Please refer to step 6 Positioning and Mobilising Patient. If more than one drainage unit is in use, they should be connected to the same suction outlet with a "Y" connection and second piece of

tubing. If suction is not applied to the drainage unit, DO NOT cover the suction outlet as this is an air vent which prevents air pressure build-up in the drainage unit. Similarly, if the suction is turned off, the suction tubing must be disconnected from the drainage unit so that the vent is open
(see diagram).



Suction outlet/ water insertion port

Atrium dry suction chest drain unit: The suction setting can be selected by dialling up the measurement on the side of the 'A' chamber. When the suction is attached, the orange bellow should be inflated to the arrow in the 'E' chamber. Increasing the wall suction will inflate the orange bellow further (see diagram below).



A: suction control regulator

B: Thoracic pressure chamber

E: Suction bellow

Express Mini chest drain unit (CHW only): The suction setting is pre-set at -20cmH20 and cannot be adjusted. When sufficient suction is attached, a tick will appear in the 'C' chamber (See diagram below).

Tick will appear in the C chamber

6. Positioning and mobilising patient

Ensure that the patient is in the best position to allow for drainage of air/fluid. Never lift drain above chest level. The unit and all tubing must be below the patient's chest level to facilitate drainage. Tubing must not hang over cot sides or bed rails. Nursing staff may assist the patient with frequent position changes and mobility as appropriate and encourage deep breathing and coughing to assist drainage[5].

Consult physiotherapist to optimise mobility.

Prior to transfers and short walks, confirm with the nurse caring for the patient if the suction can be disconnected and the drainage unit placed on free drainage.

Whilst the patient is mobilising, keep the chest drain below the level of insertion, unclamped and upright. Ensure that the suction tubing is reconnected to the drainage unit following transfers and short walks.

When mobilising, a pair of spencer wells forceps must be carried for each drain in the event of accidental disconnection. Please refer to Section 9- Trouble Shooting. Patients and parents/carers should be educated about mobilising with a chest drain under nursing staff supervision to avoid kinking or accidental disconnection.

7. Unit and tube changes

The Atrium dry suction chest drain unit only needs to be changed when it is full or at nurses discretion. Change patient tubing only if necessary, such as for blockage, air-leak or purulent drainage.

Refer to Chest drain unit change Local Work Procedure

8. Specimen Collection

Refer to Specimen collection Local Work Procedure

7 Notify Medical Officer if there is:

- A sudden increase in the amount of drainage[5].
- A change in the type of drainage (e.g., becomes cloudy/frank blood)[7].
- A sudden cessation of drainage, when previously large amounts, and change in patient's vital signs[7].
- Commencement of air bubbles and signs of pneumothorax[7].
- Large amounts of drain losses.
- Air collection in dressing around insertion site.

8 Clamping of Drains

NEVER CLAMP THE CHEST DRAIN UNLESS THERE IS A CLINICAL PURPOSE OR INSTRUCTED BY THE MEDICAL OFFICER.

Clamp drain only:

- If tubing is accidentally disconnected[7,5].
- Just prior to changing the drainage unit or removing the chest drain[7,5].
- When more than one drain is connected to one chest drain unit, both drains should be clamped prior to removal. This prevents possible fluids/air entering the second drain once the first drain is removed.
- You may be required to check for a leak in the system. Clamping off the tube systematically can identify the presence and/or location of the leak[7].
- Occasionally the consultant may request for the chest drain to be clamped to assess collection of fluid or air before removing it. While it's clamped, observe the patient for any signs of respiratory distress that could indicate the development of a tension pneumothorax. Monitor and document the patient's observations – including oxygen saturations (SpO_2), respiratory rate (RR) and heart rate (HR) ½ hourly while the drain is clamped.
- Moving/Transporting patients:
  - Cardiothoracic patients: Clamp drain when there is the risk of the drainage unit being raised during the movement of the patient causing a spill of fluid back into the chest[7, 8].

  Surgical patients: Clamping is not required.

Following administration of urokinase via the drain clamp for four hours. Refer to SCHN Intrapleural Urokinase in Empyema Drug Protocol. During this period, patient should remain in the ward for close monitoring. If the child develops respiratory distress whilst the drain is clamped, release the clamp immediately to let air/fluid escape. **Notify medical officer**.

9 Trouble Shooting

Oscillation/fluctuations (Swing) ceases

If the chest drainage unit is not on suction this could mean that there is an obstruction by a clot or lung tissue; a kink in the tubing; the patient may be lying on it; or a loop has become filled with fluid[7]. A gradual decrease in fluctuation may indicate lung re-expansion[7]. Infants may not generate enough thoracic pressure; therefor “swing” may not be present in this instance.

Blockage of drain

- Sudden cessation of bubbling (for pneumothorax) or drainage loss: considerable loss could mean the tubing is blocked or the air/drainage loss has ceased[7].
- Check tubing for kinks or obstruction.
- Tap tubing and reposition the patient.
- Chest drain manipulations should only be performed by an experienced clinician and care should be taken to avoid dislodging the tube during these attempts to tap and strip drain
- Outside of Intensive Care stripping of chest drains should only be performed by a cardiac nurse practitioner or clinical nurse consultant.
- Observe patient for respiratory difficulties/distress. Note any tachypnoea and/or dyspnoea.
- Consider changing tubing

Air bubbling – if no evidence of leak notify Resident Medical Officer (RMO)

- If there is no pneumothorax or the patient has not had a lobectomy, this will mean there is an air leak somewhere in the system between the patient and the drainage unit. Constant bubbling is usually the result of poor connections.
- To assess the presence of an air leak use two clamps to systematically clamp off the tube, only releasing one at a time and always working backwards from the patient to the chest drain unit[7].

Accidental disconnection of drainage tubing from drain

- Clamp drain immediately to avoid air entering pleural space.
- If closed suction system, the tube should be cleaned with antiseptic and the tubing reconnected. If unable to, then drain should be connected with a new drainage unit as soon as possible, using aseptic technique.
- Observe for signs of pneumothorax.
- Notify RMO who may request a chest x-ray.

When the chest drain becomes dislodged

- **If chest drain inserted to drain fluid:**
    - Close hole with fingers using gloves if possible.
    - Call a rapid response and observe for signs of a tension pneumothorax.

- Place child in Fowler position (45 – 60 degrees upright).
- Ask child (if old enough) to cough.
- Cover hole with an adhesive occlusive dressing.
- Check patient's vital signs.

- **If chest drain inserted to drain air:**
  - Call a rapid response to escalate care and observe for signs of a tension pneumothorax.
  - Secure drain site with occlusive dressing and only seal 3 sides to allow air to escape.
  - Place child in Fowler position.
  - Check patient's vital signs.

If patient develops respiratory difficulties/distress

- Administer oxygen via mask.
- Notify RMO immediately.
- Monitor and document respiratory rate, saturations and heart rate every 15 minutes.
- Note particularly rate, depth and of pattern of respirations[12].
- Escalate care accordingly.

10 Removal of chest drain

Refer to Removal of a chest drain Local Work Procedure

This procedure requires **two registered nurses**, one of whom has completed the chest drain competency.

Under the direction of the medical/surgical team, a chest drain is ready for removal when:

- There has been a cessation or sufficient decline in drainage volume[8].
- A recent CXR demonstrates resolution of collection of fluid/air[8].
- As per post-surgical notes.
- If the chest tube is damaged and/or needs replacement (a replacement tube should be in situ before the damaged tube is removed).

10.1 Preparation of Patient

1. Documentation by the medical/surgical team that drain can be removed.
2. Contact Child Life Therapist prior to procedure
3. Determine type of drain.

4. Review coagulation studies if applicable.
5. Explain the procedure to child and family, using developmentally appropriate communication tools[5].
6. Ensure child has fasted in accordance with SCHN Procedural sedation (Paediatric ward, clinic and imaging areas) Practice guideline
7. Provide appropriate analgesia and sedation as per local guidelines. CHW refer to Pain Management Practice Guideline (section 12.9) and the SCHN Procedural sedation (Paediatric ward, clinic and imaging areas) Practice guideline. Ensure analgesia is administered beforehand and given time to take effect[8].
8. Auscultate the child's lung fields to determine a baseline assessment of air entry.

10.2 Nursing observations post removal of chest drain

1. **Observe patient** for: [8]
   - Tachypnoea, dyspnoea
   - Decrease in oxygen saturation levels
   - Anxiety and/or distress
   - Decreased breath sounds on the affected side
   - Unequal chest wall movement - decreased movement on affected side.
2. **Possible complications** include[9,13]:
   - Pneumothorax
   - Recollection of fluid/air
   - Bleeding from drain site
   - Infection
   - Subcutaneous emphysema - air trapped under the skin

If any of the above signs develop, **notify medical officer immediately**.

11 Pericardial drain

A drain is inserted within the pericardial sac to remove excess fluid that can cause compression of the heart chambers, resulting in decreased cardiac output. This accumulating fluid can be acute or chronic[14].

Pericardial effusions are diagnosed by echocardiogram[14,15]. A chest x-ray should demonstrate cardiomegaly and ECG changes may be present[14].

Pericardiocentesis –puncturing of the pericardial sac to aspirate fluid[16]. This may also be performed to obtain the fluid for diagnostic purposes. Echo-guided percutaneous pericardiocentesis is recommended as it decreases the risk of life-threatening complications[14].

Subxiphoid pericardiotomy – removal of a portion of pericardial membrane to drain pericardial effusion[17].

11.1 Pericardial effusions can be caused by[16, 18-22]

- Post-operative cardiac surgery
- Infection
- Inflammation
- Autoimmune
- Malignant neoplasm or lymphoma
- Chest trauma:
  - Penetrating or blunt injury -cardiopulmonary resuscitation
  - Perforation or atrial wall puncture by transvenous pacemaker
- Drug reaction
- Myocardial infarction
- Chronic renal failure
- Radiation
- Unknown cause

11.2 Possible complications include:

- Tamponade/haemorrhage – tachycardia, dyspnoea, chest discomfort, shock, unconsciousness, hypotension paradoxical pulse, pericardial rub, venous hypertension[14,15,23].
- Arrhythmias[19]
- Infection[9]
- Dislodgement of chest drain

11.3 Removal of pericardial drains

- Refer to Removal of a chest drain Local Work Procedure on how to remove the pericardial drain, keeping in mind possible complications e.g., tamponade.
- The patient should be cardiac monitored and vital signs, including BP should be monitored ½ hourly for 2 hours post removal of pericardial drain.

12 Pigtail Catheter

A pigtail catheter is a drain designed to drain body fluids from an organ, duct or abscess. Pigtail catheters are inserted by an interventional Radiologist/Cardiologist under image guidance or in emergency, intensive care or by the cardiothoracic surgeon in the operating theatre[24]. Insertion may be performed in the emergency department for adolescents presenting with pneumothorax.

Pigtail catheters may have a 'tap' at the connection of the tubing closest to the patient's chest. It is important that this tap is in the open position unless ordered.

Pneumonia in children is often associated with parapneumonic effusions which can develop into an empyema[24]. Loculated pleural collections (empyema) are often managed with intra-pleural fibrinolytic agents, such as urokinase[25]. Children with an empyema often require insertion of a chest drain or pigtail catheter.

Occasionally the consultant may request a pleural pigtail catheter be flushed with 0.9% Sodium Chloride if there is concern the drain is blocked[26]. This should only be performed by a medical officer, Cardiothoracic Nurse Practitioner, Nurse Practitioner[11].

Nursing staff accredited to administer urokinase for empyema can flush chest drains, but **only** as part of the documented treatment plan.

12.1 Urokinase

- For more information refer SCHN Intrapleural Urokinase in Empyema Drug Protocol.

12.2 Removal of pigtail drains

Refer to Removal of pigtail drain Local Work Procedure

Under the direction of the medical/surgical team, a chest drain is ready for removal when:

- There has been a cessation or decline in drainage volume[8].
- A recent CXR demonstrates resolution of collection of fluid/air[8].
- Ultrasound shows no residual fluid.
- As per post-surgical notes.
- If the chest tube is damaged and/or needs replacement.

Certain types of pigtail drains have an internal locking suture running through the catheter which secures (locks) the loop at the end of the catheter. Before removal of a pigtail with an internal locking suture, this suture must be released (unlocked) in order for the loop of the catheter to be able to straighten and be removed easily **(See Figure I and J).**

Fig I

Fig J

Other types of pigtail drains do not have this internal locking suture but are simply sutured to the skin at the insertion site. There is not an internal locking suture that is required to be released prior to removal. **(See Figure K and L)**

Fig K

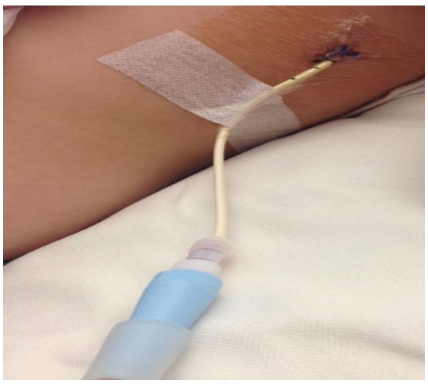


Fig L

Nursing observations post removal of pigtail drain

1. **Observe patient for**[8]:
    - Signs of haemorrhage
    - Tachypnoea, dyspnoea
    - Decrease in oxygen saturation levels
    - Anxiety and/or distress
    - Decreased breath sounds on the affected side
    - Unequal chest wall movement - decreased movement on affected side
2. **Possible complications** include[9, 13]:
    - Pneumothorax
    - Recollection of fluid/air
    - Bleeding from drain site
    - Infection
    - Subcutaneous emphysema – air trapped under the skin
    - Suture remaining lodged in the chest

13 References

1. Carroll, P. Atrium Interactive Computer-Based Training [Internet]. 2014 [cited 2014 Dec 16]. Available from: http://www.atriummed.com/EN/chest_drainage/training/101-1/index.html
2. Atrium Medical Corporation. Managing chest drainage powerpoint presentation for nursing educators [Internet]. 2014 [cited 2014 Dec 16]; Available from: http://www.atriummed.com/PDF/ManagingChestDrainage.ppt
3. Atrium Medical Corporation. Managing dry suction chest drainage [CD-ROM]. [Cited 2008 Apr 11].
4. Atrium Medical Corporation. A personal guide to managing dry suction chest drainage. New Hampshire; 2009.
5. Crawford D. Care and nursing management of a child with a chest drain. Nursing children and young people. 2011 Dec; 23(10):27-33.
6. Ferner RE, Mackenzie AA, Aronson JK. The adverse effects of nitrous oxide. Adverse drug reaction bulletin. 2014 April; 285: 1099-1102.
7. Briggs D. Nursing care and management of intrapleural drains. Nursing Standard. 2010 May; 24(21):47-55.
8. Hunter J. Chest drain removal. Nursing standard. 2008 July 16;22(45):35-38.
9. Sullivan B. Nursing management of patients with a chest drain. British Journal of Nursing. 2008 6(17).
10. Miyazaki T, Yamasaki N, Tsuchiya T, Matsumoto K, Hatachi CO, Nagayasu T. The assessment of chest tube insertion to intercostal nerve damage in thoracic surgery. American Thoracic surgery. 2013 May 22;35.
11. Woodrow P. Intrapleural chest drainage. Nursing standard. 2013 Mar;27(40):49-56.
12. Coughlin AM. Go with the flow of chest tube therapy. Nursing. 2006;36(3)36-41.
13. Given J. Management of procedural pain in adult patients. Nursing Standard. 2010 May10;25(14): 35-40.
14. Kouchoukos NT, Blackstone EH, Hanley FL, Kirklin JK. Cardiac Surgery. 4th ed. Philadelphia: Elsevier Saunders; 2013.
15. Sargrista-Sauleda J, Merce AS, Soler-Soler J. Diagnosis and management of pericardial effusion. World Journal of Cardiology. 2011 May 26;3(5):135-143.
16. Saltzman AJ, Paz YE, Rene AG, Green P, Hassanin A, Argenziano MG, Rabbanni L, Dangas G. Comparison of surgical pericardial drainage with percutaneous catheter drainage for pericardial effusion. Journal of Invasive Cardiology. 2012 Nov;24(11):590-593.
17. Muhammad MIA. The pericardial window: is a video-assisted thoracoscopy approach better than a surgical approach? Interactive Cardiovascular and Thoracic Surgery. 2010 Oct;12(2):174-178.
18. Mirhosseini SM, Fakhri M, Mozaffary A, Lotfaliany M, Behzadnia N, Aval ZA, Ghiasi SMS, Bolouursaz MR, Masjedi MR. Risk factors affecting the survival rate in patients with symptomatic pericardial effusion undergoing surgical intervention. Interactive Cardiovascular and Thoracic Surgery. 2012 Dec 18;16(2013):495-500.
19. Moss E, Miller CS, Jensen H, Basmadjian A, Bouchard D, Carrier M, Perrault LP, Cartier R, Pellerin M, Demers P. A randomized trial of early versus delayed mediastinal drain removal after cardiac surgery using silastic and conventional tubes. Interactive Cardiovascular and Thoracic Surgery. 2013 Apr 13;17(2013):110-115.
20. Bodson L, Bouferrache K, Vieillard-Baron A. Cardiac Tamponade. Current Opinion in Critical Care. 2011;17:416-424.
21. Senkus E, Jassem J. Cardiovascular effects of systemic cancer treatment. Cancer Treatment Reviews. 2010 Nov 9;37(2011):300-311.
22. Khandaker MH, Espinosa RE, Nishimura RA, Sinak LJ, Hayes SN, Melduni RM, Oh JK. Pericardial disease: diagnosis and management. Mayo Foundation for Medical Education and Research. 2010 June;85(6):572-593.
23. Maisch B, Seferovic PM, Ristic AD, Erbel R, Reinmuller R, Adler Y, Tomkowski WZ, Thiene G, Yacoub MH. Guidelines on the diagnosis and management of pericardial diseases. European Heart Journal. 2004;25:587-610.
24. Yu H. Management of pleural effusion, empyema and lung abscess. Seminars in Interventional Radiology. 2011;20(1):75-86.
25. Abu-Daff S, Maziak DE, Alshehab D, Threader J, Ivanovic J, Deslaurier V, Villeneuve PJ, Gilbert S, Sundaresan S, Shamji F, Lougheed C, Seely, JM, Seely AJE. Intrapleural fibrinolytic therapy (IPFT) in loculated pleural effusions- analysis of predictors for failure of therapy and bleeding: a cohort study. BMJ. 2013 Jan;3(2):1-6.

26. Hogg JR, Caccavale M, Gillen B, McKenzie G, Vlaminck J, Fleming CJ, Stockland A, Friese JL. Tube Thoracostomy: A Review for the Interventional Radiologist. Mayo Foundation for Medical Education and Research. 2011;28(1):39-46.
27. Kanamori LM, Guner Y, Gibbs D, Schomberg J. Are routine chest X-rays following chest tube removal necessary in asymptomatic pediatric patients? Pediatric Surgery International. 2021;37(5):631-7.