

PNEUMOTHORAX AND AIRLEAKS

PNEUMOTHORAX

Treatment of pneumothorax depends primarily on the presence of symptoms and size as well as the patient's priority of avoidance of a procedure as compared with rapid symptoms relief.

Because of better safety profile and noninferiority regarding resolution of pneumothorax, current tendency favors:

- Conservative management rather than interventional management.
- Percutaneous small $\leq 14F$ pigtail chest tube placement rather than larger tubes.

Size pneumothorax definition:

- Small pneumothorax is defined as below otherwise is considered large.
 - < 2 cm from chest wall at the hilum.
 - < 3 cm from chest wall at the apex.

Primary spontaneous pneumothorax (PSP)

First small PSP

- Clinically stable.
 - O2 and observation for 6 hr with CXR.
 - If stable, discharge.
 - If worse, percutaneous small $\leq 14F$ pigtail chest tube placement or needle aspiration (1).
- Clinically unstable
 - Percutaneous small $\leq 14F$ pigtail chest tube placement.

First large PSP

- Percutaneous small $\leq 14F$ pigtail chest tube placement.
- Consider aspiration or no intervention if asymptomatic and adequate oxygenation on room air**.
 - Place on O2 and observation with CXR follow up in 6 hours.
 - If stable, discharge and monitor CXR in 24 hours.
 - If worse, percutaneous small $\leq 14F$ pigtail chest tube placement or needle aspiration.

There is modest evidence suggesting that needle aspiration is as safe and effective as tube thoracostomy in patients with both PSP and SSP (1).

The British Thoracic Society guideline for pleural disease recommend conservative management for patient with asymptomatic PSP regardless of size (2):

- There is modest evidence that conservative management of large PSP was noninferior to interventional management, with a lower risk of serious adverse events (3, 4).
- Conservative management in this group is associated with successful pneumothorax resolution and lower recurrence.

- The hypothesis is that although the chest tubes allow for rapid re-expansion of the lung, they create a conduit for negative pressure and exacerbate the pressure gradient, whereas slower re-expansion as occur with conservative management may allow for more effective healing of the visceral pleura.
- The caveat is that the applicability of conservative management is limited to a select group of patients (asymptomatic with adequate oxygenation).

Secondary spontaneous pneumothorax (SSP)

Initial intervention

- Percutaneous small $\leq 14F$ pigtail chest tube placement.
- If small pneumothorax:
 - Consider aspiration or no intervention if asymptomatic and adequate oxygenation on room air.

Definitive intervention for first episode

- It should be performed during the same hospitalization (e.g., within three to five days) to prevent recurrence rather than waiting for a second event in most patients.
 - Medical pleurodesis with autologous blood patch pleurodesis (ABPP) is the preferred first-line or talc slurry pleurodesis.
 - VATS with pleurodesis for patients that can tolerate and willing to undergo surgery.

Traumatic pneumothorax

- Iatrogenic
 - Treated as if they had PSP.
- Non-iatrogenic.
 - Traditionally, chest tube placement has been recommended.
 - Current tendency:
 - If small and clinically stable, no intervention.
 - If large or clinically unstable:
 - Most pneumothoraces, including those with concomitant hemothorax can be treated with percutaneous small $\leq 14F$ pigtail chest tube (5).
 - Very large pneumothoraces or those with concomitant hemothorax may require percutaneous 20F or large bore 28-32F chest tubes.

Pneumothorax in patients on positive pressure ventilation

- Percutaneous small $\leq 14F$ pigtail chest tube.
- Cautious observation in stable patients with small pneumothoraces if availability for immediate chest tube placement can be provided if needed (6).

PERSISTENT AIR LEAK (PAL)

Definition:

- Air leak that persists >5 days (range 3 to 7 days).

Etiology:

- Alveolo- pleural fistula (APF).

- Distal to subsegmental airways.
- Usually, medical associated with primary or secondary pneumothorax.
- Bronchopleural fistula (BPF).
 - Mainstem, lobar, and segmental (potentially visible on standard bronchoscopy).
 - Usually post-surgery.

Severity

Cerfolio classification

- Grade 1: Present only on forced exhalation (e.g. cough)
- Grade 2: Present only during normal expiration
- Grade 3: Present during inspiration
- Grade 4: Continuous bubbling (insp + exp)

Semi-quantitative leak assessment

- Count the number of columns of leak present can be followed longitudinally to determine progression or resolution of the leak.

MANAGEMENT:

Chest tubes

- They should initially be placed on suction (no more than -20 cm H₂O) until the lung is re-expanded with early transition to water seal to facilitate resolution of the air leak.
 - Medical PAL: Usually managed with small bore pigtailed chest tube.
 - Patients on positive pressure ventilation, high-volume leaks, barotrauma, or large proximal BPF may need large-bore or multiple tubes as they may develop tension physiology with smaller drains.
 - Surgical PAL: Usually managed with large bore chest tube.
- Early transition (day 2) to water seal.
 - Post-surgical data showed that water seal is significantly superior to suction in terms of resolution of the air leak.
 - Monitor for progressive SQ emphysema which can be an early sign of uncontrolled air leak even if PTX is not expanding.

Pleurodesis

- Indicated for PAL if the patient is able to tolerate off suction or clamping without respiratory deterioration (tachypnea and/or O₂ desaturation) or tension physiology.
- Elevate drain to chest height while on water seal to allow egress of air but retain the pleurodesing agent in the chest
- Duration: 30–120 min, longer better adhesion.
- Success rates up to 80%.
- It can be achieved medically or surgically.

Medical pleurodesis:

- Autologous blood patch pleurodesis (ABPP, see figure 1)
 - Fresh venous blood via peripheral stick.
 - Instill 1–3 mL/kg (100 mL shown to be superior to 50 mL, potentially earlier resolution)

- Talc slurry pleurodesis:
 - Instilled as slurry (mixed talc and saline).
 - Doses: 4–12 g.
 - It can be painful and requires aggressive analgesia pre & post.
- For non-responder after first attempt pleurodesis, sequential use APPP and talc can be used.

Surgical pleurodesis:

- VATS with pleurodesis for PAL
- Usually first line for post pneumonectomy
 - Early BPF (<14 days), goal is expedited surgical management to repair fistula (optimize/revise stump & prevent pleural spillage and infection).
 - Late BPF (>14 days), primary BPF surgical closure is less likely successful & more likely to have a mature BPF tract.
 - Initial management with pleural space drainage & control infection followed by decortication.

Ambulatory drainage:

- For pts who can tolerate water seal and are not candidates or unwilling to undergo chemical or surgical pleurodesis

Diagnostic Bronchoscopy

- Indications
 - Most effective at locating major stump and anastomotic dehiscence in surgical patients as well as proximal BPFs.
 - When the defect is not evident in the proximal airways on direct inspection, two additional bronchoscopic techniques can be used to localize distal bronchial and parenchymal leaks to determine the location for interventions.
 - Balloon Occlusion Techniques
 - Use a Fogarty catheter to sequentially block lobar/segmental bronchi
 - Watch for leak reduction or resolution via the chest drain
 - Some parenchymal air leaks (often associated with malignancy, infection, trauma) may have collateral ventilation with other segments/lobes and often prevent complete air leak resolution needing multi-segment occlusion.
 - Dye Instillation
 - Instill diluted methylene blue via pleural drain
 - Observe airways during bronchoscopy for dye egress and target location for future interventions

Therapeutic Bronchoscopy (especially useful in non-surgical or high-risk patients).

- Valves
 - Leak resolution: 56–93% (partial success common)
 - Time to leak resolution/chest tube removal: ranged 7-21 days contributing to shorter hospital LOS
 - Major complications uncommon
 - Valves are often removable several weeks after PAL resolution

- Two unidirectional endobronchial devices FDA-approved systems for bronchoscopic “lung volume reduction in emphysema patients” can be used:
 - Spiration (Olympus) – umbrella EBV system, sizes 5–9 mm diameter, lengths 8-12 mm
 - Zephyr (PulmonX) – bird-beak design, 4.5–5.5 mm diameter, come in two lengths
- **Synthetic sealants**
 - Can be considered when surgery and valves are not viable options.
 - Case reports and small series using synthetic sealants like cyanoacrylate, fibrin glue, and tissue adhesives showed varying success.
- **Airway stents**
 - Fully covered metal stents, semiflexible vascular balloon-expandable stents, and most notably, 3D-printed, patient-specific silicone stents have emerged as cutting-edge solutions.

VV ECMO

- It can be considered to maintain gas exchange and facilitate fistula healing in patients with PAL refractory to ultra lung protective ventilation and minimization of transpulmonary pressure (TPP).
- The goal is to create conditions where the lung can heal while maintaining adequate oxygenation and ventilation without positive pressure ventilation (PPV).
- It can safely facilitate additional bronchoscopic procedures while maintaining adequate gas exchange
- Extubation or early tracheostomy with utilization of HFNC may be critical tools to eliminate PPV and further reduce TPP.

Ultra lung protective ventilation (ULPV)

- Spontaneous breathing is ideal (assuming no increased WOB) to help facilitate fistula healing.
- If PPV is unavoidable, the priority is to minimize mean airway pressures in pressure control mode.
 - Low tidal volumes ≤ 4 ml/kg
 - Short inspiratory times
 - Minimize PEEP to ≤ 10 , plateau pressure to ≤ 24 , and driving pressures to ≤ 14
 - Lower respiratory rates to ≤ 10
 - Permissive hypercapnia when feasible—with the goal of reducing airway pressures
 - In select cases with unilateral disease, independent lung ventilation (ILV) may be considered.

Blood Patch Protocol from Mayo Clinic



STEP 1

Starting with a normal chest tube arrangement where chest tube is either connected to a digital or mechanical drainage system on water seal setting, the atrium/digital drainage system is temporarily clamped & disconnected from the chest tube, sterilized, and then connected as seen in the figure to the left. If the patient has an active air leak, then this step should be efficient to prevent the patient from becoming symptomatic during the reconnection of tubing while the tube is temporarily clamped.

STEP 2

After hanging the tubing over an IV pole to hold the fluid inside the chest, have the blood drawn (3 30cc aliquots into syringes) and then inject the blood into the chest tube through 3way stopcock connected to the chest tube.

STEP 3

Suspending the tubing over IV pole to allow air to escape but keep blood in the chest. After the blood has been sitting inside the chest for 2 hours, then re-connect the tubing to the original starting configuration.



Photo of Luer-lock and tubing that connects to CT just above.

Supplies:

1. Glover tubing (this is to drape the chest tube over IV pole to prevent it all draining out)
2. 5 in 1 tubing to connect glover tube to chest tube
3. Luer-Lock connector with short tube attached (5 in 1 tube connector goes in short tube and connects to chest tube)
4. Non-vented Male Luer lock cap
5. 3 way stopcock attached to the luer lock connector with short tube attached
6. 60cc Luer lock syringes.
 - a. 3 for blood (we drew aliquots of 30ml of blood at a time-no heparin in the tube, just draw 30cc at a time to prevent it from clotting and give it right away) total 90 cc blood instilled in chest.
 - b. 1 for NS flush- we flushed 30-45 cc after blood to keep tube patent (250 cc bottle NS for flush at end of procedure to keep the tube patent).
7. Keep the patient in bed for an hour with the option of rolling from side to side. CT is kept on Wwaterseal for 2 hours during the time the blood is dwelling inside the chest. With glover tubing draped up over IV pole, you could place to suction on either digital drainage system or pleurevac if you are worried about pneumothorax developing if off suction, but the procedure works best if the tubing is kept to waterseal for 2 hrs while the blood is inside the chest. -Thoracic Surgery Division, Mayo Clinic, 2020

Taken from EMCrit Podcast by Trina Augustin MD.

References:

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6. Clements TW. OPTICC: A multicenter trial of Occult Pneumothoraces subjected to mechanical ventilation: The final report. Am J Surg 2021: 221:1252-58.
7. EMCrit Podcast by Trina Augustin MD.

Chest tube-Air leak

- Causes
 - Leak in the collection system
 - Clamping the chest tube as it connects to the pleural drainage unit will terminate the air leak seen in the suction chamber
 - Large bronchopleural fistula
 - Intraparenchymal placement
 - Outward migration of the chest tube such that one or more of its side holes sit outside the patient and can entrain air from the atmosphere
- Placement of an additional chest tube
 - If the patient is clinically unstable owing to incompletely evacuated pleural air
 - Large bronchopleural fistula that is insufficiently treated by a single chest tube
- PEEP is frequently reduced in the presence of a bronchopleural fistula to try to decrease mean alveolar pressure, reduce the magnitude of air leaking through a bronchopleural fistula, and promote closure of the fistula

Unexpandable lung

- Persistent pneumothorax despite a functional chest tube and is without an air leak
- Most common causes
 - Diseases affecting the visceral pleura all prevent the lung from normal expansion
 - Trapped and entrapped lung
 - Endobronchial obstruction with lobar collapse
 - Chronic atelectasis
 - Large lung parenchymal tumors